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EXCHANGE RATES, PRICES AND MONEY: LESSONS FROM THE 1920's

Jacob A. Frenkel

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ABSTRACT

The experience with flexible exchange rates during the 1920's has proven to be extremely important in shaping out current thinking about the operation of floating rates regime. This paper summarizes the results of a comparative empirical study of the operation of flexible exchange rates during the 1920's under both the hyperinflationary conditions (based on the experience of Germany) and under "normal" conditions (based on the experience of Britain, the U.S., and France). The three issues that are discussed are (i) the efficiency of the foreign exchange market which is analyzed by examining the relationship between spot and forward exchange rates; (ii) the relationship between exchange rates and prices which is analyzed by examining aspects of the purchasing power parity doctrine; and (iii) the determinants of exchange rates which is analyzed by examining the relationship between exchange rates, money and expectations.

Professor Jacob A. Frenkel
Department of Economics
University of Chicago
1166 East 59th Street
Chicago, Illinois 60637

(312) 753-4516

The experience with flexible exchange rates during the 1920's has proven to be extremely important in shaping our current thinking about a variety of issues including the choice among alternative exchange rate regimes, the role of speculation in the market for foreign exchange, the purchasing power parity doctrine and the determinants of equilibrium exchange rates.

Probably no event in monetary history has been studied more closely than the German hyperinflation. Economists have been attracted to study this episode since it provides an environment that is close to a controlled experiment which is so rare in the study of social sciences. It also provides a convenient starting point for the reexamination of theories in circumstances in which the predominant disturbance is of a monetary origin. However, interest in the experience with flexible exchange rates during the 1920's is not confined only to the lessons from the German hyperinflation. From the viewpoint of economic research, that experience provides also the opportunity to conduct a comparative study of the operation of flexible exchange rates under "normal" conditions. Specifically, until the return to gold by Britain (in 1925) many countries adopted a flexible exchange rate system. This system was successful in insulating most of the world from the direct consequences of the extraordinary German hyperinflation of 1921-23. Thus, during the same period in which Germany was experiencing the hyperinflation, much of the rest of the world was operating under practically "normal" conditions.

This paper summarizes the results of an empirical study of the operation of flexible exchange rates during the 1920's under both the hyperinflationary conditions (based on the experience of Germany) and under the "normal" conditions (based on the experience of Britain, the U.S. and France). Section I deals with some general characteristics of the market for foreign exchange by examining the relationship between spot and forward exchange rates. Section II deals with the relationship between exchange rates and prices by examining aspects of the purchasing power parity doctrine. Section III deals with the determinants of exchange rates within the context of a simple monetary model, and Section IV contains concluding remarks.

I. Characteristics of the Market for Foreign Exchange

This section describes some characteristics of the foreign exchange market by examining the relationship between spot and forward exchange rates. The hyperinflation period is analysed using the Mark/Pound exchange rate during February 1921-August 1923, and the "normal" period is analysed using the Franc/Pound, the Dollar/Pound and the Franc/Dollar exchange rates (of which only two are independent) during the period February 1921-May 1925. The length of the hyperinflation period was determined by the availability of data on the forward exchange rate, whereas the "normal" period was terminated by the return of Britain to gold. Data sources for the hyperinflation are the same as in Frenkel (1977) and the sources for the "normal" period are the same as in Frenkel (1978) and Frenkel and Kenneth W. Clements. All data are monthly.

To examine the relationship between spot and forward rates, I first regress the logarithm of the current spot exchange rate, $\ln S_t$, on the logarithm of the one-month forward exchange rate prevailing at the previous month, $\ln F_{t-1}$, as in equation (1).

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

If the forward exchange rate is an unbiased forecast of the future spot exchange rate, the constant terms in equation (1) should not differ significantly from zero,[1] and the slope coefficient should not differ significantly from unity. Efficiency of the market requires that the residuals from the estimated regression be serially uncorrelated. Table 1 contains the ordinary least squares estimates of equation (1). As may be seen for the "normal" period the hypotheses that the constant terms do not differ significantly from zero and that the slope coefficients do not differ significantly from unity cannot be rejected (at the 95 percent confidence level). The Durbin-Watson statistics indicate the absence of first-order autocorrelated residuals; an examination of higher order correlations (up to 12 lags) shows that no correlation of any order is significant. For the hyperinflation case the constant term is somewhat negative while the slope coefficient is somewhat above unity (at the 95 percent confidence level). Most importantly, however, the residuals from the equations are serially

Table 1

Efficiency of Foreign Exchange Markets: Monthly Data
(standard errors in parentheses)

Dependent Variable: $\ell n\ S_t$	Constant	$\ell n\ F_{t-1}$	$\ell n\ F_{t-2}$	s.e.	R^2	D.W.	m
Mark/Pound (Feb. 1921-Aug. 1923)	-.454 (.254)	1.094 (.029)		.46	.98	1.89	.38
	-.437 (.302)	1.120 (.187)	-.029 (.209)	.47	.98	1.95	
Franc/Pound (Feb. 1921-May 1925)	.169 (.179)	.962 (.042)		.07	.91	1.92	.09
	.177 (.187)	.992 (.144)	-.032 (.147)	.07	.91	1.97	
Dollar/Pound (Feb. 1921-May 1925)	.057 (.056)	.964 (.038)		.02	.93	1.54	.02
	.073 (.057)	1.181 (.143)	-.229 (.142)	.02	.93	2.11	
Franc/Dollar (Feb. 1921-May 1925)	.203 (.149)	.928 (.054)		.08	.85	1.95	.52
	.206 (.156)	.945 (.145)	-.018 (.146)	.08	.85	1.98	

Note: s.e. is the standard error of the equation. The m-statistic tests for the absence of errors in variables arising from using $\ell n\ F_{t-1}$ as a proxy for the expected future spot rate. It is distributed χ^2 with 2 degrees of freedom. To compute the m-statistic the equations were reestimated using lagged values of the dependent and independent variables, a constant, time and time squared as instruments.

uncorrelated (up to 12 lags). In all cases the inclusion of an additional lagged value of the forward rate does not lower the standard error of the regressions and its coefficient does not differ significantly from zero. This finding is consistent with the hypothesis that the forward rate prevailing at period t-1 summarizes all available information and thus the inclusion of data from period t-2 does not improve the fit.

The efficiency of the market can also be analysed from a different angle. Consider equation (2):

$$(2) \quad x_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{n} \beta_i x_{t-i} + \gamma \pi_{t-1} + w_t$$

where x_t denotes the percentage change in the spot exchange rate ($\ell n\ S_t - \ell n\ S_{t-1}$), π_{t-1} denotes the forward premium on foreign exchange ($\ell n\ F_{t-1} - \ell n\ S_{t-1}$), t denotes time, n denotes the number of lags and w an error term. If the forward premium on forward exchange summarizes all available information concerning the future evolution of the exchange rate, then given the value of the forward premium, the past history of the rate of depreciation should not "help" the prediction, and the joint hypotheses that α_1 and β_i are zero should not be rejected. Applying these tests (using 4, 5, and 6 lags) reveal that for the German hyperinflation the null-hypothesis can not be rejected at the 95 percent confidence level (for further details see Frenkel, 1980b). For the "normal" period the results are similar but somewhat less strong: in some cases the null-hypothesis is rejected (marginally) at the 95 percent confidence level but not at the 99 percent. Similar results are obtained from testing the joint hypotheses that α_1 and β_i are zero and that γ is unity. It is concluded therefore that the forward premium on foreign exchange incorporates the relevant available information contained in past exchange rate changes. It should be noted that if we regard the forward premium as a measure of the predicted change in the exchange rate, then this prediction accounts for a very small fraction of the actual variations and thus indicating that the bulk of exchange rate changes are due to "new information." This fact seems to be an empirical regularity which is found in both the hyperinflation

period as well as in the "normal" period. Further evidence from these and other periods are provided by Michael Mussa, Frenkel (1980a), and Frenkel and Mussa.

The assumption underlying equation (1) was that the forward rate $\ell n\ F_{t-1}$ measures the expected spot rate for period t. If, however, the forward rate is a "noisy" proxy for the expected future value of the spot rate (i.e., it measures it with a random error) then the assumption that $\ell n\ F_{t-1}$ and u_t in equation (1) are independent would be violated and the OLS procedure would yield inconsistent estimates due to the classical errors in variables bias. To examine this possibility I follow the specification test outlined by Jerry Hausman. The m-statistics reported in Table 1 indicate that in all cases the use of the forward exchange rate as a proxy for expectations does not introduce a significant errors in variables bias.

The principal conclusions that may be drawn from the previous discussion are that the behavior of the foreign exchange market during the "normal" period was consistent with the general implications of the efficient market hypothesis and that the forward exchange rate summarized the relevant available information concerning the future evolution of the rate. These results are somewhat less clear for the hyperinflation period where it is seen (in Table 1) that the forward rate seems to have underpredicted the future spot rate. However, in view of the unprecedented acceleration of the rates of inflation and depreciation, one could expect that, while individuals learn the new structure, mistakes would be made and expectations would initially underpredict the actual course of events. With this perspective I interpret the overall behavior of the foreign exchange market during the hyperinflation as being in accord with the broad principles of an efficiently functioning market.

II. Exchange Rates and Prices

The relationship between exchange rates and prices is summarized by the purchasing power parity doctrine (PPP) which states that the equilibrium exchange rate between domestic and foreign currencies equals the ratio between domestic and foreign prices. The intellectual origins of the doctrine can be traced back to the writings of John Wheatley and David Richardo in the early part of the 19th century and its more recent

revival owes much to Gustav Cassel's writings mainly during the 1920's. Some aspects of the doctrinal controversies and interpretations of the doctrine are analysed in Frenkel (1978).

In its general form the PPP relationship can be written as:

$$(3) \quad \ell n\, S_t = a + b\, \ell n\, P_t - b^* \ell n\, P_t^* + u_t$$

where S_t, P_t and P_t^* denote, respectively, the exchange rate, domestic and foreign price indices (with an asterisk denoting quantities pertaining to the foreign country) and where u_t denotes an error term.

From the empirical viewpoint several issues may be raised: (i) What price index should be used in equation (3)? (ii) Are the coefficients of domestic and foreign prices the same? (iii) Are the data consistent with the hypothesis that the coefficients of domestic and foreign prices are both unity, i.e., are $b = b^* = 1$?

These questions are examined below for both periods using alternative price indices. To allow for a simultaneous determination of prices and exchange rates equation (3) was estimated using a two-stage least squares estimation procedure. The estimates are reported in Table 2. Also reported in the Table are the values of F-statistics relevant for testing the hypothesis that $b = b^* = 1$.

On the whole, for the "normal" period the results show that except for one case (corresponding to the regression of the Dollar/Pound exchange rate on the ratio of the material price indices) the data are consistent with the joint restrictions implied by the homogeneity postulate. For example, the elasticity of the Franc/Dollar exchange rate with respect to the wholesale price ratio is 1.091 and the joint hypothesis that $b = b^* = 1$ is not rejected since the value of the F-statistic is 2.32 while the critical value (at the 95 percent confidence level) is 3.19. For further evidence see Frenkel (1978) and Paul Krugman.

In applying equation (3) to the hyperinflation period it was assumed that the variations in P/P* were completely dominated by variations in German prices so that the foreign price could be viewed as being fixed. As is seen in Table 2, the PPP

Table 2

Purchasing Power Parities: Monthly Data
(standard errors in parentheses)

Dependent Variable: $\ell n\ S_t$	Price Index	Constant	$\ell n(P/P^*)$	Test Restriction F(2,48)	s.e.	R^2	D.W.	ρ
Mark/Pound (Feb. 1921-Aug. 1923)	wholesale	-1.676 (.178)	1.026 (.017)	-	.221	.99	2.01	.24
	cost of living	-1.575 (.423)	1.084 (.041)	-	.367	.99	2.06	.50
Franc/Pound (Feb. 1921-May 1925)	wholesale	.562 (.207)	1.141 (.064)	4.97	.044	.97	1.82	.53
	material	.613 (.180)	1.081 (.054)	4.67	.042	.97	2.18	.48
Dollar/Pound (Feb. 1921-May 1925)	wholesale	-.118 (.482)	.897 (.267)	.53	.019	.94	1.99	.85
	material	-.073 (.453)	.847 (.245)	11.11	.022	.91	1.83	.80
Franc/Dollar (Feb. 1921-May 1925)	wholesale	1.183 (.157)	1.091 (.109)	2.32	.054	.93	1.70	.58
	material	1.243 (.130)	.992 (.085)	2.14	.050	.94	1.74	.54

Note: s.e. is the standard error of the regression. R^2 was computed as 1 - $var(\hat{u}_t)$/ $var(\ell n\ S_t)$. ρ is the final value of the autocorrelation coefficient; an iterative Cochrane-Orcutt transformation was employed. Two-stage least squares estimation was used following Fair's method with lagged values of the dependent and independent variables, a constant, time and time squared as instruments. The F-statistics test the validity of the joint restrictions that domestic and foreign prices have the same coefficients and that the elasticity is unity. Critical values for F(2,48) are 3.19 (95 percent) and 5.08 (99 percent).

doctrine seems to be satisfied for the wholesale price index where the elasticity of the exchange rate with respect to that price is 1.026. It holds less well for the cost of living index which includes prices of many non-traded goods. Nonetheless, even for the cost of living index the elasticity is not too far from unity.

In assessing these results it is important to recall that the estimates are based on monthly data, and that short-run deviations from PPP may reflect the fact that not all markets adjust at the same speed. It is also important to recognize that the PPP doctrine describes an equilibrium relationship between two endogenous variables. As such, it should be viewed as a short-cut rather than a substitute for a more complete model of the determination of prices and exchange rates. The main usefulness of the doctrine is in providing a guide as to the general trend of exchange rates rather than the day-to-day fluctuations. The main lesson for policy that is provided by the evidence in Table 2 is that the exchange rate and the price level cannot be divorced from each other and, as a first approximation, policies which affect the trend of domestic (relative to foreign)prices, also affect the exchange rate in the same manner.

III. Exchange Rates, Money and Expectations

This section analyses the determinants of exchange rates during the 1920's from the perspective of the monetary (or the asset market) approach to the exchange rate. Being a relative price of two assets (moneys), the equilibrium exchange rate is attained when the existing stocks of the two moneys are willingly held. Therefore, it is convenient (though not necessary) to analyse the determinants of the exchange rate in terms of the supply and the demand for these moneys.[2] The central insight obtained from this approach is the recognition that expectations concerning the future exchange rates are among the prime determinants of current exchange rates.[3]

A simple exchange rate equation which incorporates these considerations is specified in equation (4)

$$(4) \quad S = f(M, M^*, y, y^*, \pi)$$

where M and M* denote domestic and foreign money supplies, y and y* denote domestic and foreign incomes, π denotes the forward premium on foreign exchange (which is assumed to measure the expected depreciation of the currency) and where S denotes the exchange rate, i.e., the price of foreign exchange in terms of domestic currency. While this equation can be derived from a specific monetary model (which allows for real and monetary factors) like in Frenkel (1976) and John Bilson, a similar set of variables would also appear in the reduced form of a variety of alternative models (see Rudiger Dornbusch). The predictions are that, ceteris paribus, (i) a rise in the supply of domestic money will raise S (i.e., depreciate the home currency) while a rise in the supply of foreign money will lower S. The homogeneity postulate requires that the elasticity of S with respect to M and M* be unity and minus unity, respectively; (ii) a rise in domestic income due, for example, to a rise in productivity which raises the relative demand for domestic money, will appreciate the currency (lower S), while a rise in foreign income (which raises the relative demand for foreign money) will depreciate the currency,[4] and (iii) a rise in the forward premium on foreign exchange will lower the relative demand for domestic money and will depreciate the currency (raise S).

Estimates of equation (4) are reported in Table 3. For the hyperinflation period it was assumed that variations in the ratio of the two money supplies dominated by variations in the German money supply and that variations in the demands for moneys were dominated by changes in expectations so that changes in incomes and in the foreign money supply could be ignored. As is evident the results are fully consistent with the prior expectations. The elasticity of the exchange rate with respect to the money stock does not differ significantly from unity while the (semi) elasticity with respect to the forward premium is positive indicating that an expected future depreciation of the currency results in an immediate depreciation. The order of magnitude of the latter (semi) elasticity is similar (in absolute value) to the interest (semi) elasticity of the demand for money.

The results for the "normal" period are less definitive. OLS estimates of equation 4 (not reported here) are extremely imprecise. Due to the limited degree of variation in the series and the high degree of collinearity, the information that

Table 3

Exchange Rate Equations: Monthly Data
(standard errors in parentheses)

Dependent Variable: $\ell n\ S_t$	Constant	ℓn M	ℓn M*	ℓn y	ℓn y*	π	s.e.	R^2	D.W.	ρ
Mark/Pound (Feb. 1921-Aug. 1923)	-6.030 (1.696)	.970 (.092)				3.886 (1.131)	.340	.99	2.56	.89
Franc/Pound (Feb. 1921-May 1925)	.001 (.010)	.999 (.099)	-.972 (.099)	.188 (.281)	.926 (.520)	3.914 (.970)	.069	.92	1.86	1.00
Franc/Dollar (Feb. 1921-May 1925)	.006 (.011)	.995 (.099)	-.995 (.100)	.225 (.327)	-.369 (.370)	3.971 (.974)	.075	.86	1.81	1.00

Note: The Mark/Pound exchange rate equation was estimated using two-stage least squares following Fair's method with lagged values of the dependent and independent variables, a constant, time and time squared as instruments. ρ is the final value of the autocorrelation coefficient; an iterative Cochrane-Orcutt transformation was employed. R^2 was computed as $1 - \text{var}(\hat{u}_t)/\text{var}(\ell nS_t)$. The Franc/Pound and the Franc/Dollar exchange rate equations were estimated in first difference form using the Theil-Goldberger mixed estimation procedure with stochastic restrictions. For details see Frenkel and Clements (1978).

is contained in the sample is not sufficient to provide precise estimates of the various parameters. To obtain more precise estimates the sample information was supplemented by prior information about the elasticities with respect to the money supplies, and the forward premium (which was based on the estimates for the hyperinflation period) according to the Theil-Goldberger mixed estimation procedure. This procedure was adopted for the Franc/Pound and the Franc/Dollar exchange rates after varifying (according to a χ^2 test) that the sample and the prior information were compatible with each other; the Dollar/Pound exchange rate failed the χ^2 test.[5] As is evident from Table 3, the results are consistent with the predictions. For both exchange rates the elasticity with respect to domestic and foreign money supplies are unity and minus unity, respectively, and the (semi) elasticities with respect to the forward premium are positive. The income elasticities are not significant (at the 95 percent confidence level). In the only case where the income elasticity comes close to being significant (foreign income in the Franc/Pound exchange rate) it has the correct positive sign. While the results for the "normal" period seem to be consistent with the theoretical predictions, the fact that the sample provides very little information suggests that the data would also be compatible with different values of the prior information and that the test is not sufficiently powerful to discriminate among alternative approaches.

IV. Concluding Remarks

The experience of the 1920's provides the opportunity to conduct a comparative study of the behavior of a flexible exchange rates system under "normal" conditions as well as under highly inflationary conditions. The three issues examined in this paper are, (i) the relationship between spot and forward exchange rates, (ii) the relationship between exchange rates and prices, and (iii) the relationship between exchange rates, money and expectations.

In a recent paper dealing with inflation and unemployment Robert J. Gordon analysed the reactions of a hypothetical modern-day Rip Van Winkle who had become well acquainted with the earlier literature but who only recently awoke from a

decade-long nap. It is interesting to examine a related experiment: suppose that Rip who was well acquainted with the data reported in this paper , went to sleep in 1925 to be awoken in the 1970's. Would his human capital of the 1920's vintage be obsolete? This question is of special interest since world capital markets have become much more integrated, the role of "real" shocks in the 1970's have become much more important, views about the role of government in the conduct of macroeconomic policies have changed, the roles of tariff and non-tariff barriers to trade as well as the degree of exchange rate management have been altered and finally, the International Monetary Fund has been created.

A comparison of the lessons from the 1920's with the experience in the 1970's suggests that the answer is somewhat mixed.[6] The various characteristics of the relationship between spot and forward exchange rates which were discussed in Section I seem to be the most robust. It seems to be stable between the "normal" and the hyperinflation periods of the 1920's and the evidence from the 1970's suggests that it is also stable over time. The major difference relates to the relationship between exchange rates and prices: while the PPP doctrine held up reasonably well during the 1920's, the evidence from the 1970's indicates large departures from PPP. These departures have not yet been fully explained. Finally, the relationship between exchange rates, money and the forward premium was shown to be very significant during the hyperinflation but less so during the "normal" period. A similar pattern seems to reemerge in the 1970's where analogous exchange rate equations are more successful in circumstances with high inflation than in circumstances with low inflation.

Footnotes

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1. More precisely, if the forward rate is an unbiased forecast of the future spot rate, then the constant term in eqation (1) should equal $-0.5\sigma_u^2$; see Frenkel (1979).

2. This emphasis on the stock demand and supply of moneys was also adopted by John Meynard Keynes in explaining the value of the French Franc:"What, then, has determined and will determine the value of the Franc? First, the quantity, present and prospective, of francs in circulation. Second, the amount of purchasing power which it suits the public to hold in this shape" (introduction to French edition, 1924, xviii). The renewed emphasis on stock considerations should not be interpreted to imply that flow relationships are not important; the equilibrium is attained by the interaction of flow and stock equilibrium conditions.

3. For collections of articles representing the asset market approach see the Scandinavian Journal of Economics, 78, no. 2 (May, 1976) and Frenkel and Harry G. Johnson.

4. When one of the currencies is a reserve currency or when individuals and firms hold portfolios of many currencies the effects of changes in incomes on the relative demands for moneys (and thereby on the exchange rate) are not clear cut.

5. For details see Frenkel and Clements. For simplicity equation (4) does not include the relative price of traded to non-traded goods as an explanatory variable; this might be responsible for the results for the Dollar/Pound rate. Clements and

Frenkel show that this relative price played an important role in determining the Dollar/Pound rate. Another useful modification of equation (4) would recognize that the exchange rate effects of anticipated changes in money and income are fundamentally different from the effects of unanticipated changes.

6. For evidence on the 1970's see Dornbusch, Frenkel (1980a) and Frenkel and Mussa.

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