

THE FRENCH FRANC IN THE 1920'S

by

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ABSTRACT

This thesis uses monthly data for France to test various exchange rate models; the results are used to evaluate both historical views of the behavior of the franc and present exchange rate theory. Chapter 2 finds that the purchasing power parity hypothesis can be rejected in this case even if lagged adjustment is allowed for. Prices of imported goods are shown to equalize between France and the U.K., so that the observed PPP failure can be attributed to stickiness in domestic goods prices. Chapter 3 finds that the rational expectations hypothesis can be rejected for France even though one conventional test does not permit this conclusion. Problems of misspecification and statistical bias are considered in interpreting this result. The interest rate arbitrage condition is found to fail in several periods. Chapter 4 estimates a reduced form equation for the spot rate and uses the results to evaluate the monetarist and Mundell-Fleming exchange rate models; the evidence tends to support the latter. A dynamic model of the spot rate based on this equation is used to model the role of speculators and government monetary policy; the latter is found to be endogenous.

Thesis adviser: Rudiger Dornbusch, Associate Professor of Economics

Ralph W. Tryon was born in Ithaca, N.Y. in 1949. He attended public school in Fairbanks, Alaska, and then entered Swarthmore College, receiving a B.A. with honors in 1971. After working for a year at the Brookings Institution in Washington, D.C., he started graduate work in economics at M.I.T. in 1972. He is presently an instructor in the economics department at Northeastern University, and resides in Watertown, Massachusetts.

In memory of
Walter Conrad Muenscher
and
Frederick Gale Tryon

I am grateful to my advisors, Rudiger Dornbusch and Charles P. Kindleberger, for the inspiration, guidance, and encouragement they have given me; I only hope I have done justice to the many ideas I owe to my discussions with them. I want to thank Stanley Fischer for his continuing support and advice, Philip Abbott for many helpful discussions of econometric problems, and Pauline Sayers for typing the manuscript. My greatest debt, however, is to my wife Maida, without whom none of this would have been possible.

Chapter One

A Review of the Period and the Literature

This chapter examines the events and circumstances surrounding the French franc as it floated in the decade after World War I, and reviews the literature on the subject. Section 1 gives the history of the major events connected with the floating franc, briefly reviews the political issues of the time, and describes those French economic institutions which had special significance for the behavior of the franc. Section 2 discusses the literature, and takes note of questions about the franc that remain unanswered. In Section 3 some current work using the 1920's as a test of modern theory is described, and a theoretical framework is established to address problems in the interpretation of the floating franc.

Section 1: An overview of the franc in the 1920's

During World War I the French franc was pegged by the government and held close to its prewar level in terms of the U.S. dollar. This was made possible, in the face of rapid price inflation, by foreign currency loans from the British and American governments. This support ended shortly after the war, and in April 1919 the franc was allowed to float freely. It depreciated steadily for a year, and then fluctuated erratically until mid-1922, when it began a long depreciation. This continued until late in 1926, when the franc was stabilized at approximately 1/5 of its prewar level; it remained pegged throughout the rest of the decade.

Figure 1.1 shows the franc-dollar and franc-sterling spot exchange rates (francs per dollar or pound) for 1919-26. The franc floated freely throughout save for two episodes of intervention in March 1924 and July 1926. These are seen clearly on the graph; the first effort was abandoned after a month or two, while the second led to de facto stabilization of the franc in December 1926. The dollar was convertible throughout the whole period, so the dollar-franc rate also measures the price of gold in francs. Sterling floated until May, 1925.

Figure 1.2 plots the French CPI, WPI, money supply, and franc/dollar exchange for 1920-26; each variable is indexed at 1913-14 = 100. (The short period is due to data limitations.) It is evident from the graph that the WPI is the more volatile of the two price series, and follows more closely the movements in the exchange rate. The money supply is relatively stable, as compared with the exchange rate, until after 1924, when it begins to rise rapidly. Because of the great destruction and structural change that the

Figure 1.1: Franc/dollar and franc sterling exchange rate, 1919-26, monthly.

1913/14 = 100

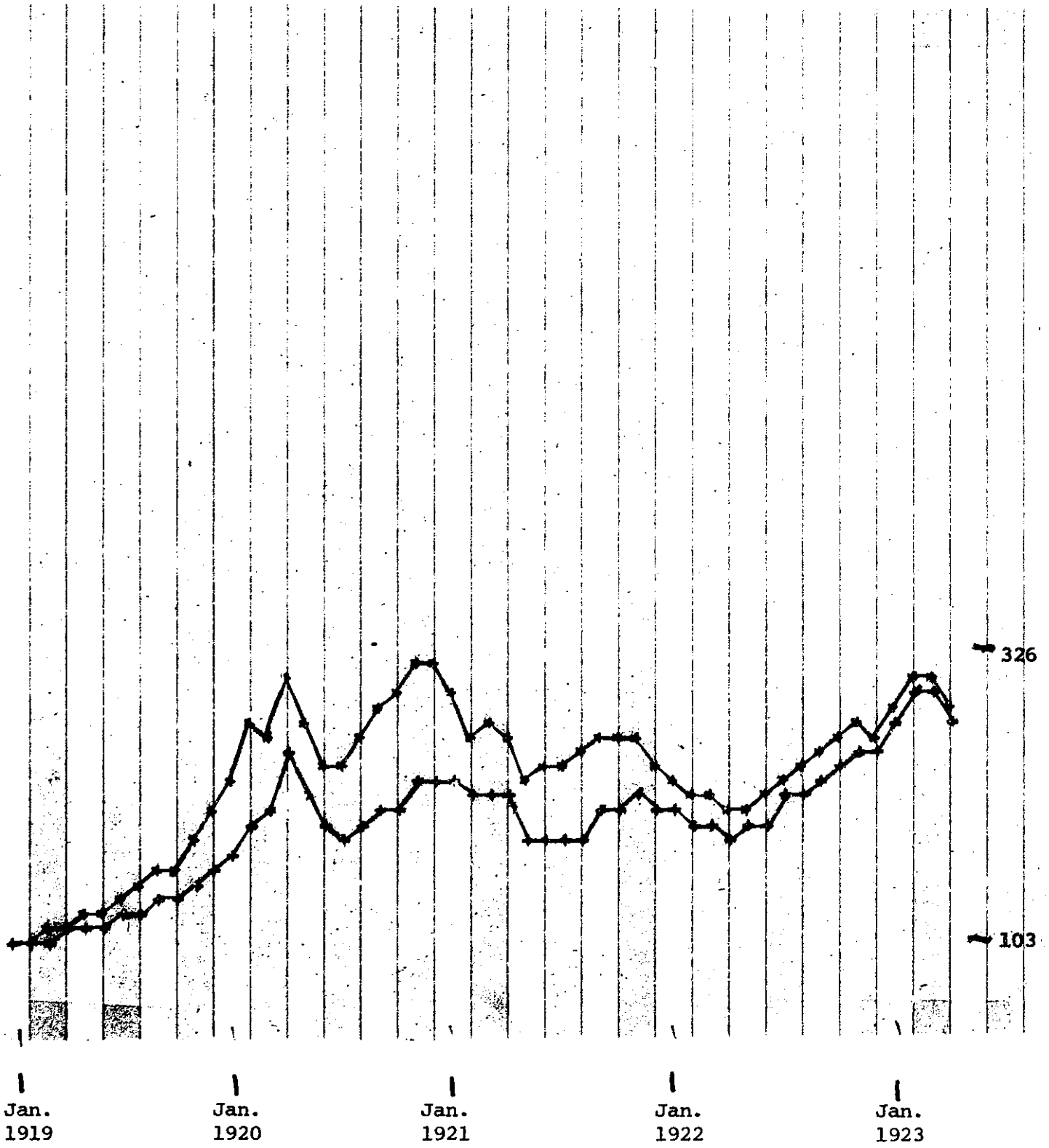


Figure 1.1, continued

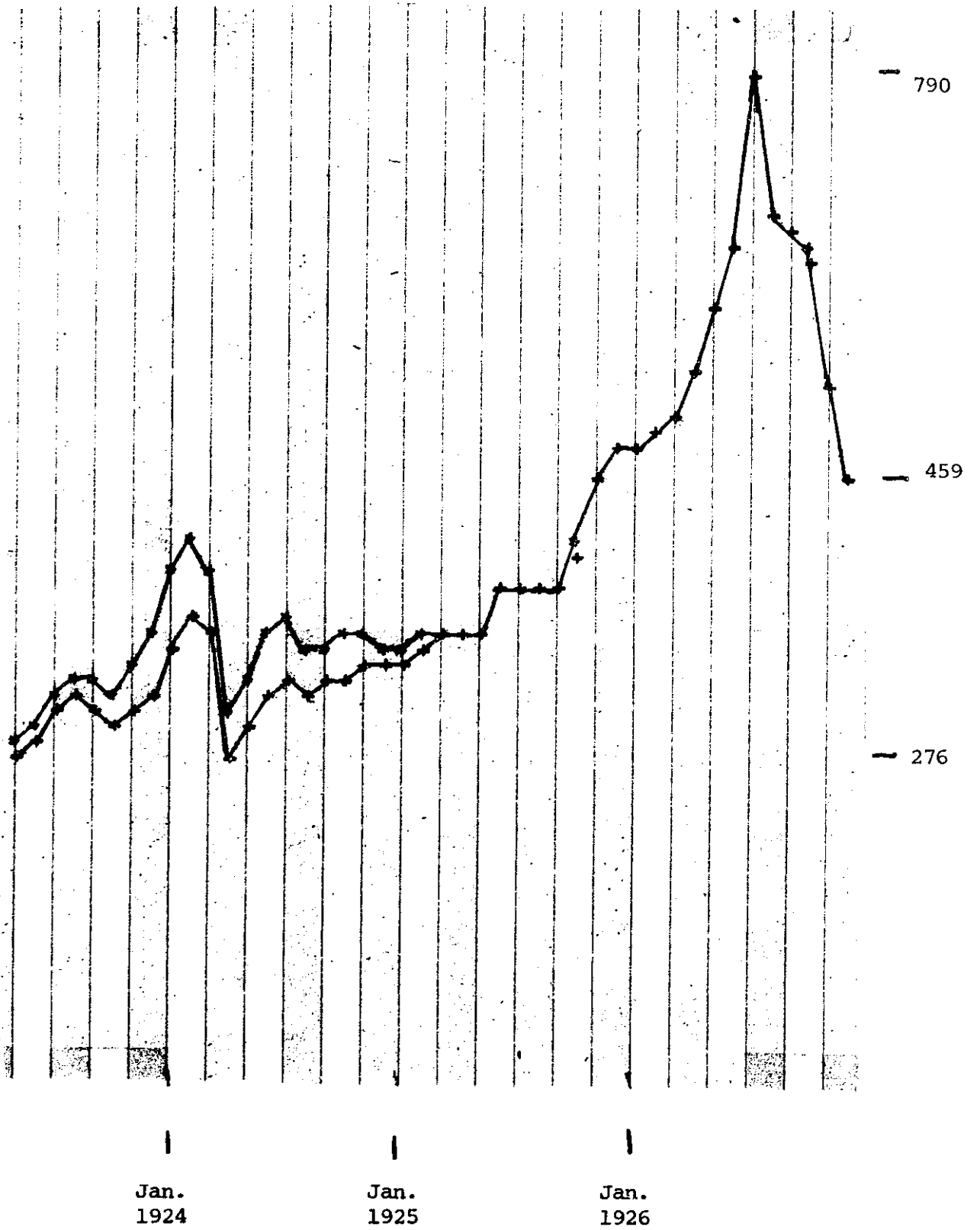
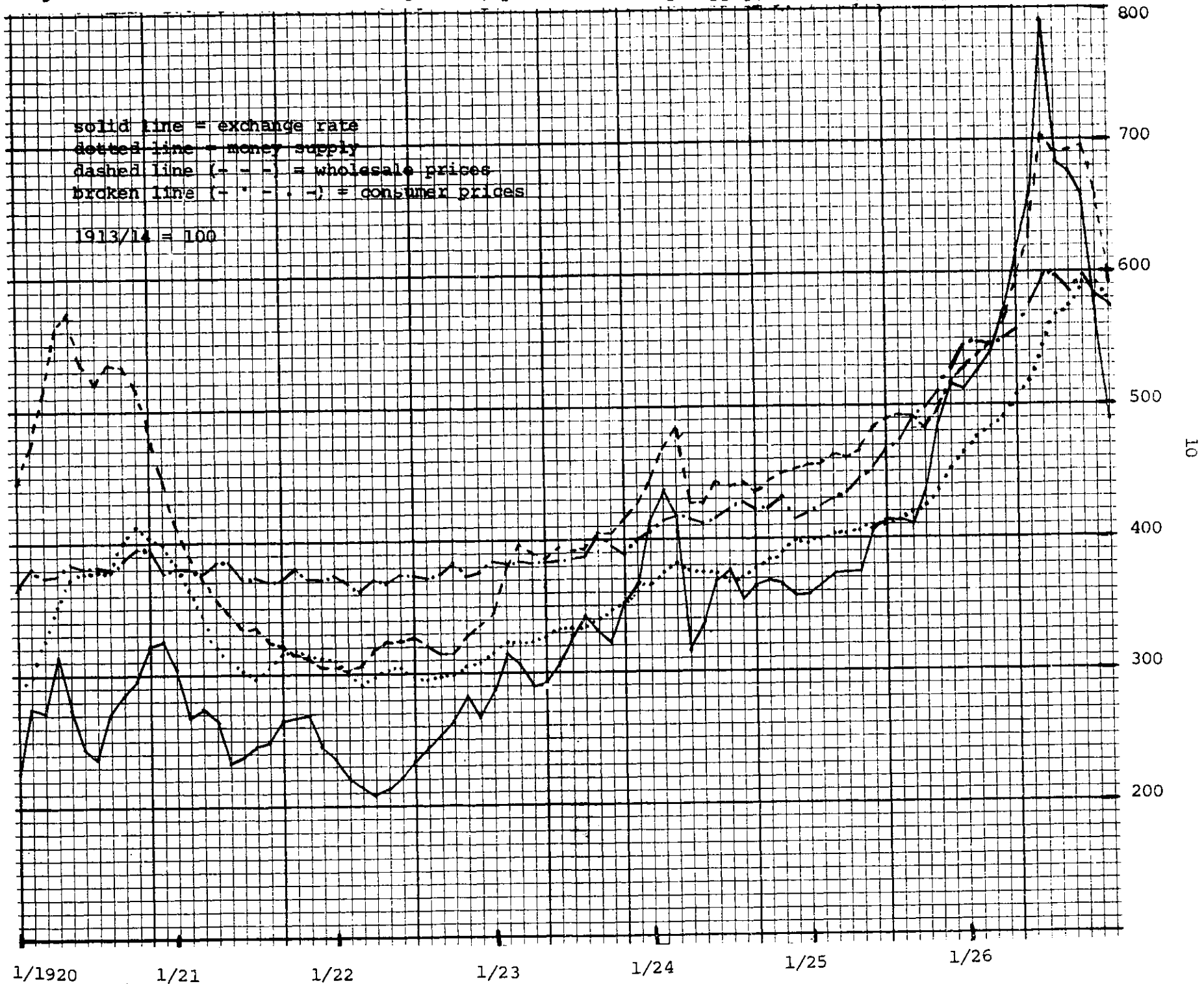


Figure 1.2: France: dollar exchange rate, prices and money supply, 1920-26, monthly.



Sources for Figures 1 and 2

Exchange rates: Sauvy, p. 445.

Consumer prices: Sauvy, p. 501.

Wholesale prices: Federal Reserve Board index, Federal Reserve Bulletin, August 1922 and later issues.

Money supply: currency: Sauvy, p. 525.

demand deposits (4 banks): Rogers, p. 77.

The currency figures are adjusted for misreporting following Moreau. Following Rogers, the money supply is computed as currency plus twice demand deposits.

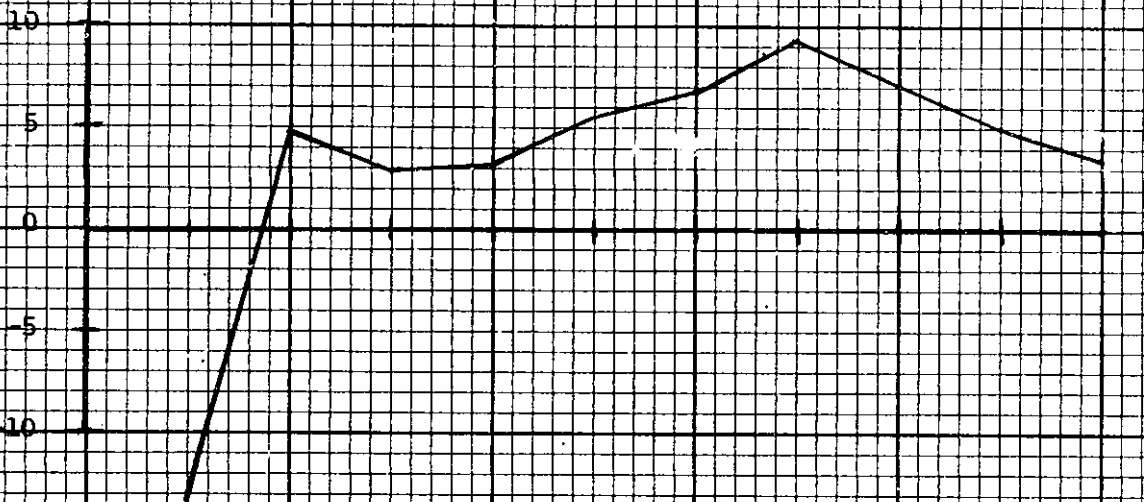
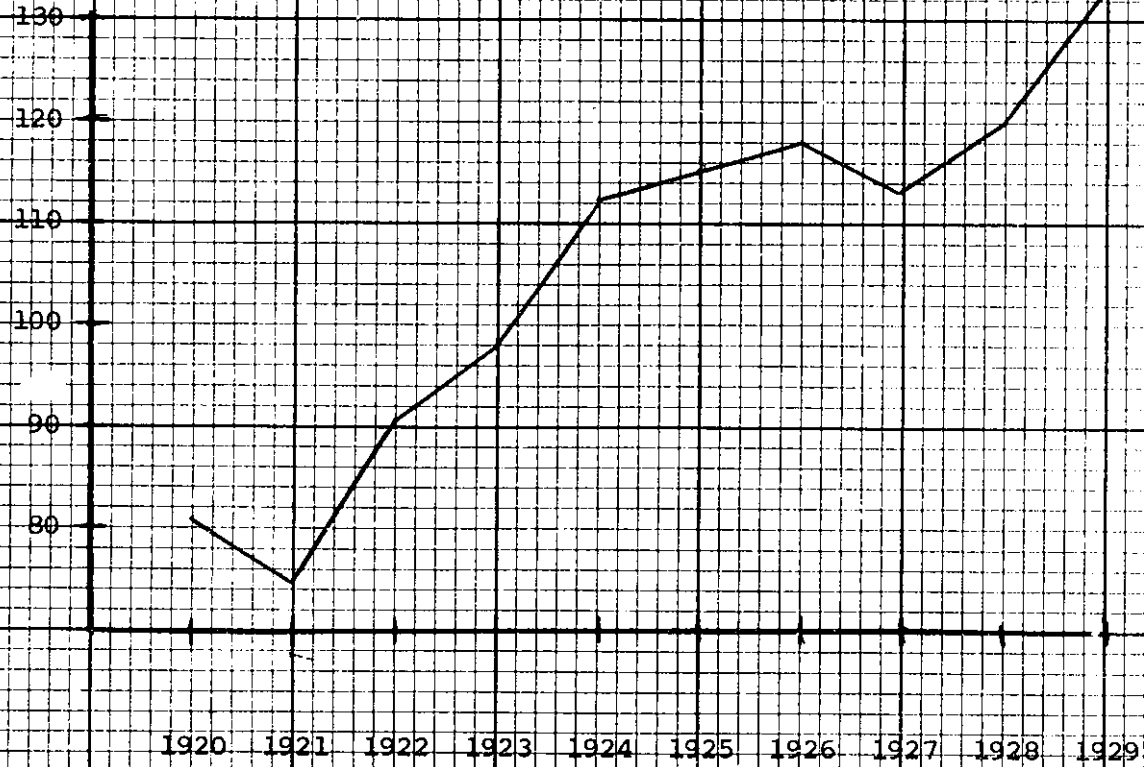
French economy underwent during the war years, comparison of the twenties and the prewar "belle époque" is difficult. Nevertheless, it seems clear that for much of the time it floated the franc was overvalued.

Overall the decade was a prosperous one for the French economy; the real sector remained fairly well insulated from the turbulent monetary events. The postwar inflation lasted until mid-1920, when a world-wide recession occurred. The ensuing slump lasted for about a year. When growth was resumed output grew steadily through 1924, in which year pre-war production levels were finally attained. After that output fluctuated moderately until the boom years of 1928 and 1929. The trade surplus improved steadily, as French production recovered and the franc depreciated. Figure 1.3 shows French GNP and the current account balance annually from 1920-29.

Budget policy

The behavior of the money supply can be traced to the difficulties the French government had in raising tax revenue, and in financing the resulting budget deficits. The government fiscal apparatus was ill-equipped to deal with the heavy expenditures needed both during the war and for reconstruction afterwards. Its inability to raise enough funds through taxation or conventional borrowing to meet spending requirements led the government to borrow directly from the central bank. The result was that the money supply rose as well since the central bank was either unable or unwilling to tighten domestic credit in response. The root of the difficulties lay in the taxation system, which until the war was based entirely on traditional indirect taxes which could not easily be raised to yield larger amounts of revenue. An income tax was imposed late in the war over great opposition, but it did not provide significant revenue until the 1920's.

Figure 3: Real Output and Current Account Balance, France: 1920-29, annual



Above: French real MNE, 1913-14 = 100

Below: French current account (trade, services, interest, gov't debt service), billions of current Francs

Source: Sauvy, pp. 277, 310-11

The government's fiscal difficulties continued after the war. France had suffered great loss to its housing stock, farms, and industrial plant, and the government was under pressure to finance reconstruction. It did so by creating a separate budget for reconstruction expenditures, the revenues for which were to come largely from German reparations. When these failed to materialize the government was forced to borrow, at first from the central bank and then from the general public. Table 1.1 shows government domestic borrowing from 1914-26.

It was generally recognized that in the absence of tax increases, which were politically and even administratively difficult to impose, the only way the government could retire this debt if the Germans did not pay reparations was by borrowing from the central bank. Since this possibility was regarded as inherently inflationary, the fate of the franc was linked in the public mind with the reparations issue.

After 1919 the government was for some years able to finance its deficit by conventional borrowing, and the money supply remained nearly constant. In so doing, however, the government accumulated a large short-term debt which had to be continually rolled over; this became increasingly difficult as the franc depreciated and as it became evident that German reparations would not be forthcoming. In 1925 the government was unable to refinance some 17 billion francs in loans, as shown in Table 1.1. It was forced again to draw on the central bank, and the resulting increase in the money supply largely contributed to the exchange crisis the following year.

Reparations

The years from 1920 to 1924 were dominated by the reparations problem. France took a hard line from the beginning, demanding that Germany pay in

Table 1.1: French Government Internal Borrowing, 1914-26, annual
(amounts in billions of current francs)

<u>year</u>	<u>long term</u>	<u>short term</u>	<u>from central bank</u>	<u>change in currency</u>
1914	0.8	2.1	3.9	4.1
1915	15.0	3.9	1.1	3.2
1916	11.2	7.2	2.4	3.5
1917	12.2	9.6	5.1	5.6
1918	33.4	5.1	4.7	8.0
1919	- 1.2	28.2	8.3	7.0
1920	31.1	1.4	1.1	0.1
1921	15.0	9.2	- 2.0	- 0.9
1922	12.2	1.8	- 1.0	- 0.1
1923	22.9	- 1.7	- 0.3	1.5
1924	8.4	2.5	- 0.7	0.7
1925	- 9.5	- 7.8	13.4	9.4
1926	13.0	2.8	0.0	2.2

Source: calculated from Rogers, pp. 3 and 50..

NNP in 1920 was 132 billion francs

cash for all the physical damage sustained by the French economy. This amount would have severely strained even a Germany committed to paying off its war debts (as the French had been in 1871); as it was the French proposals met with bitter opposition. The U.S. and U.K. took a softer position, feeling that the reparations burden on Germany should not be so great as to interfere with overall world economic recovery.

As conference after conference took place in 1921 and 1922 two things became clear: that the Germans would not willingly, and perhaps could not, pay the amounts originally set by the Allies, and that the French and the other Allies were in fundamental disagreement over how to proceed. The upshot was that in January 1923 the French government, led by the conservative Poincaré, ordered its troops to occupy the German industrial region of the Ruhr in an attempt to force payment of reparations.

The Germans responded with a passive resistance campaign; the costs of supporting the striking workers, coupled with the lost production, put an added burden on the government such that the hyperinflation continued to accelerate. After only a few months it became obvious that the occupation was not increasing reparations payments to France, and under heavy international pressure the French began to back down. In the fall of 1923 Poincaré accepted a plan for a committee of experts to report on reparations. In November the German currency was stabilized, with international assistance. In 1924 the Dawes plan for reparations reductions and a foreign loan to Germany was prepared. It was implemented in September 1924 with the approval of the leftist French government which had replaced Poincaré in the summer.

The Dawes plan was a success, the new French government took a more moderate line in foreign policy, and reparations were no longer a source of

international tension. By 1924, France had essentially completed the task of reconstruction, and had put the reparations issue largely behind it. This latter was perhaps a mixed blessing, since it laid to rest the hope that the Germans would ever pay off the French government debt. The problem of the budget remained.

Cartel des Gauches

Whatever the merits of its foreign policy, the leftist coalition ("Cartel des Gauches") that took power in France in May 1924 proved incapable of implementing an effective fiscal policy. The program for raising revenue consisted largely of a proposed capital levy, which was bitterly (and successfully) resisted. In April 1925 it was announced that the legal limit of the currency in circulation had been exceeded earlier in the year by the central bank. At this time also the redemption of Treasury bills began to exceed new issues. In July the government issued a long term bond with an interest rate tied to the exchange rate that was intended to consolidate the short term debt. This loan proved a failure, and the government was forced to borrow large amounts from the central bank.

The exchange markets were generally stable during the first year of the leftist government, but after that the franc began a rapid depreciation which culminated in the crisis of July 1926. A succession of leftist cabinets and finance ministers was unable to stop the fall of the franc, and with the public becoming increasingly restless,* Poincaré was restored to power. In a crisis atmosphere he forced through the legislature bills which raised taxes and permitted central bank intervention in foreign exchange markets. The franc immediately began to rise, and was successfully stabilized at the end of the year.

*) At the height of the crisis a bus-load of American tourists was attacked by a Paris mob, presumably for anti-French activity. (See the New York Times for July 21, 1926, p. 1.)

This was nothing more than a repeat performance by Poincaré, who had been responsible for the earlier intervention in support of the franc. Late in 1923 the franc began a sharp depreciation, which was thought by many at the time to have been deliberately provoked by foreign speculators. In January 1924 the central bank raised the discount rate; this was apparently taken by the market as a sign of weakness, and the depreciation continued. In February Poincaré obtained from the legislature special powers to deal with the crisis, and managed to push through a bill doubling certain taxes. This strengthened his hand enough to obtain a foreign currency loan, using the French gold stock as collateral, from Morgan Bank and Lazard Frères. The proceeds were promptly used to buy francs, and the franc appreciated sharply. The government was able to repurchase its foreign exchange at a profit without setting the rate back too far, but did not attempt continuing intervention. The new government did not appear to profit by this example, and the franc eventually resumed its depreciation.

French institutions

French economic institutions in the 1920's differed from those today in ways that have some important implications for the study of the franc. Here we take note of the salient points.

By 1914 France had enjoyed over a century of currency stability, and the franc was regarded with some pride as a national institution. The gold value of the franc was set by law in 1803 and had never been changed; convertibility was only suspended on two occasions, during the revolution of 1848 and the war of 1870. Thus after WWI the French public confidently expected the eventual stabilization of the franc and the return to prewar parity. This expectation had strong political overtones, in that the middle class held much of its savings in long term government bonds, and did not

relish the prospect of large capital losses.

The prewar Bank of France was more limited in its operations, particularly in foreign exchange markets, than are modern central banks. Its only policy instruments were the discount rate and the level of the currency issue, which was subject to a ceiling set by the legislature. The bank engaged in no open market operations in this period; although it did hold government debt in the form of direct loans to the treasury, these were not negotiable securities. Until 1926 the bank was legally prohibited from buying or selling gold or foreign exchange except at par, which effectively prevented it from intervening in the foreign currency markets. The Treasury could, however, and did on two occasions.

The French banking system in the 1920's was not regulated by the government. As a consequence, the available data on the money supply are very poor, since banks were not required to file any statements. Checking accounts were not used nearly so much as in the U.S. or U.K. even at that time: total demand deposits were about equal to the total currency in circulation. Thus the currency stock is often used as a proxy for the money supply, although some demand deposit data is available. The banking system was not well integrated; banks held most of their assets in the form of loans to their regular customers, borrowing little from each other or the central bank.

This lack of integration extended to the money markets. There was no organized market at all in treasury bills, apparently because banks were unwilling to risk their prestige by appearing in need of cash when offering bills for sale. The bill rate itself was pegged, the government simply issuing whatever quantity was demanded at that rate.

The Bank of France would rediscount commercial bills, but there was no real market for commercial paper until 1924, and even then it was used

largely by foreign firms. French financial transactions were typically conducted in private between the firm, its bank, and its customary clients.

Thus the authorities had little ability to control the monetary situation. The discount rate was not a powerful tool since it only affected a portion of financial transactions. The note issue was in practice determined by the Treasury's need for additional funds. Investors could quickly obtain cash in large amounts simply by failing to renew Treasury bills as they came due; thus when investors wished to sell francs for foreign exchange there was virtually nothing the central bank could do to stop them.

Finally, it is worth remembering that the administration of the Treasury (which did have somewhat broader powers) was, by modern standards, incompetent. The various budgets lacked, as Sauvy puts it delicately, "the clarity of the British accounts" (p. 364). There were separate budgets for various categories of expenditure, and no unified set of accounts was ever maintained. This was also true of the sources of revenue, and with the overall low quality of the record keeping, it was at the time and remains today impossible to determine precisely what was the total government deficit in any year. Given this state of affairs, it is hardly surprising that the Treasury lacked a systematic program for funding its deficits, managing its debt, or for stabilizing the value of the currency.

Sources

The best modern economic history of France in this period is Sauvy (1965), which is in French. Kemp (1972) provides a very readable account in English. Sauvy reprints much of the published monthly data, together with some valuable series that he has constructed. Schuker (1976) is an excellent economic-diplomatic history, and gives an exhaustive bibliography which includes the contemporary literature in French.

The best contemporary studies of the franc are both in English: Dulles (1929) and Rogers (1929). These are both very detailed, and print data which is not elsewhere published. Also of interest is Rist and Pirou (1939), in French. More specific studies are Myers (1936) on the French money market, Moreau (1954) on the Bank of France, and of course Einzig (1937) on the forward market. There is an extensive literature in French of what might be called primary sources: personal narratives, memoirs, and descriptions of various events. These seem by and large to be adequately covered in the works already cited.

The most convenient source of official French monthly statistics is the *Statistique Générale de France* (1932), much of which is reprinted in Sauvy. Unofficial data on demand deposits are printed in Rogers.

Section 2: The literature on the floating franc

The conventional history of the floating franc is replete with reference to what Hodgson (1972) terms "non-quantifiable events": reparations crises, speculative attacks, falling cabinets, and the loss of public confidence. For example, Dulles (1929), in one of the more rational accounts, writes that

A study of the curves shows at a glance that neither the quantity of money in circulation nor the movement of prices was such as to indicate clearly any influence on the exchange rates by either of these factors. (p. 157)

Thus

If time and space permitted, one could show how each marked change in value (of the franc) was contemporaneous with some new announcement regarding the reparations policy on the part of France or some new move by England. (p. 167)

Similarly,

The panic of 1924 was due, more than any other episode of the French experience, to the deliberate efforts of financiers and speculators. (p. 171)

Dulles reaches the conclusion that

we come inevitably to a psychological theory of the short run value of depreciated money. (p. 351)*

This point of view is also taken by a modern author. Schuker (1976, ch. 4) apparently accepts contemporary accounts of intervention by foreign speculators without question. He writes of the 1924 crisis:

Operating with a considerable degree of coordination, the Amsterdam-based speculators began their manoeuvre by selling francs short against sterling or dollars . . . The rate on borrowed francs soon rose to 25% on an annual basis, but this did not appear prohibitive to speculators who expected to make that much in a few days through depreciation of the currency . . . (p. 93)

Schuker says that speculators proceeded to purchase calls on foreign securities and commodity futures, and the rise in these prices "fostered a mood of panic" among French investors. He concludes that

The scheme appeared virtually foolproof . . . The speculators' ultimate objective was to provoke the wider franc-holding public into panic selling, depressing the market to a point which enabled them to liquidate their own short positions at a large profit. (p. 94)

Sauvy (1965), on the other hand, dismisses conspiratorial theories of speculation, whether based on profit seeking, on geopolitics,** or on the class struggle:

tout groupe . . . croit ses adversaires plus unis et plus volontaires qu'ils sont dans la réalité. (p. 73)

*) The classic presentation of the psychological theory of exchange rate determination is in Aftalion.

***) The fall in the franc was popularly attributed to, among others, the German government. Schuker discusses the merits of this charge.

He does, however, give colorful examples of these views from the contemporary press. Sauvy acknowledges the importance of individual speculation in the fall of the franc, but blames the government for creating the situation:

Que l'individu . . . vende ses francs parce qu'il estime cette vente de son intérêt n'est pas douteux, mais il n'en reste pas moins que la classe dirigeante sème volontiers la panique et refuse de saines mesures . . . propre à faire cesser l'intense fraude fiscale sur les valeurs mobilières.
(p. 73)

Sauvy lays emphasis on the inability of the government to balance the budget, with the attendant inflationary results. However, he also notes that the depreciation of the franc seemed to lead other measures of the overall inflation, such as prices of goods and securities, but does not give an explanation. The problem of cause and effect, among public expectations, depreciation of the franc, and the government's financial policy, is left unresolved.

This topic found its way into the technical literature on exchange rates at an early date, and was the subject of a famous debate between Ragnar Nurkse and Milton Friedman. In his study for the League of Nations, International Currency Experience (1944), Nurkse wrote

Anticipatory purchases of foreign exchange tend to produce or at any rate to hasten the anticipated fall in the exchange value of the national currency, and the actual fall may set up or strengthen expectations of a further fall. The dangers of such cumulative and self-aggravating movements under a regime of freely fluctuating exchanges are clearly demonstrated by the French experience of 1922-26. Exchange rates in such circumstances are bound to become highly unstable, and the influence of psychological factors may at times be overwhelming. (p. 118)

Friedman was not convinced:

Nurkse concludes from interwar experience that speculation can be expected in general to be destabilizing. However, the evidence he cites is by itself inadequate to justify any conclusions. (. . .) Even for the French episode the evidence given by Nurkse does not justify any firm conclusion. Indeed, so far as it goes, it seems to me clearly less favorable to

the conclusion Nurkse draws, that speculation was destabilizing, than to the opposite conclusion, that speculation was stabilizing.

(from Essays in Positive Economics (1953), p. 176)

Two themes can be noted in this discussion. One is that short run movements in the spot rate are dominated by investors' expectations about the future, which in turn are dominated by political events, rather than by the behavior of current or lagged economic variables. The implication of the "psychological theory" is that these political events are important largely for their own sake or for their effect on public confidence. However, this is not a necessary interpretation: it may be that investors rationally consider the future impact on the economy of current political events.

The second theme is that professional foreign exchange speculators somehow have the ability to manipulate the exchange rate for their own profit. This idea has two implications: that speculators act as monopolists to the extent that they can deliberately induce movements in the exchange rate, and that once started, these movements will continue on their own, so that speculators can sell out at a profit. This is one formulation of the familiar problem of "destabilizing speculation."

At least in principle these problems lend themselves to theoretical modelling and formal testing. The hypothesis that the money supply does not explain movements in the exchange rate can be tested straightforwardly using available data. The relationship between inflation and the government budgetary process described by Dulles and Rogers is essentially a statement that the money supply is endogenous. This, too, can formally be tested using the data assembled in these earlier works. The hypothesis implicit in much of this work, that real sector events such as changes in relative income levels or shifts in demand were not responsible for the course of the

franc, can also be examined empirically, although the data for the real sector are less good than are the financial statistics.

Hodgson (1972) made one of the first efforts to explain the monthly path of a floating exchange rate using "fundamental" economic variables. He uses an ad hoc partial equilibrium model to derive an equation in which the spot rate is a function of prices, money, and income in both countries and estimates it for the dollar-sterling rate in the twenties, obtaining a satisfactorily high R^2 . Thomas (1973) estimated a similar model for France, with an R^2 of .9. There are some econometric difficulties with this equation: simultaneous equation bias is not considered, and the correction for autocorrelation seems unreliable, so the estimates of the coefficients cannot be taken as unbiased. Furthermore, the period used (January 1920 - June 1924) omits a substantial part of the available data. However, these objections do not qualify the basic result, which is that a floating exchange rate can be largely explained by other economic variables; Thomas does not attempt to interpret the estimated coefficients.

Hodgson and Phelps (1975) explain the exchange rate as a function of current and lagged prices, foreign and domestic. This follows from the assumption that purchasing power parity holds, but with a lag. They approximate the lag structure using a Koyck lag, so the estimating equation is

$$(1.1) \quad \ln s_t = b_0 + b_1 \ln (P_t/P_t^*) + b_2 \ln s_{t-1} + u_t$$

where s is the spot price of foreign exchange in domestic currency, P and P^* are domestic and foreign prices, and u is the error term. They obtain a significant coefficient on s_{t-1} and an R^2 of .94. The authors do not actually test the purchasing power parity hypothesis; again the interest is in the explanatory power of the equation.

A problem with this approach is that the specification used in (1.1) is a common one, and might result from another underlying structure; if possible it would be desirable to estimate the lags either directly or using a polynomial approximation. The period used by Hodgson and Phelps is from March 1919 to April 1925, which still omits over a year of data. Nor should the problem of simultaneity be overlooked; without a full specification of the underlying model there is no a priori reason to assume that prices and exchange rates are not simultaneously determined.

While these results are hardly conclusive, they do tend to refute the extreme position that the franc can only be explained by a 'psychological' theory. On the other hand, empirical investigations into the role of speculation have tended to conclude that speculation was an important factor. Again it is possible to state the problem in formal terms as a set of hypotheses about the way investors' expectations are formed and the way the market exchange rate responds to these expectations. The difficulty is that neither expectations nor the value of the exchange rate in the absence of speculation are observable, so it is hard to derive testable implications from any such model. As a result, investigators have taken a more intuitive approach.

Both Tsiang (1958) and Aliber (1963) define the equilibrium short run exchange rate as that rate at which purchasing power parity (PPP) holds. Deviations from this level are then attributed to speculation, which is by definition destabilizing.* Tsiang is content simply to document the

*) Kohlhagen (1977) develops this argument more formally and applies it to the current experience with floating rates. He also gives an extensive bibliography of the literature on foreign exchange speculation.

existence of such deviations, while Aliber argues that speculation systematically pushes the spot rate away from its PPP equilibrium. He acknowledges that the equilibrium exchange rate is affected by other variables in addition to prices, but argues that these do not change substantially in the short run, so that at least changes in relative prices represent changes in the equilibrium exchange rate. He then argues that changes in the actual spot rate systematically exceed the changes in relative prices. (p. 217)

The two authors differ in their interpretation of this phenomenon. Tsiang suggests that the root cause of this speculative instability is to be found in the behavior of the government. Thus while he writes of a "vicious cycle of speculation, inflation, and depreciation" (p. 267), he says that the government monetary policy "would have caused great instability in the economy whether the exchange rate was freely fluctuating or controlled" (p. 275).

On the other hand, Aliber seems to feel that the speculation was an exogenous force which pushed the government into its difficulties. Domestic prices were pushed up by exchange depreciation, thus forcing the government to increase the money supply in order to fund its short term debt: "there can be little doubt that the major cause of higher prices, of the increase in the money supply, and of the recurrent fiscal and debt management crises was the impact of exchange speculation on the domestic price level" (p. 218, emphasis added).

One obvious difficulty with this whole approach is made evident in Kohlhagen's exposition. PPP is imposed as an equilibrium condition virtually by assumption, rather than as the logical result of other axioms. It is not clear why PPP should be expected to hold from month to month (nor what price indexes should be used to determine equilibrium), and there is no a priori

reason to believe that deviations from PPP are due to speculation rather than to some other type of rational maximizing behavior on the part of individuals.

Further, neither Tsiang nor Aliber test their interpretations econometrically. Inspection of the graphs (see Fig. 1.2) might suggest that this is unnecessary; it is evident that deviations from PPP did exist, whatever price index is used. But Aliber's proposition about the magnitude of relative changes is by no means obvious; it is in fact refuted by Frenkel (1978), who finds that the PPP hypothesis cannot be rejected for this case.

Aliber also uses the forward market for foreign exchange in an attempt to observe the effects of speculative behavior. He compares the forward premium on foreign exchange, adjusted for the interest rate differential between the two countries involved, with the actual changes in the spot rate to test various hypotheses about speculation. For example, "overtracking" speculation implies that investors' expectations, and hence the forward market, consistently err at turning points in the spot rate, and amplify swings in the spot rate by pulling it away from equilibrium. Aliber tests the overtracking hypothesis using daily data by computing a test statistic for each month of the franc float; he finds the statistic is significant in 26 out of 50 months, chiefly after 1924. He makes no test on the period as a whole.

Aliber adjusts the forward premium by subtracting off the interest rate differential in order to distinguish cases in which the forward market "is dominated by individuals who seek speculative profits from carrying exchange risk, rather than by commercial traders" (p. 180). This adjustment enables Aliber to argue that the forward franc was actually at a premium until November 1923, while the nominal forward rate was at a discount. Two issues

arise with this procedure. The first is whether the nominal forward discount reflects investors' expectations about the spot rate even if interest parity holds exactly (so the adjusted premium is zero.) Aliber's argument implies that it does not, but the point is not obvious. Secondly, are all deviations of the forward premium from interest parity to be attributed to speculation? Aliber argues that they are, but this surely neglects the problem of transactions costs.*

Finally, Poole (1967) tested the random walk hypothesis against the franc in the 1920's. He was able to reject the hypothesis for the French case, although the size of the autocorrelation coefficient for changes in the daily spot rate is not startling at only .09. Poole notes that transactions costs within an efficient markets model might reasonably account for this observed autocorrelation. Further, a non-random path for the exchange rate does not necessarily imply that speculation is anything but normal - such a path can result from, for example, a rational expectations model of the exchange market.

It seems clear from the work discussed that the behavior of the floating franc in the 1920's is largely a monetary phenomenon, and can in good part be explained as a function of monetary variables. However, the picture is far from complete; the story is more complex than, for example, the relatively straightforward German hyperinflation. In particular, the exchange crises of 1924 and 1926 are not well explained by the equations estimated to date (it is possible to obtain high R^2 's and still have a few very large residuals). Any explanation which seeks to use monetary variables alone must deal somehow with the fact that the money supply was relatively stable throughout 1924 in

*) See Frenkel and Levich (1975).

the face of large fluctuations in the exchange rate.

The issue of destabilizing speculation remains unresolved. Although some of the results are highly suggestive, investigators have not arrived at either a satisfactory working definition of destabilizing speculation or an unambiguous demonstration of its existence. Similarly it is by no means evident that speculation was an exogenous factor (by design or otherwise) which "caused" the depreciation of the franc.

There are some obvious econometric improvements that can be made in this area. Investigators have not made use of the French wholesale price series published in the Federal Reserve Bulletin, or the consumer prices published in Sauvy, both of which are superior to the official French government statistics. A reasonable money supply series can be constructed using the currency and demand deposit data in Rogers.* The equations should all be estimated using data for the whole period, unless the existence of structural shifts can be demonstrated.

The problem of simultaneity in the various equations has not been adequately considered (except by Krugman, 1977), and the specifications of lag structures and serial correlation can be improved. Much of the previous work at least implicitly suggests that some structural change did in fact occur, perhaps around the end of 1923; this hypothesis can be tested for statistical significance. Data for several variables are available on a weekly basis, so that short periods can be successfully modelled.

Finally, it may be helpful to put the investigation on a more rigorous theoretical foundation. We turn to this problem in the following section.

*) Rogers discusses the problem of adjusting the demand deposit data for underreporting. Moreau gives the data needed to correct the currency figures for deliberate misreporting.

Section 3: A general equilibrium model for the French case

In several recent papers Jacob Frenkel (1976, 1977, 1978) has pursued a new approach to the empirical study of the floating exchange rates of the 1920's. Instead of attempting to model and explain the events of that time, he uses the period as a test-bed for a simple general equilibrium model of an economy with a floating exchange rate. In essence he assumes that the franc was not a special case, and that it can be used to validate a model which has general applicability to events then and now. By and large the effort has been successful, in that Frenkel has obtained results consistent with his model.

The model used by Frenkel is derived from the general monetarist approach to balance of payments and exchange rate problems. A good exposition is given in Bilson (1978). In its simple form the model can be expressed as follows

$$(1.2) \quad M = P m(y, r) \quad \text{domestic money demand}$$

$$(1.3) \quad M^* = P^* m^*(y^*, r^*) \quad \text{foreign money demand}$$

$$(1.4) \quad P = s P^* \quad \text{PPP equation}$$

$$(1.5) \quad r = r^* + \left(\frac{f}{s} - 1 \right) \quad \text{interest parity equation}$$

where M is the nominal money stock, P is the overall price level, r the interest rate, y real income, s the spot price of foreign exchange in domestic currency, and f the forward price of foreign exchange, which is assumed to be the anticipated future spot rate. An asterisk denotes foreign values. (This notation is used throughout.) The model is not closed unless we assume many of the variables to be exogenous (typically all but P , r , and s).

However, if the model is in fact correctly specified, the implicit relationship between the spot rate and the other variables holds whether or not the model is closed.

By substituting (1.2) and (1.3) into (1.4) we obtain an equation explaining the spot rate as a function of the money stocks, incomes, and interest rates in both countries. If we assume that the money demand functions are log-linear and are identical in both countries, we obtain an attractively simple equation:

$$(1.6) \quad \ln s = \ln (M/M^*) - b_1 \ln (y/y^*) + b_2 \ln \left(\frac{1+r}{1+r^*} \right)$$

where b_1 is the income elasticity of the demand for money and b_2 is the interest elasticity, and is presumably negative.* We can further substitute from (1.5) for the interest rate term and get:

$$(1.7) \quad \ln s = \ln (M/M^*) - b_1 \ln (y/y^*) + b_2 \ln (f/s)$$

where the last term can be interpreted as the forward premium on foreign currency. These equations are similar to those used earlier by Thomas and Hodgson, except that the forward rate is introduced, and that a definite interpretation can be placed on the coefficients. The equations can be estimated as they stand, or the model can be made richer in several ways.

Adding an equation explaining the formation of expectations (f) can introduce dynamics into the model. If expectations are rational, for example, f will depend on the future path of money and incomes, which may be predictable. Bilson discusses this case. On the other hand, expectations may depend on past events, as suggested by the discussion on speculation.

*) More precisely, it is the elasticity of money demand with respect to $(1+r)$, which is approximately equal to the percentage change in M due to a change in the level of r of one percentage point.

The role of interest rates can be elaborated. In the money demand equation the interest rate reflects, among other things, anticipated long run inflation, while in the interest parity equation it is the nominal cost of short term borrowing. Frankel (1978) handles this by introducing a long term interest rate, Bilson by using a rational expectations model of future inflation based on a Phillips curve.

While the PPP hypothesis has been accepted by many writers who use this approach, Dornbusch (1976) has suggested that prices do not adjust nearly so quickly as this implies. If, for example, parity holds only for prices of traded goods, we have in general:*

$$(1.4') \quad \ln s = \alpha \ln (P/P^*)$$

where α can have any value. Clearly, the coefficient on M in (1.6) need no longer be 1.0, although the form of the equation still holds if α is a constant. If $\alpha = 1.0$, the price of traded goods relative to nontraded goods is constant; if α is constant there is a constant elasticity of one with respect to the other. Since this price ratio reflects both lags in adjustment and real changes in the economy, we might expect α to vary over time or with the value of the exchange rate.

The specification and interpretation of (1.5) are also open to discussion. Interest parity does not hold as an identity; Frenkel and Levich have shown that the differential can usually be attributed to transaction costs. But even so the errors in (1.5) may well be autocorrelated. Nor is it clear that f is always to be regarded as the anticipated spot rate, as discussed in chapter 3, section 5, below. These points do not affect equation (1.6), but

*) See chapter 2, section 4, below.

obviously must be considered if the substitution in (1.7) is to be made.*

The questions in the interpretation of the French experience with floating rates that were raised in section 2 above can be presented in terms of this model. In so doing we can derive simple tests of the hypotheses involved, and perhaps clarify the earlier discussion.

The basic problem of explaining the movement of the franc, which led earlier investigators to appeal to a "psychological" theory, is simply a matter of whether the relationships in the model are stable enough to be successfully estimated. ("Success" must ultimately be defined by the investigator--or reader--in terms of the desired R^2 or fit for specific periods.) Put another way, the problem is to specify sufficiently the arguments list of the money demand function and the structure of domestic and foreign prices.

The role of the government budget policy in exacerbating depreciation can be modelled in two ways. One argument is that the trend of government borrowing from the central bank influenced expectations directly. This hypothesis can be tested by regressing the forward discount on the actual change in government borrowing, which is available by week and month. This alone, however, does not affect the reduced form equations (1.6) and (1.7). But if government borrowing is in turn dependent on current or lagged depreciation (because investors redeem government bills) we can have a dynamic effect operating through the money supply. We can estimate an equation describing the money supply, and then derive a difference equation for the spot rate.

*) Unless interest parity holds as an identity, this substitution necessarily results in an errors-in-variables problem.

Destabilizing speculation is less straightforward, largely because the entire concept is somewhat nebulous. The confusion stems first from the attempt to define what the "equilibrium" exchange rate would be in the absence of any speculation, and secondly from the determination of what constitutes "destabilization" of this equilibrium rate.* This seems a difficult thought experiment at best, and here we suggest an alternative approach. Instead of trying to define destabilizing speculation, we ask two simple questions.

- 1) How do investors (not speculators) form their expectations about the future spot rate? Do expectations depend on any lagged variables?
- 2) Is the spot rate determined by a stable process? (i.e., does it converge to a steady state, if shocked?)

This seems to capture the essential points of the argument, without attempting the task of pinning actual instability, if any, on professional speculators.**

The first question can be addressed, although not necessarily conclusively answered, by testing various hypotheses about expectations using forward market data. Two obvious candidates are that expectations are rational, and that they are determined solely by lagged changes in the spot rate or in government borrowing from the central bank. This approach assumes that the forward rate is in fact a measure of expectations. The alternative is to make an assumption about expectations, use it to solve the model for a spot rate equation, and see if this equation is consistent with the data. Unfortunately this approach may be expected to have very little power to discriminate among different hypotheses.

*) Aliber, section II, makes a valiant effort to set all this out.

***) We avoid, for example, trying to decide whether rational expectations ever be, in any sense, destabilizing.

The second question can be answered by estimating a dynamic model of the spot rate, which in this case would presumably consist of equation (1.7) plus difference equations for the money supply and for expectations, each perhaps involving the spot rate. The path of the spot rate in response to a shock can then be analyzed for stability.

The monetary model of exchange rates can be tested in two basic ways. One is to estimate the reduced form equation for the spot rate, and test the observed coefficients for the expected sign and value. The difficulties with this method are first that the coefficients predicted by the model are sensitive enough to various factors that it is hard to reject the model. As noted above, any bias in PPP will affect the coefficients, as will any difference in money demand between the two countries. The choice of interest rate and the variables used as income proxies may also affect the results.

Secondly, the reduced form equation is not unique to this model,* so that estimating an equation that is not inconsistent with the monetary model does not tell us very much about what is going on. The number of inferences we can legitimately draw from the coefficients in (1.6) is small. On the other hand, if the equation fits well, it can be of great interest in modelling the response of the spot rate to various events.

Bilson solves the first problem by specifying a priori the ranges for the coefficients and the goodness-of-fit which are "assumed to be consistent with the monetary approach to the exchange rate" (p. 85), and then testing this joint hypothesis using a chi-square statistic due to Theil. This solution is perfectly valid if one wishes to attach a strict definition to "the monetary approach to the exchange rate", but it is a little puzzling

*) For example, it is a special case of Stein and Tower's short run partial equilibrium model of the foreign exchange market (1967, p. 177).

that one should not simply estimate the structural parameters of the model (most of the data are also used in the reduced form, and are thus available).

The other way of testing the model is to estimate each of the "structural" equations* to verify each part of the model. Frenkel (1978) does this, in part, for France in the 1920's by testing the PPP hypothesis and the rational expectations hypothesis. He is unable to reject either, and concludes that the data are consistent with the monetary approach. Unfortunately, some of the same econometric problems that were discussed earlier can be raised in regard to these results. Frenkel does not estimate his equations for the full period for which data are available, and some of the data series used can be improved upon. Nor does he correct for simultaneous equation bias, which Krugman (1977) has shown can lead to spurious results in PPP tests. These points are more or less serious depending on what the results are intended to show, but there does seem to be merit in additional tests.

This thesis, then, attempts two things. One is to use the French data to test as carefully as possible the elements in the exchange rate model presented above. These elements include the money demand equations, purchasing power parity, interest rate arbitrage, and rational expectations. These are of interest both in their own right, and as components of this particular model. We try to identify the mechanism by which changes in the money supply bring about changes in the exchange rate. Does a rise in M result directly in price inflation, thus creating exchange depreciation via the PPP assumption? Or does an increase in M bring about a capital outflow, thus lowering s and (eventually) bringing up prices? In the long run the result is the same

*) Equations (1.4) and (1.5) are, strictly speaking, themselves reduced forms.

either way, prices and exchange rates both fully adjust, but using monthly data we may be able to measure short run dynamics.

The second goal is to use the model, modified as necessary by what we learn from the investigation of its parts, to address some of the long standing questions about the behavior of the franc in this period. We examine the ability of the model to explain the path of franc using ordinary economic variables. We do not model speculation directly, but test several hypotheses about the formation of expectations of investors generally. We model the relationship between government budgetary policy and the exchange rate using data on borrowing from the central bank. Finally, we consider the stability of the entire system: using the equations obtained for the spot rate, the money supply, and expectations we ask whether it can be said that in the absence of intervention the franc would have inevitably continued to depreciate, as has often been described.

What follows is organized into four chapters. The first considers the PPP hypothesis, and explores the relationship between traded and non-traded goods. The second examines the forward market, testing the rational expectations and interest rate arbitrage hypotheses and using the results to interpret the adequacy of the forward discount as a measure of investors' expectations. In the third chapter the reduced form of the model is estimated, and the performance of the monetary model in this case is discussed. Finally, the stability of the spot rate is analyzed using different equations for the money supply and expectations, and some conclusions are drawn.

Chapter Two

Testing PPP Against a Floating Exchange Rate

In this chapter we test the purchasing power parity (PPP) hypothesis for a country with a floating exchange rate (France in the 1920's). The purpose is two-fold: to provide a test of an old and popular theory of exchange rate determination, and to shed some light on the behavior of the French exchange rate. By testing it against the PPP hypothesis we can measure the performance of the simple models which underly PPP, choose among them, and determine the need for a more complex explanation of exchange rate behavior.

The PPP hypothesis is one of the most durable propositions in modern economics. It was first stated in its modern form by Gustav Cassel in 1916, but as shown by Frenkel (1977) and Officer (1976) the origins of PPP can be traced back as far as 1803. In its strong, or absolute, form the hypothesis states that the rate of exchange between any two currencies will be equal to the ratio of their purchasing powers. In other words, equal values of two currencies will buy equal amounts of goods in either country. The relative version of PPP holds merely that the ratio of purchasing powers is constant over time, without asserting that the ratio is exactly one. Both versions imply that

the exchange rate will adjust to offset the difference in price inflation between two countries.

The PPP hypothesis has considerable intuitive appeal; it has been tested frequently over the years and has on occasion been used in formulating actual stabilization policy. (Officer (1976) reviews the extensive literature.) However, there remains substantial disagreement over the empirical validity and practical importance of the hypothesis. Three specific problems arise in the interpretation of PPP: what is the appropriate price index to use in calculating purchasing power, what is the appropriate time period over which PPP should be assumed to hold, and whether PPP applies to the actual, observed exchange rate or to its long run equilibrium value. Disagreement over these issues has led to disagreement over empirical results.

Much of this confusion can be traced to a certain lack of clarity about the theoretical basis for PPP. Indeed, the PPP result is rarely derived as a formal proposition following from given assumptions. Rather it is presented as an assumption by itself, so it is perhaps not surprising that the assumption takes varying forms. Thus it is helpful at the outset to consider three very different models which yield PPP as a result.

Section 1: Three PPP models

In the first model PPP is the direct result of the behavior of asset holders, who value financial assets in terms of their goods value or purchasing power. PPP results from simple arbitrage: if prices in one country rise, the goods value of that country's currency falls, and investors will sell it, until its price, the exchange rate, has fallen in proportion. In this case PPP should hold continually, because arbitrage in financial markets can occur

almost instantaneously. The absolute version of PPP is applicable, and the appropriate prices are consumer prices.

Frenkel cites several early writers who argued for this view, and it still finds some support today. (Officer (p. 7) quotes Yeager, writing in 1968, as approving the idea.) The major difficulty is that asset holders are assumed to ignore the interest returns and expected capital gains in holding different currencies. The attractive feature of this model is that PPP does not depend on goods trade to equalize prices, with the attendant index number problems that arise.

The second PPP model is based on goods arbitrage, or the "law of one price". The basic proposition is that goods traded in international commerce must sell at the same price everywhere, or else arbitrage will occur. Thus if one country's exchange rate changes, domestic prices of traded goods will change in proportion.

The extension of this argument to imply PPP based on some general price index raises a number of problems. Tariffs, transport costs, and price controls may interfere with goods arbitrage. Non-traded (and not potentially tradable) goods must presumably be excluded. Index number problems ensue if countries do not have identical export and import bundles (at least one country must be different, if there is to be any trade at all).

While this approach, too, has a long and distinguished history, it is evident that PPP can only hold approximately if it depends on the law of one price, although for many purposes it may be a useful approximation. Tariffs, transport costs, imperfect information, and the like, will in practice prevent perfect adjustment. Clearly the relative hypothesis is more likely to hold than the absolute in this model, because barriers to trade can introduce price differentials between countries without preventing correlation

between those prices. On this approach we might not expect PPP to hold at every moment in time, or without lags of some kind.

Finally, if we assume that the trade deficit is a function of relative price levels and the exchange rate, PPP can be derived from a macro model in which the size of the trade deficit is fixed. This could be either because trade must balance due to capital immobility, or because real income and domestic expenditure are fixed and the trade balance must equal net saving, which is fixed. We write

$$(2.1) \quad \bar{B\bar{O}T} = X(sP^*/P) - Q(P/sP^*/y)$$

where

- $\bar{B\bar{O}T}$ = trade balance (fixed)
- X = real exports
- Q = real imports
- y = real income
- P = domestic price level
- P* = foreign price level
- s = exchange rate: price of foreign currency in domestic units

If real income is fixed at full employment, it is evident that P/sP^* is a constant, which means that, ceteris paribus, PPP must hold. Note that the absolute version of PPP cannot hold, since the value of the constant depends on $\bar{B\bar{O}T}$ and on y. The appropriate price index is clearly a general one, since prices of non-traded goods influence export and import demands.*

The major difficulty is that the mechanism which enforces PPP is likely to be a sticky one, unless expectations of foreign exchange traders play a role in maintaining equilibrium. Any real shocks to the system will change the value of P/sP^* , so we would not expect to observe PPP holding over some period of time. This approach to PPP is a more recent one, and has its intellectual roots in the Mundell-Fleming macro model of an open economy and

*) X and M would include tourism and direct investment, which are influenced by prices of services and otherwise non-traded goods.

the Chicago-monetary approach to the balance of payments.

Applications of PPP

Until recently interest in PPP centered on the absolute version of the hypothesis, and it was generally tested by analyzing cross section samples of different fixed exchange rates. The policy emphasis was on identifying exchange rates that were over or under valued at some fixed level. (See Officer's review article for a discussion of these). This approach favored the long view--investigators used annual data and often explicitly tried to correct for cyclical fluctuations; price indexes and exchange rates were frequently trade-weighted. Thus PPP was not used as a theory of exchange rate behavior in the short run; rather it attempted to identify long run equilibrium values, which might or might not be reached in the course of events.

With the advent of floating exchange rates in 1973, and the monetary approach to the balance of payments, there has been a revival of interest in using PPP to explain short run exchange rate fluctuations. The Chicago school in general and Jacob Frenkel in particular (1976, 78) have argued for this approach and produced a large body of empirical work using monthly data to support it, with results which are generally favorable.

This approach emphasizes the correlation between the price level and the exchange rate--indeed one of the principle uses of the PPP hypothesis is to provide an extra equation to tie down the price level in a macro model. Thus it is the relative version of PPP that is of interest. This represents a notable contrast with the earlier approach to PPP in that PPP is expected to hold, if not continuously, at least over short periods of time. In many respects it is a different theory altogether, and one that earlier PPP supporters might not accept.

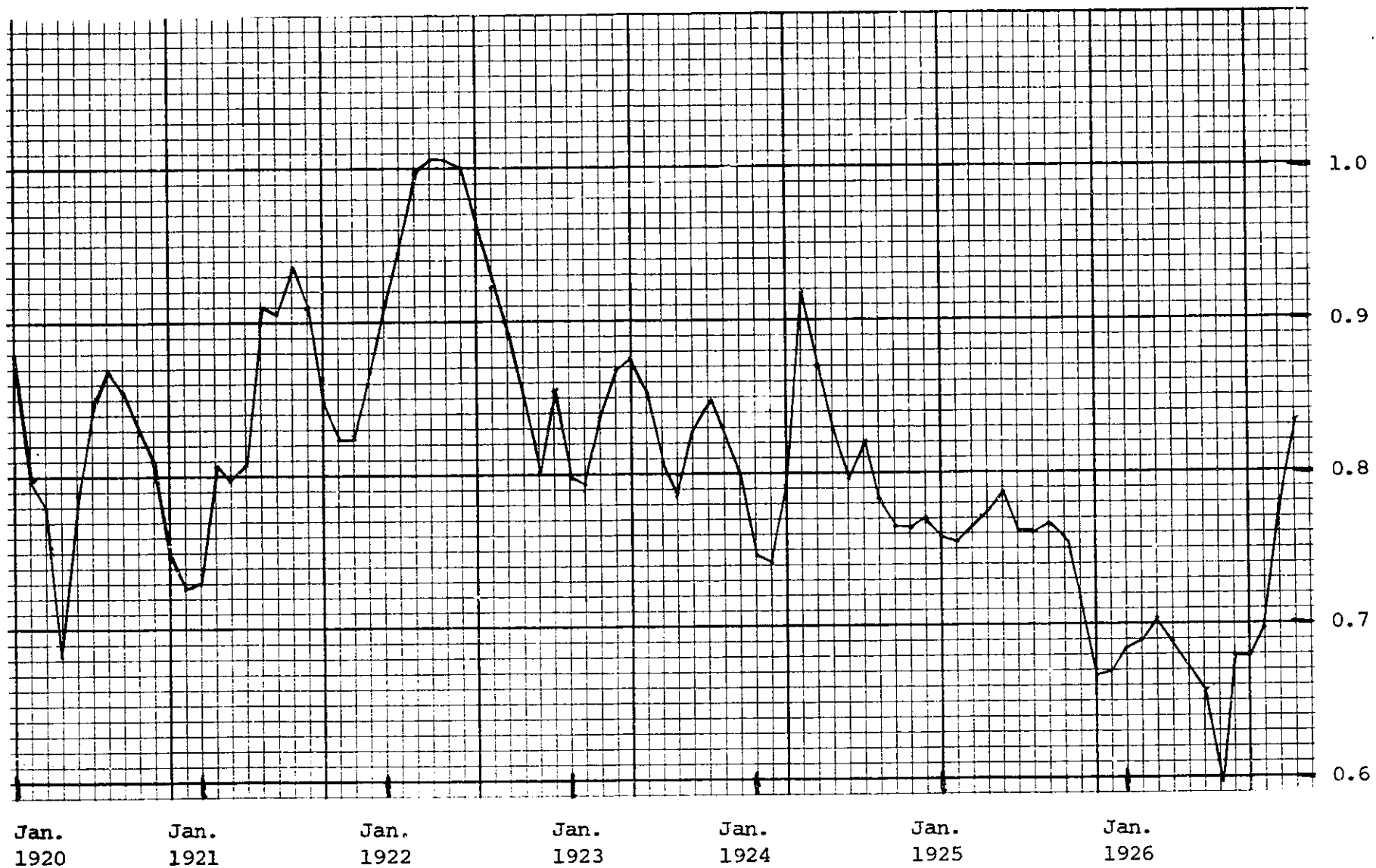
Thus, there is not one single PPP theory which can be tested and then unequivocally accepted or rejected. Instead the hypothesis must be put in the context of a theoretical framework in order for a test to have much meaning. In this ~~chapter~~ we test PPP along the lines of this second approach, using as a theoretical basis the second and third models discussed above. We attempt to use the formal test results to make inferences about the models and the underlying economic structure.

We examine the PPP hypothesis using monthly data for France during the period January 1920-December 1926. The first year for which data are generally available is 1920, so it was selected as the starting point for the tests; 1919 was in many respects a war-time year for the French economy, so the omission is not too serious.

Figure 2.1 shows French wholesale prices divided by the product of the ~~franc-sterling rate and the U.K. WPI~~ (the "real" exchange rate) for this period. If PPP held at all times this rate would be constant. The units are chosen so that the prewar value of the real exchange rate is 1.0, which provides a direct test of absolute PPP if we accept that the prewar period is an equilibrium. It is evident that the real franc-sterling rate is not constant - it exhibits sharp fluctuations from month to month, and oscillates about a generally upward trend. These variations coincide with those in the spot rate, suggesting that prices do not fully offset changes in the exchange rate.

Figure 2.1:
"Real" franc/sterling exchange rate, 1920-26, monthly.

Prewar parity = 1.0



Source for Figure 2.1:

$$\text{Real exchange rate} = 100 \times \text{WPI}_{\text{France}} / (\text{WPI}_{\text{U.K.}} \times \text{spot rate})$$

where the spot rate is in francs per pound sterling

all variables indexed at 1913/14 = 100

$\text{WPI}_{\text{France}}$: FRB, various issues (Federal Reserve index)

$\text{WPI}_{\text{U.K.}}$: "

spot rate: Sauvy, p. 445.

Table 2.1. Exchange rates and wholesale prices, annual averages, 1913-14 = 100

<u>year</u>	<u>(1)</u> <u>franc/sterling</u>	<u>(2)</u> <u>P_{UK}</u>	<u>(3)</u> <u>P_{France}</u>	<u>(1) * (2) / (3)</u>
1920	210	308	512	126
1921	206	198	344	119
1922	217	159	319	108
1923	301	159	394	121
1924	338	166	446	126
1925	407	160	479	136
1926	607	148	620	145

source: see section (3)

This is an unpromising start for the PPP hypothesis. However, the annual average data suggest that the overall impact of events on relative prices was not so severe. Table 2.1 presents the annual average values for the exchange rate and prices, again with 1913-14 = 100. These show that while there was a steady rise in the real exchange rate, it was not nearly as great as the increase in prices or the actual rate. (Compare Figure 1.2 above.) The years 1923-24 are noteworthy--these saw one of the most acute exchange crises in French history, yet from one year to the next France's relative price position only changed by 4%. And by 1923 France had endured a

six-fold exchange depreciation and price inflation, but only a 45% change in relative prices.

Thus again, any evaluation of PPP must take into account the purposes for which the model is being used. In this chapter we focus on the short run, and see what develops from more detailed tests. We consider only the relative PPP hypothesis, because the data needed to calculate absolute purchasing power for either currency are not readily available.

Section 2: Testing the PPP hypothesis

In its most literal form the PPP hypothesis may be written as follows:

$$(2.2) \quad \frac{s_t P_t^*}{P_t} = c e u_t$$

where P_t and P_t^* are the domestic and foreign price levels, respectively, s_t is the spot price of foreign exchange in domestic currency, and c is some constant. The error term u_t is assumed to be random, with mean zero. In the absolute version of PPP, c equals one if the prices are measured in currency units, so that foreign and domestic prices are equal. In the relative version, c is any constant: the ratio of foreign and domestic prices is constant over time.

This equation may be tested as it stands, by calculating the deviation of $(s_t P_t^* / P_t)$ about its mean and applying various tests to see whether the sample residuals could reasonably have been generated by a random error process. The difficulty with this approach is that if we were to reject PPP it would provide no clues at all to the underlying structure. Furthermore it is unnecessarily restrictive, because it rules out versions of PPP, such as the third model given above, which imply only that the elasticity

of the ratio with respect to any component is zero, not that the ratio itself is actually constant. We can rearrange (2.2) to yield

$$(2.3) \quad s_t = c P_t / P_t^* e^{u_t}$$

which is the conventional form of the PPP equation.*

Since we have not yet specified any structure to the model, (2.3) cannot be seen as implying any causality, and the arrangement of the terms is entirely arbitrary. We can estimate the equation by taking logs and adding a coefficient:

$$(2.4) \quad \ln s_t = \ln c + b \ln (P_t / P_t^*) + u_t$$

and a test of the hypothesis that $b = 1$ is a test of PPP.**

Equation (2.4) provides a very strict test of PPP because changes in prices and the corresponding changes in the exchange rate must occur simultaneously. Whatever process it is that maintains parity must work itself out very quickly. Since we are using monthly data, this may seem an overly strong assumption, and we may wish to allow for lags in the adjustment mechanism. Frenkel (1978) has suggested that prices are slower to react than are exchange rates, and that therefore the current price ratio reflects the influence of exchange rates (or the factors that also determine exchange rates) for several periods back. Thus we have as an estimating equation

*) It is perhaps worth noting that taking the first difference of (2.3) does not yield a valid test of the relative PPP hypothesis. This would only be correct if there were perfect autocorrelation in the u_t series. Taking first differences assumes that the rate of exchange depreciation is related to the rate of relative price inflation independent of the level of either, whereas the relative hypothesis states that prices and the exchange rate adjust over time to maintain a given ratio of purchasing power.

***) Note that the hypothesis does not imply that the coefficients on both P and P^* are equal to 1.0; there can be relative changes in P/P^* . Thus it is unnecessary to test the validity of that constraint. PPP holds if and only if the coefficient on $\ln (P/P^*)$ is 1.0, regardless of what the other coefficients may be.

$$(2.5) \quad \ln (P_t/P_t^*) = c + \sum_{i=0}^n b_i \ln s_{t-i} + u_t \quad 0 \leq b_i \leq 1$$

If the coefficients b_i in (2.5) sum to one the equation is consistent with PPP if the hypothesis is applied to steady state levels. These are given by

$$(2.6) \quad \ln (\bar{P}_t/\bar{P}_t^*) = c + \sum_{i=0}^n b_i \ln \bar{s}_{t-i} + u_t = c + \bar{s} \sum b_i + u_t$$

where a bar denotes the steady state value of a variable, such that it is equal in all time periods. It is evident that the elasticity of (\bar{P}/\bar{P}^*) with respect to \bar{s} is the sum of the lag coefficients (b_i). If these sum to unity, a one-time change in the exchange rate results in a gradual change in the price ratio which continues until the new equilibrium price levels are reached and PPP is restored.*

Unit long run elasticity in this model does not imply either that we will observe PPP holding at some point ($P_t/sP_t^* = c$ for some t) or that PPP will hold if the prices and exchange rates are averaged over some suitably lengthy period. Both would depend on the stability of the adjustment process implied by (b_i) as well as the behavior of the exogenous variables in the system.

Estimation of the equation

In general, P , P^* , and s are endogenous variables generated by some unspecified process. Unless we are willing to assume an explicit pattern of causality, the system is simultaneous and two-stage least squares is the appropriate estimating technique.** In equation (2.5) the lagged variables

*) This is one formulation of Officer's second PPP proposition, that PPP determines the long run equilibrium exchange rate (and that whether the exchange rate follows this path is a separate issue). (1976, p. 3)

***) This was apparently first pointed out by Krugman (1977), who analyzes a case where the money supply is also endogenous. But this is not a necessary condition--so long as both prices and the exchange rate depend on the money supply the problem exists. Frenkel (1978) argued that the exchange rate is exogenous, and estimated his lagged equations (2.5) using ordinary least squares (with a correction for autocorrelation).

may be regarded as predetermined, but the term in s_t will still be correlated with the errors, requiring estimation by 2SLS.

The instrumental variables technique used in estimating (2.4) takes as instruments the constant term, a time trend, and a monthly index of French industrial output, together with the left- and right-hand-side endogenous variables lagged one period; the inclusion of the lagged variables as instruments ensures consistent estimates. We use the iterative two-stage Cochrane-Orcutt technique to estimate the autocorrelation coefficient.

The lagged coefficients in equation (2.5) can be estimated either directly or by imposing some structure on them, such as a Koyck or a polynomial distribution. The Koyck lag is the simplest, but imposes a strict form on the coefficients and also has the disadvantage that its estimating equation is identical to that implied by several other structures. The difficulty with direct estimation is that the lagged explanatory variables are likely to be highly correlated with each other, making their coefficients hard to estimate with any confidence. In this paper we adopt the next most general approach by specifying a broad polynomial form for the lag distribution (second degree polynomial, five period lag, with no constraints on any lagged coefficients) and estimating the coefficients using the standard Almon technique.

A problem arises here in connection with the instrumental variables. Since the Almon procedure estimates a regression in which the several explanatory variables are linear combinations of all lagged variables, including the values for the current period, it is clearly necessary to correct for simultaneity. However, no standard procedure was available to implement this correction, so the following technique was used.

The explanatory variable in (2.5)--the one to be lagged--was regressed using ordinary least squares on the set of instruments described above for the IV technique. The fitted values from this regression were then used as the explanatory variable for the standard Almon-lag regression, in which a Cochrane-Orcutt correction for autocorrelation was made. This procedure should ensure that all the explanatory variables are independent of the left-hand-side variable, and thus ensure consistent estimates of the (b_i) .

Section 3: Empirical results

PPP is tested using wholesale and consumer prices for two country pairs, France-U.S. and France-U.K., for which data are readily available. The French price series used in most of the tests in the literature is the whole-sale price index calculated by the French government (Statistique Générale de France). This is somewhat unsatisfactory, because it is unweighted and contains only prices of primary commodities. However, the U.S. Federal Reserve Board calculated its own WPI for France in this period. The index is weighted, and includes a broader range of products, so it is more nearly comparable to the indexes used for the U.S. and U.K. This is the series used in these tests; it is published in the Federal Reserve Bulletin for 1921-29.

The Federal Reserve index for France was part of a series published for purposes of international comparison; the other countries covered were the U.S., U.K., Canada, and Japan. The data include separate export and import price indexes, which we use below. Unfortunately, the series was discontinued after 1925, because the other national indexes were thought to be satisfactory by that time. France was the only exception--its series was published through 1929. In order to include 1926 in the sample we have used the national

wholesale price indexes: the Bureau of Labor index published in the Survey of Current Business (SCB) for the U.S. and the Board of Trade index published in the monthly bulletin of London and Cambridge Economic Service (LCES) for the U.K.

The French official consumer price data is fragmented and incomplete, but Sauvy has published an adjusted monthly series for the whole period which is used here. The NICB consumer price index for the U.S. (published in the SCB) and the Ministry of Labor CPI (LCES) for the U.K. were used. The exchange rates used here are monthly averages of Paris prices for sterling and the dollar, taken from Sauvy.

The results for the basic PPP equation (2.4) follow. The numbers in parentheses are the standard errors; "TSCORC" denotes the instrumental variables technique described in section 2. The t-statistics shown test the null hypothesis that the coefficient on $\ln (P_t/P_t^*)$ equals 1.0.

All equations are for January 1920 - December 1926, monthly data.

Franc-dollar, wholesale prices

$$\text{TSCORC:} \quad \ln s_t = 1.591 + 1.259 \ln (P_t/P_t^*) \\ \quad \quad \quad (.145) \quad (.137)$$

$$R^2 = .972 \quad \rho = .815 \quad (.064) \quad t = 1.89$$

Franc-sterling, wholesale prices

$$\text{TSCORC:} \quad \ln s_t = 3.277 + 1.178 \ln (P_t/P_t^*) \\ \quad \quad \quad (.107) \quad (.107)$$

$$R^2 = .984 \quad \rho = .835 \quad (.061) \quad t = 1.66$$

Using consumer prices we obtain higher estimates for the price coefficients:

Franc-dollar, consumer prices

$$\text{TSCORC:} \quad \ln s_t = 1.671 + 1.454 \ln (P_t/P_t^*) \\ \quad \quad \quad (.174) \quad (.202)$$

$$R^2 = .949 \quad \rho = .797 \quad (.067) \quad t = 2.25$$

Franc-sterling, consumer prices

$$\text{TSCORC:} \quad \ln s_t = 3.384 + 1.395 \ln (P_t/P_t^*)$$

$$(\text{.090}) \quad (\text{.119})$$

$$R^2 = .969 \quad \rho = .757 \quad (\text{.072}) \quad t = 3.32$$

We note that except for the case of sterling wholesale prices, which is marginal, the t-statistics are all above the critical value of 1.67 for the 95% confidence level, so the PPP hypothesis is not consistent with the data.* Substantial values for rho are obtained, suggesting that the model is misspecified. The results for the dollar and sterling are fairly close, which is to be expected given that the dollar-sterling exchange rate was relatively stable, compared with the franc.

These equations cover the full period of the franc float, which includes the two episodes of intervention described in chapter 1. This is appropriate if we assume PPP will hold given any change in the exchange rate. But intervention caused some particularly large downward shocks to the rate, and it is possible that the PPP mechanism could cope with "normal" fluctuations but not with these exogenous shocks. We test this by excluding the last five months of 1926 from the sample and estimating (2.4) with a dummy variable ("D424") for April 1924:

Franc-dollar, wholesale prices

$$\text{TSCORC:} \quad \ln s_t = 1.350 + 1.520 \ln (P_t/P_t^*) - .134 D424$$

$$(\text{.111}) \quad (\text{.108}) \quad (\text{.048})$$

$$R^2 = .971 \quad \rho = .753 \quad (\text{.075}) \quad t = 4.82$$

*) This contradicts the results for the franc/dollar market obtained by Frenkel (1978) and by Krugman, who were able to reject PPP. The difference is apparently due to the use of different price data for France and to a longer sample period. Frenkel uses the period January 1921 - May 1925; the smaller sample size raises the estimated standard errors and makes it harder to reject the hypothesis, given the same point estimates.

Franc-sterling, wholesale prices

$$\text{TSCORC: } \ln s_t = 3.159 + 1.327 \ln (P_t/P_t^*) - .118 D424$$

$$(.105) \quad (.107) \quad (.046)$$

$$R^2 = .984 \quad \rho = .843 \quad (.061) \quad t = 3.07$$

Again we obtain higher coefficients on consumer prices:

Franc-dollar, consumer prices

$$\text{TSCORC: } \ln s_t = 1.216 + 2.064 \ln (P_t/P_t^*) - .229 D424$$

$$(.138) \quad (.169) \quad (.063)$$

$$R^2 = .951 \quad \rho = .715 \quad (.080) \quad t = 6.29$$

Franc-sterling, consumer prices

$$\text{TSCORC: } \ln s_t = 3.248 + 1.633 \ln (P_t/P_t^*) - .254 D424$$

$$(.086) \quad (.120) \quad (.060)$$

$$R^2 = .969 \quad \rho = .746 \quad (.076) \quad t = 5.278$$

In all cases the price coefficients are significantly greater than 1.0 at the 99% confidence level, and are larger in magnitude than those obtained for the full period. It is evident that government intervention in the FX markets did not cause PPP failure in this case, but rather improves the performance of the model.

The intuitive interpretation of these results is a little easier if we reverse the implied causality and note that a unit change in S is associated with (but does not necessarily cause) a smaller change in wholesale prices, and a still smaller change in consumer prices. This provides a formal rejection of the PPP hypothesis, but we cannot infer from the test that the system deviates from PPP in any economically meaningful way. The economic impact of a non-unitary elasticity of the exchange rate depends on how much the exchange rate actually changes. For example, if the exchange rate fluctuated in the short run about some constant value, the average PPP ratio would not change. If the real sector responded slowly to price changes, the effect on output of the PPP deviation would likely be small.

We now use the French and U.S. wholesale prices to test Frenkel's "long-run" PPP hypothesis (equation 2.5). The idea is that the relative price ratio responds to the exchange rate with a lag, so the implicit causality runs from s to (P/P^*) . Using the distributed lag technique described in section (2) we obtain:

France - U.S., wholesale prices, 1920-26*

$$\begin{aligned}
 \text{IV-PDLCORC: } \ln (P_t/P^*_t) &= -1.046 + .236 \ln s_t \\
 &\quad (.087) \quad (.049) \\
 &+ .090 \ln s_{t-1} + .054 \ln s_{t-2} + .080 \ln s_{t-3} \\
 &\quad (.033) \quad (.030) \quad (.030) \\
 &+ .123 \ln s_{t-4} + .138 \ln s_{t-5} \\
 &\quad (.033) \quad (.050) \\
 R^2 &= .983 \quad \rho = .633 (.088) \quad n = 77 \\
 \text{mean lag} &= 2.25 (.27) \text{ months} \\
 \text{sum of lag coefficients} &= .721 (.030)
 \end{aligned}$$

The equation fits the data very well; the lag coefficients are all significantly positive. However, the estimated long run elasticity is only .721, and is significantly less than one, and we still can reject the PPP hypothesis. The same test using French and British wholesale prices yielded a very similar fit and an estimated elasticity of .603 with a standard error of .091. **

This result demonstrates that even over a period of six months, relative prices do not fully "catch up" with a change in the exchange rate. The fact

*) Because of their specification this price equation and those that follow are much less sensitive to exchange rate shocks than is the basic PPP equation, and so that are estimated for the full period without the dummy variable for government intervention.

***) Frenkel (1978) uses Koyck lags to estimate the same equation, and obtains a higher estimate of the elasticity, which is not significantly less than one. As noted above, his data and sample period are somewhat different from those used here.

that the estimated lag coefficients steadily become smaller as the lag lengthens suggests that merely allowing more time would not bring about full adjustment. (This is not, however, proof against an argument that over the course of years such adjustment would occur.)

It is evident from inspection of the data (see section 1) and from the consumer price equations presented above that the asset market version of PPP does not apply to this case. The magnitude of the fluctuations in the ratio sP^*/P rules out this theory. The third category of PPP, based on the trade balance, is not consistent with the observed coefficients on the exchange rate, even if a lagged adjustment is incorporated. Again, all we can say is that we have measured systematic deviations from PPP and found them to be statistically significant. We can pass no judgment on the importance of these deviations from parity. The model may well be useful as an approximation for a given purpose.

The second type of PPP model, based on price equalization, is also ruled out, but only insofar as it implies that wholesale prices are subject to goods arbitrage. There is still room to argue that traded goods prices will follow the PPP hypothesis, and we take up this possibility in the next section.

Section 4: Traded goods prices

The argument for PPP has often been challenged on the grounds that the presence of non-traded goods, or of different commodity weights between countries, in the price indexes used in the comparison invalidates the result.* This is indeed the case, if PPP is assumed to follow from the equalization of prices of internationally traded goods. (Weight differentials do not, however, invalidate the asset-market or trade balance models of PPP discussed in section 2). In this section we analyze the problem and show that the results obtained above are consistent with a model in which PPP holds for traded goods only. We then test this latter model, using the Federal Reserve Board series of export and import prices described in section 3.

Bias in PPP due to non-traded goods

It is readily shown that in general the estimates of b in equation (2.4) are biased away from 1.0 if PPP is not assumed to hold for non-traded goods. The extent of this bias depends on the correlation between traded and non-traded goods prices--if they are perfectly correlated we have the familiar result that PPP still holds.

Assume two countries have identically weighted price indexes P and P^* , each made up of identical bundles of traded and non-traded goods:

$$(2.7) \quad \ln P = a \ln P_T + (1-a) \ln P_N$$

$$(2.8) \quad \ln P^* = a \ln P_T^* + (1-a) \ln P_N^*$$

*) This argument has been made by, among others, Keynes, Viner, Vanek, and Samuelson. See the discussion in Officer (1976, p. 14).

By assumption, traded goods prices must be equal when measured in the same currency:

$$(2.9) \quad \ln P_T = \ln s + \ln P_T^*$$

and in both countries there is an equal correlation between traded and non-traded prices:

$$(2.10) \quad \ln P_N = b \ln P_T$$

$$(2.11) \quad \ln P_N^* = b \ln P_T^*$$

The coefficient b is the elasticity of P_N with respect to P_T . In principle it can have any value, but presumably ranges from 0 to 1. Substituting (2.10) and (2.9) in (2.7) gives

$$(2.12) \quad \begin{aligned} \ln P &= (a + b(1-a)) \ln P_T \\ &= (a + b(1-a)) (\ln s + \ln P_T^*) \end{aligned}$$

Similarly, we can solve (2.8) for P_T^* :

$$(2.13) \quad \ln P_T^* = (1/(a + b(1-a))) \ln P^*$$

and substituting this in (2.12) we obtain

$$(2.14) \quad \ln P = (a + b(1-a)) (\ln S + (1/(a + b(1-a))) \ln P^*)$$

or

$$(2.15) \quad \ln S = \frac{1}{a + b(1-a)} \ln (P/P^*)$$

which is in the form of the basic PPP equation (2.4).

If non-traded goods prices are constant, and unaffected by P_T , then $b = 0$ and the coefficient on $\ln (P/P^*)$ is $1/a$, which is greater than one. If there are no relative changes between P_T and P_N , then $b = 1$, the coefficient is one, and PPP holds. If non-traded goods prices are sticky, but do change in the same direction as P_T , the $0 < b < 1$ and the coefficient lies between 1 and $1/a$,

This is consistent with the point estimates obtained in section (3), which range from 1.178 to 2.064. A smaller weight on traded goods implies a higher value for the price coefficient--this is consistent with the higher coefficients on consumer prices, which give larger weight to non-tradables such as services and housing than do wholesale prices. Thus, the observed PPP failure could possibly be due simply to the presence of non-traded goods. We cannot test this explanation directly because P_N and P_N^* are not observable. We can, however, use the Federal Reserve Board export and import price data to test the hypothesis that PPP holds for traded goods prices. First we investigate the bias due to different weights within traded goods indexes.

Bias from weight differentials

Even if all goods are traded, and price parity holds across countries for all individual goods, differences in weights between the two countries will in general bias the estimated coefficient away from 1.0. The only exception, as before, is the case where there are no relative price changes within either country.

Consider two price indexes of n traded goods:

$$(2.16) \quad \ln P = \sum_{i=1}^n a_i \ln P_i \quad 0 \leq a, a^* \leq 1$$

$$(2.17) \quad \ln P^* = \sum_{i=1}^n a_i^* \ln P_i^*$$

where P_i and P_i^* are the prices in domestic and foreign currencies, respectively. By assumption of price equality we have

$$(2.18) \quad \ln P_i = \ln s + \ln P_i^* \quad \text{for all } i$$

we also assume each individual price is related to the overall index by

$$(2.19) \quad \ln P_i = b_i \ln P \quad \sum_i b_i = 1 \quad (*)$$

(*) by substitution of (2.19) in (2.16).

$$(2.20) \quad \ln P_i^* = b_i^* \ln P^* \quad \Sigma a_i^* b_i^* = 1$$

These coefficients b_i are functions of the a_i and whatever exogenous variables drive the system.

Substituting (2.18) in (2.17) we obtain

$$(2.21) \quad \begin{aligned} \ln P^* &= \Sigma a_i^* \ln P_i^* \\ &= \Sigma (a_i^* (\ln P_i - \ln s)) \\ &= \Sigma a_i^* \ln P_i - \ln s \Sigma a_i^* \end{aligned}$$

or

$$(2.22) \quad \ln (sP^*) = \Sigma a_i^* \ln P_i$$

Substituting in (2.19) for the P_i we get

$$(2.23) \quad \begin{aligned} \ln (sP^*) &= \Sigma a_i^* (b_i \ln P) \\ &= (\Sigma a_i^* b_i) \ln P \\ &= \{ \Sigma (a_i^* - a_i) b_i + \Sigma a_i b_i \} \ln P \end{aligned}$$

and since $\Sigma a_i b_i = 1$, we can rearrange (2.22) to get

$$(2.24) \quad \ln P = \{ 1 / (1 + \Sigma (a_i^* - a_i) b_i) \} \ln (sP^*) + u$$

Thus equality between individual domestic and foreign prices only implies equality between price levels if

$$(2.25) \quad \Sigma (a_i^* - a_i) b_i = 0$$

The error term u in (2.24) is a linear combination of the errors in (2.18), which have been suppressed for clarity.

The condition for price equality (2.25) can also be written as

$$(2.26) \quad \Sigma (a_i^* - a_i) (b_i - 1) = 0$$

Since the $(a_i^* - a_i)$ must sum to zero the added term drops out. However, the interpretation is a little easier--we require that the weight differential for each price times the percentage change in that price relative to the overall index sum to zero.

If the weight patterns are the same, (2.26) clearly holds because $(a_i^* - a_i)$ is always zero. And it holds if relative prices are constant, because then all the b_i are equal to one and that term is zero. Otherwise, the condition will not in general be met; the magnitude and sign of the bias will depend on the correlation between $(a_i^* - a_i)$ and $(b_i - 1)$.

Empirical tests of equality in traded goods prices

We estimate equation (2.24) using the export and import prices for France and the U.K. computed by the Federal Reserve Board. The U.K. was chosen for the test because of the countries for which the FRB data is available it is the closest to France in size, proximity, and economic structure. Thus if traded goods prices equalize between any two countries they should do so for France and the U.K.

The result just obtained (2.26) means that we cannot reject price equality on the basis of estimated coefficients different from one unless we make some assumption about the bias due to weight differentials. Fortunately, the weights for the indexes used have been published in the Federal Reserve Bulletin, so we can obtain the $(a_i^* - a_i)$. But since the individual prices are not published we cannot obtain the coefficients b_i . However, as it happens the actual weight patterns can provide some help.

The export price indexes are sufficiently alike in structure that we can virtually rule out any weighting problems and test whether prices of individual commodities tend to equalize. On the other hand, the French and British import prices have very little in common; we can use them to measure the tendency toward price equalization even when weights are greatly different. Table 2.2 presents the weights for the major items in the two export indexes.

Table 2.2. Major components of French and U.K. export prices (FRB)

<u>Item</u>	<u>U.K. weight</u>	<u>French weight</u>	<u>absolute difference</u>
cotton products	89.5%	90.3%	0.8
rubber	1.0	1.1	0.1
burlap	2.5	-	2.5
wool products	3.3	-	3.3
coal	1.0	-	1.0
silk products	-	2.7	2.7
iron products	-	3.0	3.0
butter	-	1.8	1.8
other--U.K.	2.7	-	2.7
<u>other--France</u>	<u>-</u>	<u>1.1</u>	<u>1.1</u>
Total	100.0%	100.0%	19.0%

Source: calculated from Federal Reserve Bulletin, Feb., Aug., 1922.

It is not entirely clear that these weights reflect the actual composition of exports for either country (they include re-exports, and are based on prewar data). However, it is evident that the two published series measure essentially the same price--that of cotton cloth. Table 2.3. shows the major components of the two import indexes and their weights; we see that the French index is more diverse, and is chiefly determined by wheat, coal, leather, and rubber prices, while the U.K. index is moved by cotton, wool, and lumber prices.

Table 2.3. Major components of French and U.K. import prices (FRB)

<u>Item</u>	<u>U.K. weight</u>	<u>French weight</u>	<u>absolute difference</u>
wheat	2.2%	12.0%	9.8
corn	0.2	3.6	3.4
tea	4.4	-	4.4
coffee	-	2.1	2.1
wine	-	3.2	3.2
cotton	38.1	4.8	33.3
wool	8.5	1.9	6.6
silk	-	3.9	3.9
coal	-	19.1	19.1
leather	-	26.6	26.6
rubber	2.3	9.8	7.5
lumber	40.9	-	40.9
petroleum	2.2	2.3	0.1
soda	-	1.9	1.9
oil seeds	-	2.1	2.1
other--U.K.	1.2	-	1.2
<u>other--France</u>	<u>-</u>	<u>6.7</u>	<u>6.7</u>
Total	100.0%	100.0%	172.8%

Source: *ibid.*

The third column in each table shows the absolute value of the weight differentials in each index. These can be used as a gauge of the magnitude of the relative price changes ($b_i - 1$) needed to account for a given estimated coefficient using the bias from weight differentials.

Estimating equation (2.24) using the IV technique described in section 2 with the two export price series, we obtain

France-U.K., export prices, 1920-25

$$\text{TSCORC: } \ln P_t = 2.270 + .396 \ln (sP^*)_t$$

(1.151) (.121)

$$R^2 = .973 \quad \rho = .951 \quad n = 70$$

In view of the low coefficient on foreign prices we estimate the same equation by fitting a polynomial distributed lag to the (SP*) term using the technique described above, and obtain a long run elasticity of only .455 (.119). The mean lag was only .34 (.66) months, suggesting that there is no significant lagged effect of British on French prices.

This result is striking in that it shows that the short run elasticity of the French price of cotton goods with respect to the price in francs of British goods is only 40%. If we allow for lagged adjustment the long run elasticity rises to 46%, but this is still much less than we might expect for a good that was one of the mainstays of international commerce at the time.

The result can hardly be due to relative changes in the individual prices in the index, because the differentials in the weights are so small. As shown in Table 2.2 the sum of the absolute differentials is only 19%. This means that in order to obtain a coefficient of .396, $(b_1 - 1)$ would have to average 8.03^* in absolute value of the whole period and have the correct sign--this possibility can be safely dismissed.

However, the evidence for the two import price series gives a much different result. These indexes have much greater weight differentials, yet the prices come close to equalizing. (Even if the two indexes had no goods at all in common we should still find a tendency toward equalization because, ceteris paribus, a change in the French exchange rate will change French prices proportionately.) Estimating the import price equations as above we obtain

*) From (2.24) we have $\frac{1}{1 + (.19)(8.03)} = .396$

France-U.K., import prices, 1920-25

$$\text{TSCORC: } \ln P_t = -2.438 + .903 \ln (sP^*)_t$$

(.42) (.045)

$$R^2 = .987 \quad \rho = .717 \quad n = 70$$

(.283)

The estimated elasticity of about .9 is significantly less than one at the 95% confidence level, but in this case it is much easier to attribute the non-unitary coefficient to the effect of weight differentials; as Table 2.3 shows, the total of the absolute weight differentials is 172.8%. To obtain an estimated coefficient of .9 requires an average relative price change of only 6.4% if each price changes in the right direction.* This may or may not strike one as plausible, but it is at least not unthinkable, particularly since some individual categories have weight differentials of around 40%. Thus a modest change in one or two relative prices might lead to an estimate of .9 instead of 1.0.

The results of this section suggest that the problems of non-traded goods and differential weights can go a long way toward explaining the observed failures of PPP. However, price equalization is evidently not a truism, since we observe wide discrepancies in individual markets. This may simply be due to an anomaly in the cotton goods market, but there is a more general interpretation.

Isard (1977) has argued that in practice, at least, the law of one price cannot be verified except for basic commodities. For manufactured goods, quality differences and product differentiation between countries prevent price equalization. This argument may well apply to French and

*) From (2.24) we have $\frac{1}{1 + (1.728)(.0643)} = .9$

British cotton goods, and to exports generally. We can argue further that import prices have a greater tendency to stay at world levels, because a country must act as a price taker in imports but can set its own price for exports. Import prices would respond quickly to exchange rate changes, because importers' costs change quickly, while exporters might be slower to react to exchange depreciation, especially if their prices are set equal to domestic prices of the same goods.

If this interpretation is correct the terms of trade for a single country should be affected by changes in the exchange rate, since import prices will change promptly but export prices will not. We test this hypothesis by estimating

$$(2.27) \quad \ln (P_x/P_m) = a + b \ln s_t + u_t$$

for France, using the franc-sterling exchange rate. We would expect to find b less than zero. We obtain

France: terms of trade, 1920-25

$$\text{TSCORC:} \quad \ln (P_x/P_m) = .722 - .186 \ln s_t$$

(.157) (.0368)

$$R^2 = .832 \quad \rho = .687 \quad n = 70$$

(.067)

The coefficient on S_t has the predicted sign and is significantly less than zero--this is consistent with the hypothesis.

Section 5: Conclusions

One reason why PPP might fail if it depended on the behavior of traded goods prices is that price controls, tariffs, or transport costs might prevent prices from equalizing. In this section we consider whether these factors could have accounted for the observed deviations from parity. While it is not possible to make a quantitative estimate of their impact, the evidence suggests that they were not of major importance.

Price controls

The French government instituted a more or less comprehensive system of price controls during WWI, including a general prohibition of "illicit speculation".* These remained on the books until October 1922, but apparently were not strictly enforced. Since 1921 and 1922 were years of price deflation the restrictions were presumably not binding; it is possible that the inflationary spurt in 1920 was somewhat restrained by price controls. Certainly there was no lack of public indignation about the levels to which prices did rise, which suggests that the controls were not too onerous. (Sauvy, p. 318).

Price controls were of the most importance for consumer prices. Rents were fixed by the government throughout the 1920's, changed infrequently, and rose by about half as much as other consumer prices. Food prices were also controlled, but the agricultural policy seems to have been more concerned with keeping prices high for farmers than with protecting consumers. These restraints would tend to keep the CPI from rising as much as the exchange rate depreciated, and thus partially explain the results obtained above. It is no surprise to find that PPP does not hold for consumer prices, but the data do not permit making an estimate of the relative importance of the prices that were controlled, so the PPP failure cannot be positively attributed to price controls.

We can be a little more specific about the wholesale prices. The Federal Reserve Bulletin article which describes the construction of the French price index reports that price controls on goods included in the index were significant through mid-1921, when the last controls (on grain) were lifted.

*) This discussion is based largely on the treatment in Sauvy, ch. 17.

twenties, but there was a continuing, if erratic, upward adjustment in the specific rate schedules to account for inflation. The resulting lag caused real tariff rates to fall, which might have had a marginal effect in holding down French prices.

However, we cannot stretch this argument to explain the cotton textile export price result. It is true that a falling real tariff on cotton imports would slightly affect the export price, but it is clearly insufficient to explain the observed price changes. A high tariff wall might insulate the prices of otherwise tradable goods and thus permit deviations from world prices, but this does not apply to goods which are actually traded.

Finally, transport costs might explain differences in traded goods prices. However, France and the U.K. are, relative to markets in Africa, Asia, or the Americas, very close together. For goods that are traded between the two countries, transport costs would be important. But for a product such as cotton, which is exported to Africa, the raw material for which comes from the United States, the differences in transport costs between France and England are surely negligible. We can also cite the import price results from the previous section as evidence that transport costs did not prevent price equalization for a broad range of products.

Conclusion

As it is conventionally applied, i.e., to wholesale or consumer prices, we can reject the PPP hypothesis. The estimated price coefficients obtained in section 3 show that the elasticity of the exchange rate with respect to price changes is greater than one. The implication of this is that when the

exchange rate changes, prices change less than proportionately, and the result is a change in the ratio P/sP^* . This interpretation can be tested directly by estimating the equation

$$\ln (P/sP^*)_t = a + b \ln s_t + u_t$$

If PPP holds, $b = 0$. If not, on the interpretation given above we would expect to find $b < 0$, since an increase in s_t should raise the denominator of the left-hand-side variable more than it raises the numerator.

Estimating this equation for French-U.K. wholesale prices, we get

France-U.K., wholesale prices, 1920-26

$$\text{TSCORC: } \ln (P/(sP^*))_t = -2.612 \quad -.189 \ln s_t \\ (.328) \quad (.074)$$

$$R^2 = .873 \quad \text{rho} = .835 \quad (.061)$$

This indicates that the PPP ratio is not in fact independent of the exchange rate in the short run. However, if we estimate the same equation for the French and British import prices we obtain results which support PPP:

France-U.K., import prices, 1920-25

$$\text{TSCORC: } \ln (P/(sP^*))_t = -3.093 \quad -.062 \ln s_t \\ (.246) \quad (.057)$$

$$R^2 = .629 \quad \text{rho} = .749 \quad (.079)$$

The estimate of the coefficient b is smaller in magnitude and not significantly less than zero.

One interpretation of these results is that exchange rates are exogenous, and that prices, being sticky, are slow to respond. This is more or less what would be predicted by conventional wisdom and the Mundell-Fleming model. In this model, capital mobility implies that an increase in the money supply results in a capital outflow, stimulated by a temporary fall in the interest rate. This capital outflow in turn results in a depreciation

of the domestic currency. The effect on prices comes from this depreciation, in several ways:

- i) the rise in S raises exports and lowers imports. This in turn raises aggregate demand, resulting in either increased output or price inflation.
- ii) the rise in S raises import prices, and generates cost-push inflation through wage indexation.*
- iii) the rise in S generates inflationary expectations among goods traders, who bid up prices.

It is clearly possible that these various forces could cause the price level to rise in the same proportion that the exchange rate depreciates, so that PPP is observed to hold. However, this will not in general be the case, particularly if real income adjusts in the short run to absorb some of the increase in aggregate demand generated by the depreciation.

We might very well observe results similar to those obtained in the French case: prompt and nearly complete adjustment of import prices, which are set at world levels, gradual response of wholesale prices of domestic goods, and a much slower response of consumer goods and services, which are partially regulated and largely independent of foreign prices. There will be a strong link between prices and exchange rates, but no particular reason for them to move exactly together. Other variables affect prices, which show up as the autocorrelation in the PPP equations.

Thus the observed results have a ready interpretation in conventional economic theory. Statistically significant deviations from PPP do not refute the basic assumptions behind the recent work in this area, namely

*) This possibility has been analyzed in a paper by Jeffrey Sachs (1978).

that the exchange rate is largely a monetary phenomenon and that the rates of exchange depreciation and domestic price inflation are closely related. In fact, the results tend to support this view, given that the PPP equations fit the data so well--exchange rate movements are clearly very highly correlated with price movements. Estimates of b that are different from one only indicate that we are able to measure the existence of some non-monetary phenomena.

However, there is a more direct approach to testing the Mundell-Fleming model; the obvious implication of this explanation is that the money supply largely determines prices and the exchange rate, and this hypothesis can be tested directly. Furthermore, there is no implication in these PPP results that the exchange rate is determined by a stable or efficient process, and this, too, can be tested. We turn to these questions in the following chapters.

Chapter Three

Tests of the market for forward exchange:

Rational expectations and interest rate arbitrage

This chapter analyzes the market for forward foreign exchange in France in the 1920's. The forward rate is of interest for two reasons. First, the forward exchange rate is a variable in the general equilibrium model of an open economy, and by understanding its behavior we are helped to understand the economy as a whole. Second, the forward rate can be interpreted as a direct observation of individuals' expectations about future spot prices. Thus it provides an opportunity to test hypotheses about how expectations are formed. In this chapter we focus on the rational expectations model of forward market behavior; on the basis of test results we are able to reject it. We then discuss an alternative model based on interest rate arbitrage, which is found to be more attractive, although not without qualification.

Figure 3.1 plots the monthly spot and the lagged one-month forward franc/sterling exchange rates. The spot rate (s_t) is the current price of sterling in francs; the forward rate (f_t) is the current price quoted

for a contract to buy or sell sterling one month in the future.* We note two things from the graph: the spot rate fluctuates sharply from month to month, and is closely followed by the forward rate. The difference between the spot and forward rates in any one month is generally very small, much smaller than the difference between the forward rate and the spot rate one month in the future.

This can be seen more clearly in Figure 3.2, which plots the actual percentage change in the spot rate for each month ($s_t/s_{t-1} - 1$) and the percentage change that was predicted by the forward market in the previous month (the forward discount, $d_{t-1} = f_{t-1}/s_{t-1} - 1$). Table 3.1 shows the numbers for this graph. It is evident that the forward discount has very little power to predict actual changes in the spot rate, and that using last month's change as a predictor, or predicting no change at all, would do about as well. This does not, however, mean that it is a biased predictor; we now turn to consider this problem.

*) The spot rate is the monthly average of Paris prices given in Sauvy (1965). The forward rate is calculated using the spot price and the forward discount (monthly average of weekly figures) in Einzig. The forward data start in 1921, so we use the period 1921-26, while the franc floated.

Figure 3.1: Spot and lagged forward franc/sterling exchange rate, 1921-26, monthly.

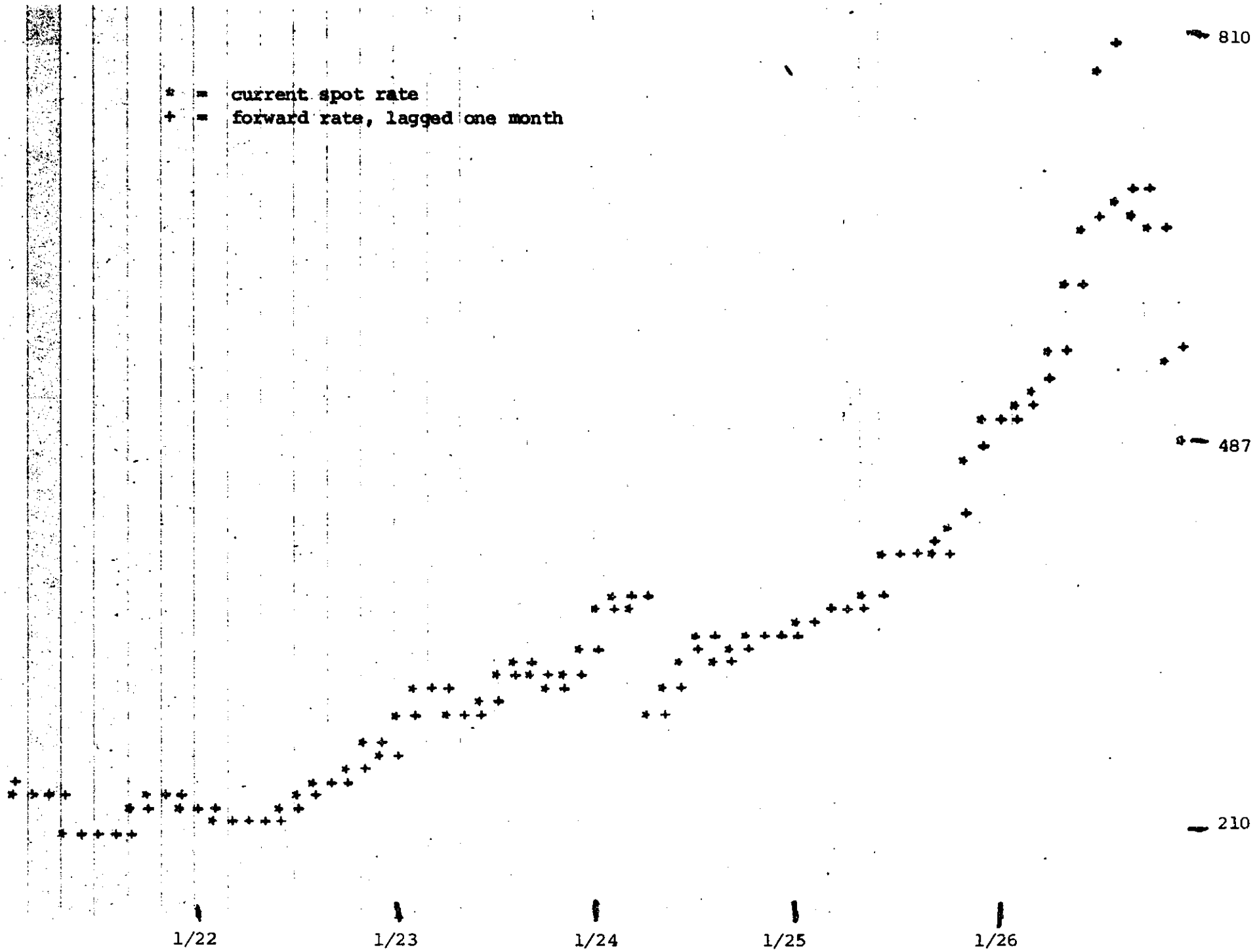


Figure 3.2: Actual and predicted depreciation, franc/sterling exchange rate, 1921-26.

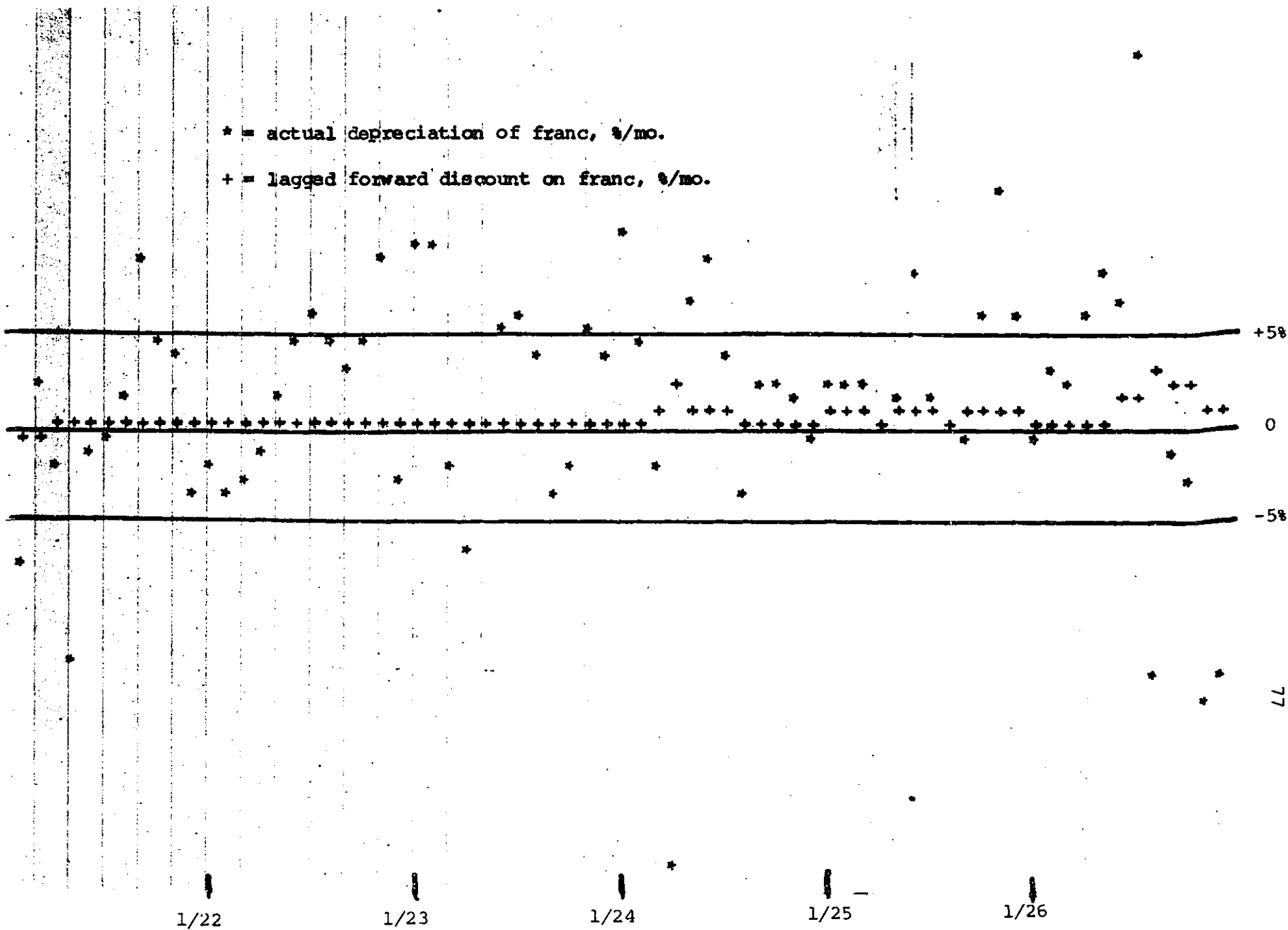


Table 3.1: Franc/sterling exchange rates, 1921-26, monthly.

<u>year and month</u>	<u>Percentage change, spot rate</u>	<u>Percentage forward discount lagged 1 month</u>
<u>1921</u> February	-.07067	-.00671
March	.02479	-.00389
April	-.01860	-.00361
May	-.12638	-.00221
June	-.01411	-.00126
July	-.00683	-.00128
August	.01333	0.00000
September	.08510	.00064
October	.04557	.00039
November	.03423	.00056
December	-.04033	.00054
<u>1922</u> January	-.02450	.00038
February	-.03400	-.00019
March	-.02820	0.00000
April	-.01338	0.00000
May	.01710	0.00000
June	.04471	.00021
July	.05850	.00020
August	.04210	.00130
September	.02972	.00160
October	.04148	.00086
November	.08779	.00100
December	-.02761	.00259
<u>1923</u> January	.09413	.00126
February	.09521	.00100
March	-.01990	.00157
April	-.06666	.00120
May	-.00243	.00057
June	.05165	.00057
July	.06112	.00068
August	.03767	.00051
September	-.03568	.00062
October	-.02326	.00051
November	.04867	.00066
December	.04014	.00113

Table 3.1 (continued)

<u>year and month</u>	<u>Percentage change, spot rate</u>	<u>Percentage forward discount lagged 1 month</u>
<u>1924</u> January	.09986	.00060
February	.04737	.00274
March	-.02439	.00387
April	-.23651	.02307
May	.06283	.00506
June	.09098	.00926
July	.03576	.00412
August	-.03441	.00211
September	.01939	.00073
October	.01997	.00071
November	.01807	.00140
December	-.00481	.00275
<u>1925</u> January	.01956	.00564
February	.01963	.00372
March	.01959	.00476
April	.00304	.00293
May	.01807	.00595
June	.08386	.00500
July	.01520	.00647
August	.00048	.00290
September	-.00695	.00492
October	.06174	.00457
November	.12308	.00458
December	.05708	.00448
<u>1926</u> January	-.00656	.00139
February	.02803	.00062
March	.02576	.00113
April	.05795	.00206
May	.07920	.00264
June	.07004	.01135
July	.19955	.01615
August	-.13526	.02598
September	-.01185	.01999
October	-.02658	.02299
November	-.14727	.01099
December	-.12970	.00397

Section 1: Tests of the rational expectations hypothesis

The idea behind the rational expectations (RE) hypothesis is that individuals' expectations about the future value of some economic variable are the same as the mathematical expectation of that future value. That is, individuals form their expectations 'rationally', and do not, for example, blindly assume that past trends will continue in the future. The hypothesis is now widely used in macroeconomic modelling both because it is simple and because it is consistent with a world view of an economy made up of orderly markets, which is what many economists seem to be trying to model.

In this connection the forward exchange market is of interest because we can (presumably) observe investors' expectations about the future and thus test directly the validity of the RE hypothesis as it applies to the foreign exchange market. This sheds light on the general problem of how expectations are formed; if we accept the hypothesis we can also draw inferences about the foreign exchange market itself.

Specification of a test

We can write the rational expectations hypothesis as follows:

$$(3.1) \quad {}_t a_{t+1} = E_t(s_{t+1})$$

where ${}_t a_{t+1}$ is the spot rate that individuals at time t anticipate will hold at time $t+1$ and E_t denotes mathematical expectation, given the state of the world at time t .^{*} If we assume further that the forward

*) This assumes individuals have access to all relevant information. Frankel (1978) discusses a more general case in which E is defined over various sets of information.

price of FX is the anticipated future spot price, we have:*

$$(3.2) \quad f_t = {}_t a_{t+1}$$

and it follows that

$$(3.3) \quad f_t = E_t(s_{t+1})$$

$$\text{or} \quad E(s_{t+1} - f_t) = 0$$

or

$$(3.4) \quad (s_{t+1} - f_t) = u_{t+1} \quad E(u_t) = 0, E(u_t u_{t-i}) = 0, i \neq 0$$

Rational expectations clearly implies that u_t is uncorrelated with any previous errors, because otherwise its expectations at time $t-1$ would not in general be zero.

This model can be tested in several ways, since it makes several implicit assumptions about the variables s , f , and u . The most straightforward is to test the hypothesis that $E(u_t) = 0$ by calculating the sample residuals defined by (3.4) and applying various tests to see if they could reasonably have come from a truly random distribution. Another approach is to estimate the coefficients in (3.4) using linear regression techniques. We can write

$$(3.5) \quad s_t = c_0 + b_0 f_{t-1} + u_t \quad E(u_t) = 0$$

The RE hypothesis is then that $c_0 = 0$ and $b_0 = 1$; the earlier test is simply a test of $c_0 = 0$ when b_0 is constrained to be 1.0. In practice,

*) Levich (1977) was the first to argue that this may not be a sensible assumption. The problem is considered in the following section.

the equation is usually estimated in log form:*

$$(3.6) \quad \ln s_t = c + b \ln f_{t-1} + u_t$$

where the null hypothesis is the same: $c = 0$ and $b = 1$.

It is important to remember that failing to reject the hypothesis that $c_0 = 0$, $b_0 = 1$ in (3.5) does not prove that RE holds. This equation is one implication of rational expectations, but it is not the only one. For example, if we subtract s_t from both sides of (3.4) and rearrange, we get

$$(3.7) \quad (s_{t+1} - s_t) = (f_t - s_t) + u_{t+1}$$

The expression $(f_t - s_t)$ has a ready interpretation--it is the forward premium on foreign currency or the forward discount on domestic currency.

The rational expectations hypothesis implies (in 3.4) that the forward price now is an unbiased predictor of the future spot rate; it also implies (in 3.7) that the forward discount now is an unbiased predictor of the change in the spot rate in the future. This second implication can be tested by estimating regression coefficients for (3.7):

$$(3.8) \quad (s_t - s_{t-1}) = c_1 + b_1 d_{t-1} + u_t$$

*) This is the specification used by Frenkel (1976,78). There is some disagreement in the literature over whether (3.5) or (3.6) is the appropriate form to use. On the one hand, Krugman (1977) has pointed out that since $E(s_{t+1} - f_t) = 0$ does not imply $E(\ln s_{t+1} - \ln f_t) = 0$ the estimated coefficients in (3.6) are biased due to specification error. This view is endorsed by Krasker (1977). However, the multiplicative error implied by the log form ($s_{t+1} = f_t e^{u_t}$) has an intuitive appeal: it seems reasonable that larger absolute values for f_t should result in larger absolute forecast errors (but a constant percentage error). This matters because if s_t is correlated with time the additive error term is heteroskedastic. Frankel (1978) makes an argument for the log form on other grounds.

where d_{t-1} is the forward discount ($f_{t-1} - s_{t-1}$), and testing the hypothesis that $c_1 = 0$, $b_1 = 1$.

This test is not equivalent to the previous one, i.e., $b_0 = 1$ in (3.5) does not imply that $b_1 = 1$ in (3.8). This can be seen by rearranging (3.8) to yield

$$(3.9) \quad s_t = c_1 + b_2 s_{t-1} + b_1 d_{t-1} + u_t \quad b_2 = 1.0$$

Estimating (3.5) as it stands in effect constrains the coefficients b_1 and b_2 to be equal. If in fact they are not, equation (3.5) is misspecified and the estimates are subject to aggregation error. The estimate of b_0 depends on the values of b_1 and b_2 and the correlation between s_{t-1} and d_{t-1} , thus $b_0 = 1$ does not imply anything about b_1 or b_2 .

On the other hand, if $b_1 = b_2 = 1$, obviously $b_0 = 1$, and if $b_0 \neq 1$, RE is still rejected, so (3.5) is a special case of the more general test, (3.8). (Of course, (3.8) is not an exhaustive test, either, since it does not rule out the possibility that still other variables can explain ($s_t - f_{t-1}$).) Again, for purposes of estimation we write the test equation (3.8) in log form:

$$(3.10) \quad \ln (s_{t+1}/s_t) = c + b \ln d_t$$

where $d_t = f_t/s_t$.

Estimation

We test for rational expectations by fitting equations (3.6) and (3.10) to the data set described above using ordinary least squares, with the Cochrane-Orcutt iterative correction for serial correlation.*

*) Since the explanatory variables are clearly predetermined, there is no problem of simultaneous equation bias, and OLS is the appropriate method to use if the error term u_t is well behaved. Arguments that it is not are taken up below.

First we present the results of two conventional tests, and then the test using the forward discount, d .

We can simply test the prediction error for zero mean by constraining $b = 1$ in equation (3.6):

Franc/sterling, 1921-26, monthly

$$\ln s_t - \ln f_{t-1} = .008024$$

$$(.010441)$$

$$R^2 = .0450 \quad \rho = .218 (.117) \quad n = 70$$

The figures in parentheses are the standard errors. The constant term is not significantly greater than zero, so we cannot reject the hypothesis that expectations are unbiased predictors of the future. However, since the estimate of ρ is significantly positive at the 95% level, the prediction error is not completely independent of information available at time $t-1$ (namely the coefficient ρ) and we can formally reject the RE hypothesis.

We obtain a similar result estimating (3.6) without this constraint:

Franc/sterling, 1921-26

$$\ln s_t = .181 + .9607 \ln f_{t-1}$$

$$(.122) \quad (.0275)$$

$$R^2 = .969 \quad \rho = .244 (.116) \quad n = 70 \quad SSR = .3126$$

Neither the constant term nor the coefficient on f_{t-1} is significantly different from its hypothesized value, but again ρ is significantly positive. We can test the joint hypothesis that $(c = 0, b = 1)$ given the value obtained for ρ by forming an F statistic with the sum of squared residuals from the constrained regression (.3246). The value for $F(2,68)$ is 1.306, and we cannot reject the constraint. Thus the evidence of autocorrelation is the only basis for rejecting rational

expectations using the conventional tests.* Estimating (3.10) we get
Franc/sterling, 1921-26

$$\ln (s_t/s_{t-1}) = .0312 - 5.730 \ln d_{t-1}$$

(.0130) (1.689)

$$R^2 = .1666 \quad \rho = .360 \quad (.112) \quad n = 70 \quad SSR = .2659$$

This is a startling result, because the coefficient b is not only significantly different from one, it has the wrong sign. A higher forward discount is associated with a more appreciated exchange rate in the next period. The estimates of ρ and the constant are both significantly positive; we can easily reject the RE hypothesis at the 99% confidence level. In this case the test on the forward discount leads to a different result than the conventional test, since it establishes that current expectations are a biased (and apparently perverse) predictor of the future.

However, the coefficient on the forward discount warrants further investigation. Inspection of Table 3.1 and Figure 3.2 in the previous section reveals that the actual depreciation in the spot rate usually has the same sign as the lagged forward discount. The principle exceptions are in April 1924 and August-December 1926, when the franc appreciated sharply in response to intervention by the French government. It is evident that the negative correlation for these periods outweighs the positive correlation in the other months.

*) This result differs slightly from that of Frenkel (1978). He estimated the same equation (3.6) over a shorter period (February 1921-May 1925) and found no evidence of autocorrelation. We can confirm this result using this data set. However, using the shorter period did not affect the results obtained for equation (3.10): we can reject RE in either period.

We can justify omitting the intervention periods from the sample in a test of R^2 if we assume that the intervention was truly unpredictable by investors. In effect, we must say that in March 1924 no rational foreign exchange trader would have considered the possibility that the government would borrow dollars from New York banks and intervene to support the franc. While this may seem to contradict the spirit of rational expectations models, there is considerable historical support for this view. Throughout most of period up to 1926 the franc floated without intervention; the monetary authorities were forbidden by law to deal in foreign exchange. And through 1923 the government had given the public little reason to believe that it had an effective policy to control its own budget, much less the foreign exchange rate; contemporary accounts suggest that the intervention by the Poincaré government took the market completely by surprise.*

We reestimate equation (.3.10) for the period February 1921 - July 1926, with a dummy variable (D424) for April 1924, and obtain:

Franc/sterling, Feb. 1921 - July 1926

$$\ln (s_t/s_{t-1}) = .00965 + 7.316 d_{t-1} - .4375 D424$$

$$(.00775) \quad (1.943) \quad (.0567)$$

$$R^2 = .532 \quad \rho = .192 (.122) \quad n = 65 \quad SSR = .1105$$

The result is very different: the coefficient on the forward discount has about the same magnitude as before but a different sign; it is significantly greater than one at the 99% confidence level. The constant and rho are no longer significantly positive. Thus if we accept that the government intervention was exogenous we can reject the

*) See, for example, Schuker (1976, ch. 4)

rational expectations model because the actual change in the exchange rate was consistently greater (by a factor of seven) than that forecast by the forward market one month earlier. We now turn to a discussion of possible explanations of these results which are consistent with rationality.

Section 2: Specification error in tests of RE

The result we have obtained above is that the actual change in the spot rate is systematically different from the change predicted by the forward market, which contradicts the rational expectations hypothesis as stated. There are two general ways in which specification errors could mean that we have incorrectly rejected RE. One is that, due to a non-normal distribution of the residuals u_t in equation (3.4), the statistical methods we have used are inappropriate, and we have not in fact demonstrated that the true coefficients are different from their hypothesized values, either because the point estimates are biased or because the standard errors are too low. The other argument is that the observed results are statistically valid, but due to factors previously omitted from the analysis, they are not in fact inconsistent with the rational expectations model.

Two lines of argument can lead to either difficulty. One, stated by Levich (1978) and Obstfeld (1978), is that risk aversion by investors means speculators require a positive expected return before they will undertake transactions in the forward market. Thus the forward price of foreign exchange is not identically equal to the spot price investors actually expect to prevail in the future. Equation (3.2) does not hold by definition, and we must make some assumption about risk before proceeding.

On the other hand, Frankel (1978) and Krasker (1977) have argued that the possibility (or actuality) of some large disturbance in the error (u_t) due to government intervention in the exchange markets means

that the distribution of u_t is non-normal. If this problem is sufficiently serious it can lead to a spurious rejection of RE. (This is the Peso Problem, so called because tests on the Mexican peso before its devaluation in 1976 led to rejection of RE, suggesting to some that the market was rationally anticipating the event.)

We consider each problem in turn. We conclude that the econometric problems with the residuals do not invalidate the estimates obtained; i.e., the spot rate really does change significantly more than predicted. (This may, perhaps, be taken as self-evident from Figure 3.2.) It is possible to construct a model, based either on risk aversion or on anticipated intervention, in which the observed results are consistent with rational expectations. These models are essentially untestable; however, some indirect evidence and a priori reasoning leads us to reject them both, and to turn to other explanations of the behavior of the forward rate.

Risk

Clearly, if there is a constant risk premium, so that the forward rate is always higher or lower than the anticipated future spot rate, the observed results are consistent with rational behavior.* We can rewrite (3.2) as follows

$$(3.2) \quad f_t = q_t a_{t+1} + v_t$$

where q is a scalar and v_t is a random error term, but one which may have nonzero mean and/or autocorrelation. If $q \neq 1$, the risk premium is

*) More precisely, the observed relation implies that the risk premium (if any) is expressed as a constant percentage of the expected future depreciation, not as a constant amount in francs.

consistent over time, and it is evident that we would not expect to find $b_0 = 1$ in equation (3.5). But even if the risk premium fluctuates in sign (and perhaps in magnitude as well) from month to month, so that $q = 1$, the result is an errors-in-variables problem, as Obstfeld (1978) has pointed out, due to the random term v_t . In general the estimated coefficient on f_t in (3.5) will be biased toward zero if the forward rate is not exactly equal to the anticipated future spot rate, and the same problem applies to equation (3.10). However, the point is moot in our case: since the observed coefficients are all greater than one in absolute value, appealing to errors-in-variables makes the case for rational expectations worse. To support RE on the grounds of risk aversion it is necessary to assume that the risk premium consistently favors one currency.

The difficulty with this argument is that it is not clear why the risk premium should have the observed sign.* The effect of a risk premium is to make the expected return for holding one currency higher than for holding another. Mere uncertainty about the future (and dislike of it by investors) does not establish this result--we need to show why one currency is preferred to the other.

The empirical result we have obtained is that the franc consistently depreciated more than the forward market anticipated it would. (Except in the case of the two interventions, which for the moment we take as

*) And as Frankel (1978) has shown, it is not clear why there should be a risk premium at all. Risk aversion alone is not a sufficient condition to guarantee $f_t \neq E(s_{t+1})$, because in general investors can handle risk aversion through portfolio diversification.

exogenous.) Rational expectations implies that investors did accurately forecast this depreciation, but refrained from bidding up the forward rate accordingly. The implicit risk premium here is in favor of sterling:

$$E(s_{t+1} - f_t) > 0$$

implies a positive return to an investor who held sterling and sold forward francs uncovered, planning to buy the needed francs later. The converse operation, holding francs and selling sterling forward, would have a negative expected return, and presumably would not occur.*

Given that the franc was the unsettled currency in the twenties, and that sterling was in the process of being stabilized at a very high level, this seems counter-intuitive, at the very least. There is no apparent reason why investors should have demanded a premium in order to hold sterling, and accepted a discount in order to hold francs; rather the reverse. Thus we can feel reasonably confident in holding a presumption against risk aversion as an explanation of the observed failure of rationality.

The Peso Problem

Another possible explanation is that there is some finite probability of a drastic event, such as a sudden devaluation or pegging of the exchange rate. In this case, the actual spot rate can be systematically different from its expected value in the previous period even if investors are not risk averse, and if rational expectations holds. (This idea is due to

*) This assumes that interest rates are equal in both countries. In fact the interest differential was negligible, compared with the difference between the forward discount and actual depreciation.

Frankel.) We can write the RE model as

$$(3.11) \quad f_t = E(s_{t+1}) = p \underline{s} + (1-p) s_{t+1}^*$$

There is probability p that in period $t+1$ the exchange rate will be stabilized at \underline{s} . Otherwise its expectation is s_{t+1}^* , the mean of the path taken by a floating exchange rate. It is evident that in general $f_t \neq s_{t+1}$, and if stabilization never occurred, and if each s_t^* comes from a normal distribution, testing RE in the conventional way gives perfectly good estimates of the coefficients in (3.5). We would find

$$c_0 = p\underline{s} / (1-p) \neq 0 \quad b_0 = 1/(1-p) \neq 1$$

which does not in general permit us to reject RE, since the coefficients can in principle have any values.

If stabilization does occur, the residuals are presumably non-normal because of the large errors in one or two periods, and the estimation problems described by Krasker (1977) ensue. Thus it seems appropriate to exclude periods of intervention from the sample. But further complications come readily to mind: \underline{s} and p may not be independent of s_{t+1}^* , or of f_t , or of lagged values of s . This approach can obviously explain any result, given suitable choice of p and \underline{s} . The problem is that it presumes that intervention is more likely to occur in one direction than another; which direction this is, is much easier to determine after the fact.

The implication in our case is that investors were hedging against possible appreciation of the franc (or depreciation of sterling). If so events proved them right on two spectacular occasions. The question then is simply, were they smart or were they lucky? While it is tempting to argue that the investors knew what they were doing all along, a good case can be made that if they were hedging at all it was in the opposite direction.

The franc at this time (1924-26) had depreciated far below its prewar value, and the ability of the government to control the situation was not at all evident to the French public, which had before it the example of the German hyperinflation in 1923. A priori, it would seem reasonable to assume that investors thought it no more likely that the government would intervene to save the franc than that they would completely lose control and allow a hyperinflation.

Some evidence on this point can be gleaned from the monthly data shows in Table 3.1. If in fact investors were hedging against the possibility of intervention in support of the franc, the forward rate ought to have gone to a premium on the franc as soon as the nature of the government operation became evident. In fact, it did not do so. In the 1924 crisis, the franc/sterling price peaked in late March, when the government intervened. As shown in Figure 3.1, the action in March was enough to cause a small appreciation in the franc for the month on average. This should have warned any speculators who really believed in the likelihood of intervention, yet in the next month (April 1924) the franc jumped to its highest discount to date, while the government continued to push the franc in the opposite direction. The same thing happened in 1926. In July the government intervention caught the market by surprise, but the market continued to forecast depreciation while the government pushed the franc up for four months straight. We conclude that the market was not expecting government intervention, and did not believe it could be effective one it occurred.

The remaining argument along these lines is that even after omitting the periods of intervention the residual errors are not normally distributed. The particular problem suggested by Frankel and by Krasker is that there is higher order autocorrelation. This is always a possibility in any equation, but in this case it seems unlikely to have affected the overall result.

Section 4: Market efficiency

If a market is efficient, any predictable profit will be competed away to zero. Thus efficiency in the forward exchange market would imply that the rate of return to forward market speculation

$$(3.12) \quad r_t = s_{t+1} - f_t$$

averages to zero, since otherwise speculators competing with each other, or with new entrants, would offer lower margins and drive down profit rates. By implication, the rate of return r_t must be uncorrelated with its previous values, and with any other explanatory variables that would permit a rational (and presumably risk neutral) investor to predict whether the future spot rate will be greater or less than the current forward rate, and thus to make a profit.

Market efficiency and rational expectations have at least one major result in common, namely that $E(s_{t+1} - f_t) = 0$. But there is a different emphasis: RE is a hypothesis about how expectations are formed, while market efficiency is a hypothesis about how competitors behave. In this section we ask whether the observed failure of RE implies that the forward exchange market was inefficient. In other words, could someone have profited from knowledge of the systematic behavior of the rate of depreciation? This does not necessarily follow; a trend may be statistically significant without being large enough to be worth arbitraging away. Furthermore, it is one thing to perform ex post tests on the whole sample period which prove expectations were not perfectly rational, and quite another to use the same model to forecast future depreciation.

Transactions in the forward market do not yield a rate of return in the conventional sense because there is not necessarily any investment: the operation can be a pure bet. If an investor thinks that $E(s_{t+1} - f_t)$ is positive he will sell francs forward for sterling at a price in sterling of $1/f_t$ per franc. When the contract is due the investor buys spot francs at a price of $1/s_{t+1}$ using the sterling received from the sale. Apart from transactions costs the difference is all profit (or loss). The amount of the gain depends on the size of the forward contract; except for margin requirements there is no investment required.

In order to have a standard measure of profits we express r_t as a percentage of the price of the forward contract:

$$(3.13) \quad r_t = (s_{t+1} - f_t)/f_t$$

This is simply the ratio of the profits made to the size of the bet; it is equivalent to a percentage return on investment if margin requirements are 100%, which gives some basis for comparison. In order to measure profitability over the whole period we assume that an investor makes a bet of constant real size once every month. His average profit rate is then the average of the monthly percentage errors r_t .*

Column 2 of Table 3.2 shows the value of r_t for the franc-sterling exchange rate. This number is the percentage return on an uncovered contract to sell forward francs (betting rule 1), times .01. The mean return is 1.06%/month. The rejection of rational expectations in the previous section implies that these returns are not uncorrelated with variables in time $t-1$, and therefore can in principle be forecast.

*) This assumes a zero discount rate (or that all profits are consumed): a 1% gain in period one is exactly offset by a 1% loss four years later.

Table 3.2: Return to forward speculation in franc/sterling market.
 (%/month x .01)

Rule 1: always bet against franc
 Rule 2: always bet the way that would have
 made a profit last period

<u>year and month</u>	<u>Rule 1</u>	<u>Rule 2</u>
<u>1921</u> March	.02868	-.02868
April	-.01498	-.01498
May	-.12417	.12417
June	-.01284	.01284
July	-.00555	.00555
August	.01333	-.01333
September	.08447	.08447
October	.04518	.04518
November	.03367	.03367
December	-.04088	-.04088
<u>1922</u> January	-.02488	.02488
February	-.03381	.03381
March	-.02820	.02820
April	-.01338	.01338
May	.01710	-.01710
June	.04450	.04450
July	.05830	.05830
August	.04080	.04080
September	.02812	.02812
October	.04062	.04062
November	.08679	.08679
December	-.03021	-.03021
<u>1923</u> January	.09288	-.09288
February	.09421	.09421
March	-.02147	-.02147
April	-.06786	.06786
May	-.00301	.00301
June	.05108	-.05108
July	.06044	.06044
August	.03716	.03716
September	-.03630	-.03630
October	-.02377	.02377
November	.04801	-.04801
December	.03901	.03901

Table 3.2 (continued)

<u>year and month</u>	<u>Rule 1</u>	<u>Rule 2</u>
<u>1924</u> January	.09925	.09925
February	.04463	.04463
March	-.02827	-.02827
April	-.25958	.25958
May	.05777	-.05777
June	.08172	.08172
July	.03164	.03164
August	-.03651	-.03651
September	.01866	-.01866
October	.01926	.01926
November	.01667	.01667
December	-.00756	-.00756
<u>1925</u> January	.01392	-.01392
February	.01591	.01591
March	.01483	.01483
April	.00011	.00011
May	.01212	.01212
June	.07887	.07887
July	.00873	.00873
August	-.00241	-.00241
September	-.01188	.01188
October	.05717	-.05717
November	.11850	.11850
December	.05259	.05259
<u>1926</u> January	-.00795	-.00795
February	.02741	-.02741
March	.02462	.02462
April	.05589	.05589
May	.07656	.07656
June	.05869	.05869
July	.18340	.18340
August	-.16123	-.16123
September	-.03184	.03184
October	-.04957	.04957
November	-.15826	.15826
December	-.13367	.13367

Perhaps the simplest way to do this is to use the previous value of the return. We test for first order autocorrelation in the r_t and obtain:

Return to forward speculation, 1921-26

$$r_t = .00804 + .222 r_{t-1}$$

$$(.00811) \quad (.121)$$

$$R^2 = .047 \quad D.W. = 1.901 \quad n = 70$$

This equation indicates that there is significant autocorrelation, but we note from the R^2 that the equation actually explains very little of the variation in r_t . However, in order to make a profitable bet in the forward market it is not necessary to predict the actual value of r_t , only its sign. The positive correlation between r_t and r_{t-1} suggests a simple betting rule: always assume that the return ($s_{t+1} - f_t$) will have the same sign next month that it did this month, and bet accordingly. Column 3 of Table 3.2 shows the monthly percentage returns that would result from following this procedure ("Rule 2").

The average return is much higher, 2.65%/month, than that to straight speculation, although it is hard to attach any particular meaning to this number. We note that the difference is largely because the hypothetical bettor receives warning of the intervention in April 1924, and thus is able to bet the right way in that month; this should perhaps be regarded as a fluke.

Finally, we need to ask whether it is reasonable to assume that an investor would have perceived that either of these betting rules would be profitable. Consider an investor who sat out the first three years, and then tried to formulate a rule based on that experience. He would find evidence of autocorrelation:

Return to forward speculation against franc, 1921-23

$$r_t = .0106 + .287 r_{t-1}$$

(.0083) (.164)

$$R^2 = .0878 \quad D.W. = 1.788 \quad n = 34$$

The coefficient on r_{t-1} is significant (barely), so the logical implication is that Rule 2 would be profitable.

An even simpler approach would have been to compute the average return over 1921-23 to straight speculation against the franc (1.36%/month) or to the second rule suggested (1.87%/month). If any of this had convinced an investor to try his luck he would have earned, over the period 1924-26, .78%/month by betting always against the franc, and 3.38%/month by following Rule 2.

It is not immediately clear how to interpret these findings, or whether an average return to a bet of one or even three percent should reasonably have been competed away. Any systematic relation is potentially profitable and any investor with enough nerve and a good statistics book could, ex post, have made a lot of money. The difficulty is knowing whether a trend, once observed, will continue in the future. It does not seem implausible that investors, confronted with the probability, as they saw it, of any number of drastic events, declined the challenge. The observed failure of RE does not necessarily imply a failure of competition--the large potential profits may simply confirm that investors were not in fact able to predict the future efficiently, or rationally.

Section 4: Interest rate arbitrage

The results of the previous sections lead us to question the model of the forward market in which the forward exchange rate is determined by speculators who bring it into line with their expectations about the future, whether or not those expectations are unbiased predictors of the future. We note that the forward discount alone has almost no power to explain the actual change in the exchange rate. What little it does explain it does so with a systematic bias which refutes rational expectations and which ought to have been arbitrated away by any reasonably aggressive speculators who were dealing in the forward market.

One possible explanation is simply that there were no such speculators, because the risk and uncertainty were simply too high to permit making any predictions about the future. In this case the forward exchange rate would presumably be determined by the interest rate arbitrage condition

$$(3.14) \quad (f_t/s_t) + r_t^* = r_t$$

The left-hand-side is the covered return to holding foreign exchange, measured in domestic currency; arbitrage will set this equal to the return on domestic assets. Any systematic relation between the actual rate of depreciation and the forward discount would then be due to correlation between the former and the interest rate differential.

Figure 3.3 shows the forward discount (f_t/s_t) and the interest rate differential $(r_t - r_t^*)$ for the franc/sterling exchange rate in the 1920's. Table 3.3 gives the numbers for the same series; the interest rates and forward discount are all on a monthly basis. The difference between the two (column 4) is the monthly rate of return on interest rate arbitrage.

If arbitrage is occurring this return should not exceed transactions and information costs.

The interest rates used require a little explanation. For the U.K. we use the three month prime commercial paper rate, published by the London and Cambridge Economic Service. There was no organized money market in France at this time; however, there was a call money market associated with the stock market, for which interest rates are published by the Statistique Générale de France (SGF 1932). We use the average of the mid-month and end of month figures.

For the first half of the period, through December 1923, the forward discount is, with one exception, smaller in magnitude than the interest differential, and the difference between the two is always less than 1/4%/month. (We neglect the first period as influenced by start-up problems in the forward market.) The mean absolute difference (return to arbitrage) is .077%, which compares favorably with the results for the dollar/franc market in the 1970's, where the same figure is .193%/month (see section 5). We conclude that at least for 1921-23 the evidence is consistent with a model in which the forward discount is determined by the interest differential.

From 1924 on the picture is very different. The forward discount is always larger in magnitude than the interest differential, and the mean absolute arbitrageable difference is .60%/month. It is not entirely clear that this is the true measure of a foregone profit opportunity; the reported interest rates may not have been market clearing rates. (Einzig, in his chapter on the forward franc, reports that during the 1924 crisis Swiss

Figure 3.3: Covered interest arbitrage, franc/sterling market, 1921-26

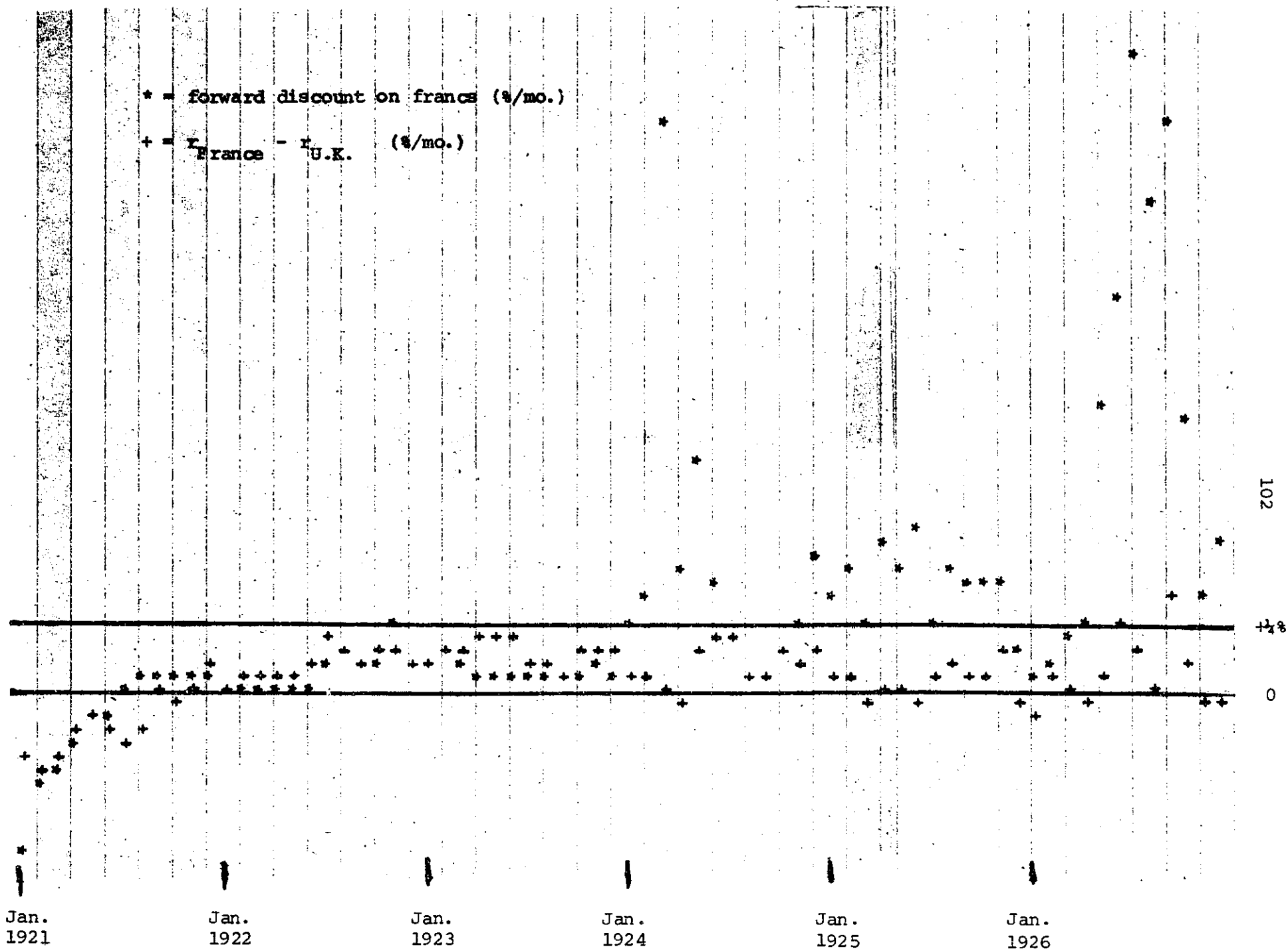


Table 3.3: Covered interest arbitrage, franc/sterling, 1921-26
(percent per month x .01)

<u>year and month</u>	<u>forward discount</u>	<u>interest differential</u>	<u>return to arbitrage</u>
<u>1921</u> January	-.00671	-.00308	-.00363
February	-.00389	-.00357	-.00031
March	-.00361	-.00303	-.00059
April	-.00221	-.00145	-.00075
May	-.00126	-.00128	.00001
June	-.00128	-.00195	.00067
July	0.00000	-.00216	.00216
August	.00064	-.00146	.00210
September	.00039	.00003	.00036
October	.00056	-.00083	.00139
November	.00054	-.00024	.00078
December	.00038	.00094	-.00056
<u>1922</u> January	-.00019	.00002	-.00022
February	0.00000	.00023	-.00023
March	0.00000	.00065	-.00065
April	0.00000	.00043	-.00043
May	.00021	.00073	-.00053
June	.00020	.00094	-.00074
July	.00130	.00235	-.00105
August	.00160	.00186	-.00026
September	.00086	.00115	-.00028
October	.00100	.00154	-.00055
November	.00259	.00177	.00083
December	.00126	.00128	-.00002
<u>1923</u> January	.00100	.00117	-.00017
February	.00157	.00174	-.00017
March	.00120	.00167	-.00047
April	.00057	.00241	-.00184
May	.00057	.00203	-.00145
June	.00068	.00215	-.00146
July	.00051	.00100	-.00049
August	.00062	.00122	-.00060
September	.00051	.00074	-.00023
October	.00066	.00135	-.00069
November	.00113	.00150	-.00038
December	.00060	.00138	-.00078

Table 3.3 (continued)

<u>year and month</u>	<u>forward discount</u>	<u>interest differential</u>	<u>return to arbitrage</u>
<u>1924</u> January	.00274	.00075	.00199
February	.00387	.00061	.00326
March	.02307	-.00011	.02319
April	.00506	-.00040	.00546
May	.00926	.00156	.00769
June	.00412	.00191	.00221
July	.00211	.00198	.00013
August	.00073	.00051	.00021
September	.00071	.00059	.00012
October	.00140	.00145	-.00005
November	.00275	.00091	.00184
December	.00564	.00157	.00407
<u>1925</u> January	.00372	.00067	.00305
February	.00476	.00076	.00399
March	.00293	-.00042	.00335
April	.00595	.00007	.00588
May	.00500	-.00031	.00531
June	.00647	-.00086	.00733
July	.00290	.00027	.00263
August	.00492	.00087	.00406
September	.00457	.00064	.00393
October	.00458	.00033	.00425
November	.00448	.00133	.00315
December	.00139	-.00038	.00177
<u>1926</u> January	.00062	-.00092	.00155
February	.00113	.00059	.00055
March	.00206	-.00023	.00229
April	.00264	-.00053	.00317
May	.01135	.00055	.01080
June	.01615	.00285	.01330
July	.02598	.00177	.02420
August	.01999	.00012	.01987
September	.02299	.00373	.01927
October	.01099	.00078	.01021
November	.00397	-.00083	.00479
December	.00619	-.00039	.00658

banks were placing newspaper ads offering 2% per month for French franc deposits.) The differentials all favor borrowing francs and selling sterling forward; given the undeveloped character of the French money market at this time it is perhaps not surprising that the posted rates did not reflect the true cost of borrowing francs in a crisis.

However, it is clear that the forward discount is not being set by the interest differential; something is pushing the discount to 1 and 2 percent per month, while interest rates differ by a tenth of that. We can safely conclude that this is due to speculation: in times of crisis investors are willing to bet on the further devaluation of the franc.

Thus we cannot explain the failure of rational and efficient speculation by saying that there never was any speculation, and we must try to draw some conclusions about the way in which investors formed their expectations. First we reestimate the RE test equation (3.10) for the shorter period (1924-26), in order to consider the possibility that our earlier results were somehow affected by the (presumed) fact that speculation did not occur until 1924.*

*) This division into periods is not entirely arbitrary. There was a general shift in the attitude of the French public at this time, from a somewhat remarkable belief that prewar conditions would be restored (with the help of German reparations) to resignation and general loss of confidence in the government. The end of 1923 saw the German hyperinflation and collapse of the mark, and the failure of French reparations policy; 1924 brought the "battle of the franc" and the beginnings of a long series of exchange crises. See Schuker for a discussion.

The results are very similar to those for the full period:

Franc/sterling, 1924-26

$$\ln (s_t/s_{t-1}) = .0484 - 6.474 \ln d_{t-1}$$

(.0229) (2.206)

$$R^2 = .219 \quad \rho = .298 \quad (.161) \quad n = 35$$

Again we have the perverse coefficient on the forward discount, and again the sign is reversed when we exclude periods of intervention:

Franc/sterling, Jan. 1924-July 1926

$$\ln (s_t/s_{t-1}) = -.001 + 8.725 \ln d_{t-1} - .464 \quad (D424)$$

(.011) (2.043) (.051)

$$R^2 = .783 \quad \rho = .0998 \quad (.1817) \quad n = 30$$

Conclusions

Thus we can still reject the hypothesis of rational expectations. From the results in the previous section we have that there were predictable and profitable speculative strategies that could have been followed. Given that speculators were participating in the forward market, why did they fail to take advantage of them?

There are a number of possible explanations, including the risk aversion and hedging models discussed above. We have rejected these, largely on circumstantial evidence, but we cannot rule them out entirely. Investors could have been hedging against intervention in support of the franc (but not against complete collapse), or they could have felt that holding sterling was somehow riskier than holding francs, and thus required a risk premium in favor of sterling.

Another interpretation, which was very popular at the time, is that the large profits to speculation demonstrate that the forward market was

not in fact competitive, and was being manipulated by foreign exchange traders who were looking for new worlds to conquer after cleaning up in the German hyperinflation. The argument runs that pushing the franc to a large forward discount caused an accelerating depreciation in the spot rate and resulted in large profits for those who bet against the franc.

We could also argue that the statistical significance of the results is in question, due to high order autocorrelation or skewness in the residuals. In principle this can be corrected for, if a specific model of the residuals could be deduced from theory.

But the simplest interpretation, preferred on the principle of Occam's razor, is to accept the results at face value: speculators did, after 1923, predict that the franc would depreciate, but simply were wrong about how much. Presumably they saw the previous trend, but simply did not believe it would continue. When intervention occurred and the franc appreciated, they did not believe that would continue, either. The hypothesis that expectations were rational is thus rejected. Speculators who bet against the franc, if any, sometimes made large profits, but regarded these as windfalls, and did not attempt to use them as a basis for forecasting. What remains undetermined in this analysis is the process which actually caused the spot rate to depreciate so fast; we consider this problem in the next chapter.* In the remaining section here we compare the behavior of the franc in the 1920's with its behavior in the 1970's.

*) The fact that actual depreciation systematically exceeded expected depreciation is virtually a prima facie case for destabilizing speculation, as the concept is usually defined. We have not, however, established any causality between the two variables.

Section 5: The franc-dollar market in the 1970's

In this section we apply the analysis of rational expectations developed above to the dollar/French franc exchange rate when it floated in the 1970's. The circumstances are not identical--in particular the present float is not nearly as free of intervention on a continuing basis as was the case in the twenties. Yet the results are very similar. This reduces the likelihood that the earlier results should be attributed to problems with the data, or to the imperfect functioning of a "pre-modern" market.

The foreign exchange data used are monthly averages of weekly quotations for the spot and one month forward dollar/franc rates taken from the Harris Bank Weekly Review. The interest rates are the Federal Funds rate for the U.S. and the "day to day money" rate for France, taken from various issues of the Federal Reserve Bulletin and converted to a monthly basis. The period used is January 1973-November 1977.

Figure 3.4 shows the monthly percentage change in the spot price of francs compared with the percentage forward discount on the dollar. Again we see that the actual change is much larger than the predicted, and there is no obvious correlation between the two. The effect is very close to that in Figure 3.2, for the twenties. The forward rate is still a very poor predictor, whether or not it is unbiased.

We test the RE hypothesis first by estimating equation (3.10) with b constrained to be 1.0:

Figure 3.4: Actual and predicted depreciation, dollar/franc rate, 1973-77, monthly.

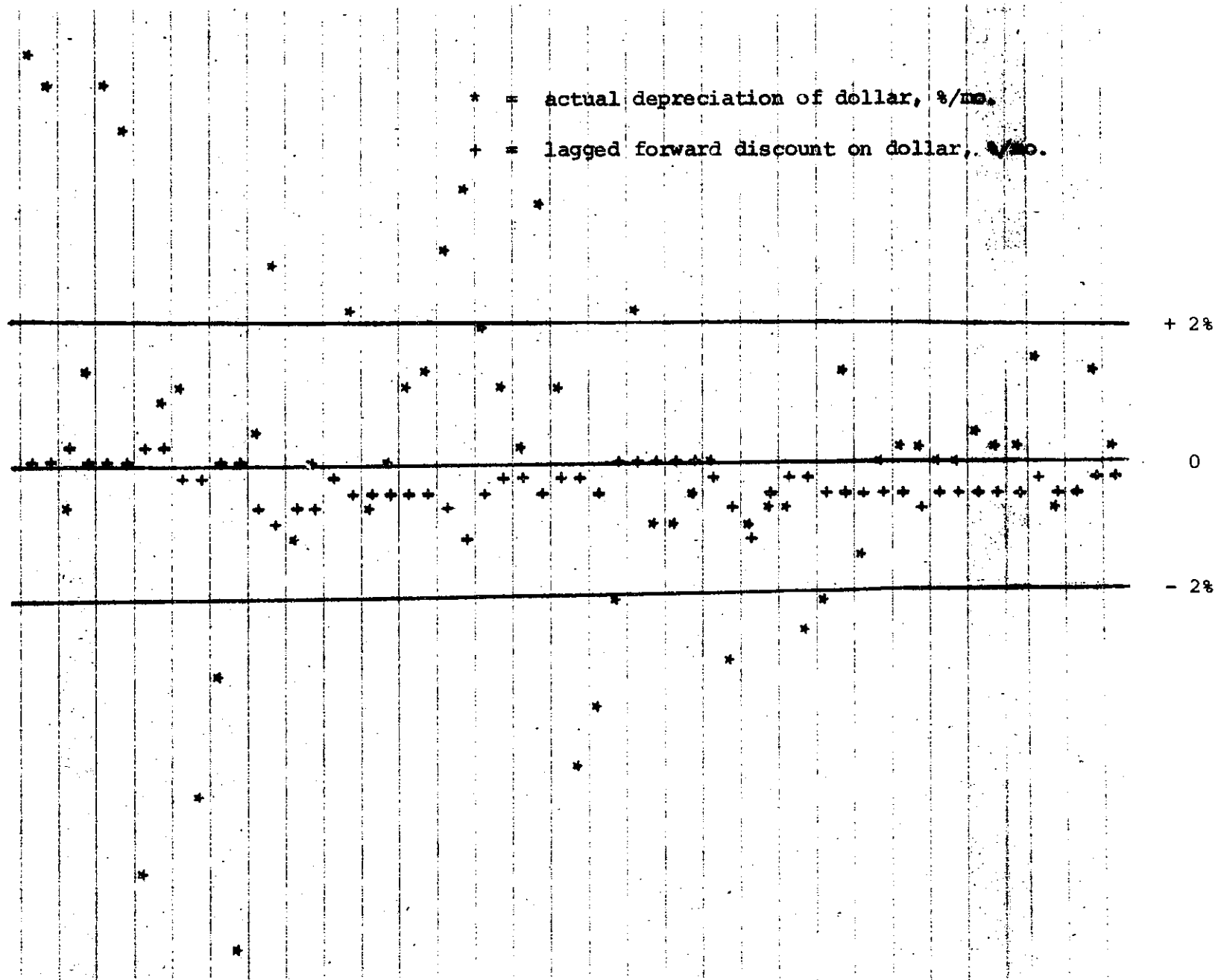
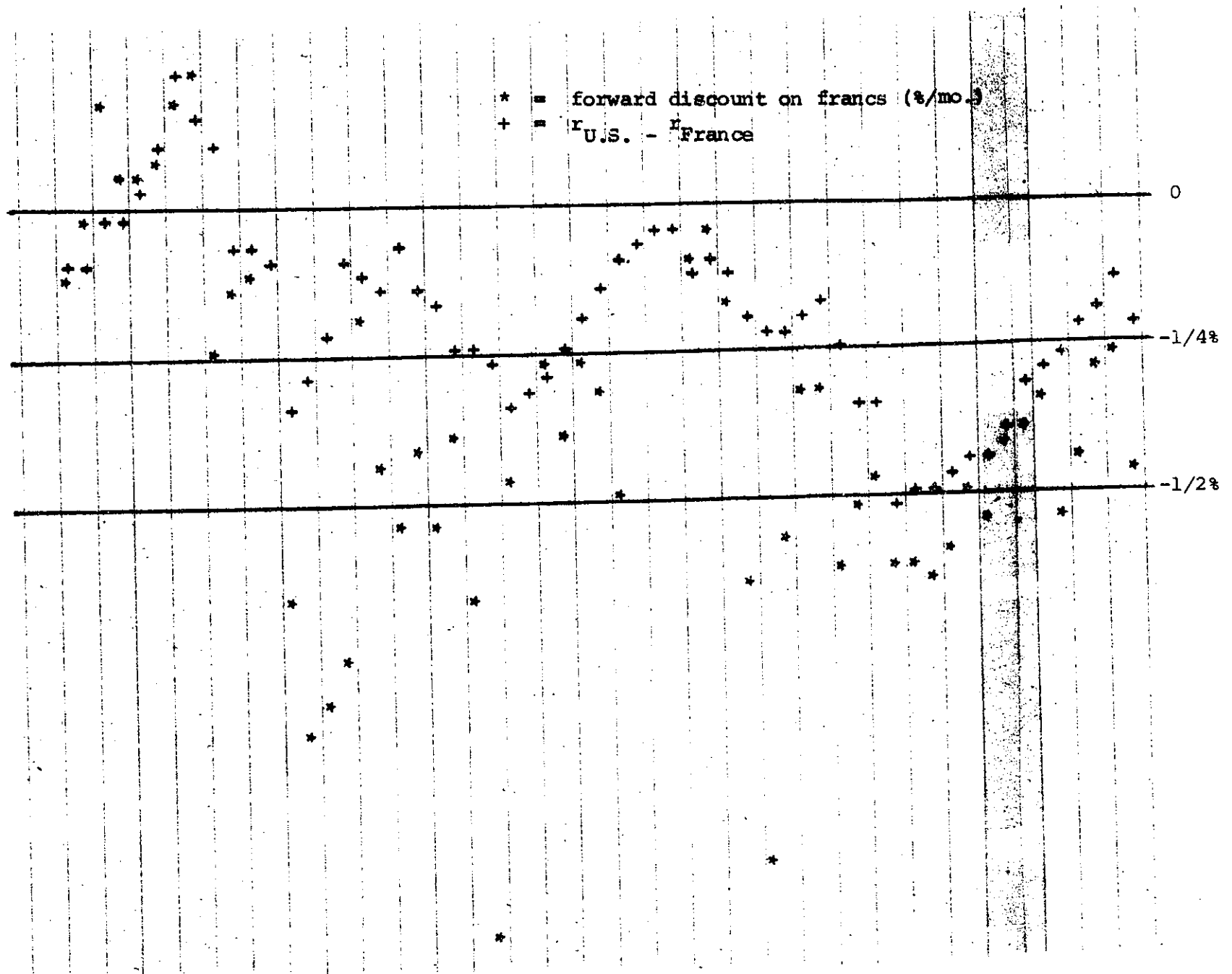


Figure 3.5: Covered interest arbitrage, dollar/franc market, 1973-77



dollar/franc, 1973-77, monthly

$$\ln s_t - \ln f_{t-1} = .003091 \\ (.004681)$$

$$R^2 = .0780 \quad \rho = .268 (.128) \quad SSR = .03748 \quad n = 57$$

The constant term is not significantly positive, but the estimate of rho is: thus expectations are unbiased but the prediction error is not uncorrelated with previous information. Estimating the equation unconstrained we get

dollar/franc, 1973-77

$$\ln (s_t/s_{t-1}) = -.00689 - 1.664 \ln d_{t-1} \\ (.00706) \quad (1.392)$$

$$R^2 = .1046 \quad \rho = .303 (.126) \quad SSR = .03518 \quad n = 57$$

The coefficient on d_{t-1} , the lagged forward discount on the dollar, is perverse in sign and is significantly less than one at the 95% level ($t = 1.91$). Rho is also significant, and as before we can reject rational expectations because the forward discount is a biased predictor of actual depreciation. (However, without further investigation we cannot properly rule out problems such as those raised in section 3 above.)

Figure 3.5 shows the forward discount plotted with the interest rate differential. They tend to move together, more so than in the earlier period, but there are still occasions on which the forward discount jumps sharply away from the interest differential, presumably as the result of speculative pressure. The monthly returns to arbitrage are typically less than .15%/month, but are frequently above .25% and occasionally above .5%. The mean absolute return is .193%. The markets are doubtless better integrated in France now than in the twenties, but this clearly does not eliminate all swings in the forward rate away from interest parity.

This picture of the current situation seems to follow our analysis of the situation in the twenties fairly well. The forward discount is a poor predictor of actual depreciation, and by and large seems to have been set by the interest differential. From time to time speculators have an idea and push the forward rate in one direction or another; when they do so they are wrong enough of the time that overall one can detect a systematic bias. As in the case of the twenties, it seems probable that speculators accept these gains and losses largely as random, and do not attempt to make forecasts on the basis of historical deviations from rationality.

Chapter FourThe Money Supply and the Exchange Rate

In this chapter we develop an equation explaining the spot exchange rate as a function of foreign and domestic money supplies, real income levels, and the forward premium on foreign exchange. We show that such an equation can be derived from either of two models which have very different mechanisms bringing about equilibrium in the exchange market. These are the "monetarist" and "Mundell-Fleming" models, discussed above. The differences between them have implications for the parameters of the exchange rate equation, so that a test of the two theories is possible.

Because the domestic demand for real money balances plays an important role in both models, we estimate money demand equations for France and the U.S. Then the spot rate equation is estimated, and the results used to evaluate the two theories, given our other empirical results. It is shown that while some tests on the reduced form equation support the monetarist model, there are empirical inconsistencies between this equation and the others which lead us to reject it. Other interpretations of the evidence are discussed.

Later, we incorporate into the spot rate equation the dynamic behavior of the French money supply and the forward exchange premium, in order to model the stability of the system with respect to action by the government and by foreign exchange traders. We use these results to evaluate various historical interpretations of the behavior of the franc.

Section 1: A model of the spot rate

Our starting point is the monetarist model presented in chapter 1 above, which is easily solved for an equation of the desired form. The model centers on the foreign and domestic demand for money and the purchasing power parity hypothesis:

$$(4.1) \quad \ln M = \ln P + b_1 \ln y - b_2 r$$

$$(4.2) \quad \ln M^* = \ln P^* + b_1^* \ln y^* - b_2^* r^*$$

$$(4.3) \quad \ln P = \ln s + \ln P^*$$

where M is the money supply, P the price level, s the spot price of foreign exchange, and r the log of one plus the interest rate. An asterisk denotes foreign variables. Substituting in (4.3) we obtain an equation for the spot rate:

$$(4.4) \quad \begin{aligned} \ln s &= \ln P - \ln P^* \\ &= \ln M - \ln M^* - b_1 \ln y + b_1^* \ln y^* + b_2 r - b_2^* r^* \end{aligned}$$

If we assume the interest parity condition holds:

$$(4.5) \quad r - r^* = \ln f - \ln s$$

where f is the forward price of foreign exchange, then provided that $b_2 = b_2^*$ we can substitute the forward discount for the interest rate term in (4.4).

This model is attractive for our purposes since it allows us to focus on the behavior of the money supply and the forward discount, which have been described as being influenced by the lagged spot rate or by deliberate manipulation. But before proceeding we must take note of various theoretical difficulties with the model, which affect the specification and estimation of (4.4).

PPP failure

One of the obvious weak points in the monetarist model is the PPP assumption.* The appropriate price index used in the money demand equation is broadly based; in order to obtain equation (4.4) we must assume that PPP holds for consumer prices from month to month, which is certainly a strong version of that hypothesis. If we adopt the more limited proposition that PPP holds for traded goods prices only:

$$(4.6) \quad \ln P_T = \ln s + \ln P_T^*$$

we can use the result from chapter 2 (equation 2.15) that

$$(4.7) \quad \ln s = \frac{1}{\alpha + \beta - \alpha\beta} (\ln P - \ln P^*)$$

where α is the weight of traded goods prices in the overall price index and β is the elasticity of nontraded goods prices with respect to traded goods prices (or more loosely, the correlation between the two). Again substituting for P and P^* we obtain a modified equation,

$$(4.8) \quad \ln s = \frac{1}{\alpha + \beta - \alpha\beta} (\ln M - \ln M^* - b_1 \ln y + b_1^* \ln y^* + b_2 r - b_2^* r^*)$$

If either $\alpha = 1$ (all goods are traded) or $\beta = 1$ (perfect correlation between prices of traded and nontraded goods), PPP holds and the coefficients on money in the spot rate equation will be one. But this will not in general be the case.

Since it is difficult to imagine that PPP necessarily holds for nontraded goods (i.e., that 4.3 is a structural equation) or alternatively that all goods are traded, the best case for the monetarist result seems to be that $\beta = 1$. This is consistent with the view that disturbances

*) Dornbusch has pursued this objection in several papers (1976, 1978).

to the system are largely monetary: if these result immediately in domestic price inflation we might well observe traded and nontraded goods prices rising together.

In fact, the results in chapter 2 suggest that this is not the case; estimates of equation (4.7) yield coefficients significantly different from one. However, this does not necessarily refute the basic monetarist approach - so long as there is some systematic link between prices and the exchange rate we can construct a model explaining changes in the spot rate as a function of changes in the money supply via the demand for real balances.

Interest rate arbitrage

The specification of the interest rate term in (4.4) is not a clear cut matter. As noted in chapter 1, Frankel (1978) suggests including both short and long term interest rate differentials. The short rates should capture the Mundell-Fleming capital flow effect,^{*} while the long rates reflect expected inflation and thus their signs should be consistent with the monetarist model.

The substitution of the forward discount for the interest rate differential extends the scope of the model by including expectations about the future as a determinant of the spot rate. (See, for example, Bilson, 1978). However, within the context of the monetarist model this substitution can only be made by assumption of interest rate parity. This requires first of all that the interest rates used in the money demand equation be appropriate for interest arbitrage, and further that the interest parity condition

^{*}) See below.

actually be met. As the results of chapter 3 show, this is not always the case, particularly in times of very rapid depreciation.

If we adopt Frankel's procedure and include two interest differentials we can presume that the short rates are suitable for interest arbitrage. This leads to an intriguing result: since the coefficient on the short rate differential, $r-r^*$, is presumed negative in the M-F model, an increase in the forward premium on FX, $\ln f - \ln s$, is associated with an appreciated spot exchange rates.

Finally, it is not necessarily true that the forward exchange rate accurately reflects expectations about the future, as we have discussed in chapter 3. And if the forward discount does in fact measure expected depreciation it may deserve to be included in the spot rate equation as a direct measure of demand for foreign exchange, apart from interest arbitrage.

Real sector equilibrium

The Mundell-Fleming (M-F) model reaches a result similar to that of the monetarist model, but by a different route.* We add an equation for the goods market, but do not assume PPP. For an open economy the equilibrium condition for the real sector is given by

$$(4.9) \quad y = E(y,r) + T(sP^*/P, y)$$

where y is the level of real income, E is domestic expenditure, and T is the trade balance. E is assumed to increase with y and fall with r , while T increases with the terms of trade sP^*/P but falls with income as import demand increases. We can write this in log-linear form as

*) For another discussion of the M-F approach, see Dornbusch (1978).

$$(4.10) \quad \ln y = c_0 + c_1 \ln y - c_2 r + c_3 (\ln s + \ln P^* - \ln P) - c_4 \ln y$$

Solving this for s we obtain

$$(4.11) \quad \ln s = \ln P - \ln P^* + \frac{(1 - c_1 + c_4)}{c_3} \ln y + \frac{c_2}{c_3} r$$

Substituting the money demand equation for P as before, we obtain

$$(4.12) \quad \ln s = \ln M + \left(\frac{1 - c_1 + c_4}{c_3} - b_1 \right) \ln y + (c_2/c_3 + b_2) r - \ln P^*$$

This equation is similar in form to (4.4), but we note that the coefficient on y is no longer unambiguously negative, and the coefficient on r is larger. Since the M-F model is generally applied to the small country case, we assume that P^* is set at the world level, and do not substitute for P^* . For the same reason, y^* is not included as an argument in the trade surplus function.

A major difference between the two approaches is in the response of the spot rate to an (exogenous) change in income. In the monetarist model, an increase in domestic real income simply creates excess money demand, requiring lower domestic prices to maintain equilibrium, and hence by PPP, an appreciated exchange rate. This effect does occur in the M-F model, but in addition the increase in income creates an excess aggregate supply, requiring an increased trade surplus and hence a depreciated exchange rate. Prices eventually adjust downwards to restore monetary equilibrium, but not enough to offset the exchange depreciation, since the terms of trade must change permanently.

In the monetarist model a change in the money supply quickly results in a corresponding change in prices, so real money balances are unchanged. In the M-F model prices are sticky, so that a change in the money stock initially raises or lowers the interest rate. By assumption of perfect

capital mobility, this interest rate change results in a net capital flow which affects the exchange rate, and hence the trade surplus and real income. We note from (4.4) and (4.12) that in both models the coefficient on the money supply is 1.0; the difference is that in the M-F model the money supply does not normally change ceteris paribus, but instead also affects income.

A similar analysis applies to PPP in the M-F model. Ceteris paribus, a rise in the domestic price level must be offset by a proportional exchange depreciation, to keep the terms of trade constant and preserve goods market equilibrium. But in general prices do not change independently of income, so that the terms of trade must also change, and we do not actually observe PPP holding. It may still be true that prices of traded goods are always equal; if so, terms of trade changes occur via changes in the relative price of nontraded goods.

In both models the equilibrium impact of a change in the interest rate is the same: a higher rate requires an exchange depreciation. This is because a higher interest rate creates an excess supply of money, raising domestic prices and hence the price of foreign exchange, and also because a higher interest rate creates excess aggregate supply, requiring depreciation to encourage exports.

The difference is that in the M-F model the interest rate is assumed to be held at the world level by perfect capital mobility. Thus truly exogenous changes in the domestic interest rate are due to short run changes in the real domestic money supply, and reflect a transient disequilibrium in the capital market. The capital outflow associated with, say, a drop in the domestic interest rate should cause exchange

depreciation, so that with short run data we should observe a negative coefficient on r in equation (4.12).

The difference between the monetarist and M-F approaches is not a theoretical controversy but a disagreement over the empirical importance of various effects. The issue is whether on a month to month basis prices adjust quickly enough to justify concentrating attention on monetary variables, or whether they are sticky enough to permit observation of disequilibrium adjustment via international capital markets.

Formally, the extreme monetarist position must make one of the following implicit assumptions. The terms of trade SP^*/P must be held always constant by PPP, or real income must be constant, or the trade surplus must be insensitive to the terms of trade, in order for the exchange rate to be independent of the real sector equilibrium condition. On the other hand, the Keynesian position is that PPP does not always hold, and that real money balances are not constant. Again, the point is not whether any of these assumptions is literally true, but whether they can be shown to be appropriate with available statistics for a given period under study. In what follows we address this problem for the French case.

Simultaneity and causality

Equation (4.4) can only be regarded as a true reduced form, that is, a function only of exogenous variables, if specific assumptions about the adjustment mechanism are made. In the monetarist model, the exchange rate is affected only by changes in prices resulting from excess demand for or supply of money. Further, prices instantly adjust to maintain money market equilibrium, so that a change in nominal M does not affect y or r . Thus income, money, and interest rates can all be regarded as exogenous (and independent), and equation (4.4) can be estimated using ordinary least squares, if any serial correlation is corrected for.

On the other hand, in the M-F model income, the exchange rate, and prices are all determined simultaneously: a change in M affects s , and thus y , with a further impact on s . In a pure form of the model interest rates are either constant or uninfluenced by the exchange rate, but this seems unlikely to be true in real life. Inspection of the interest parity condition (4.5) reveals that changes in s , f , and the interest rates are closely related, and unless the causality is all in one direction simultaneity results. Finally, the money supply itself may be endogenous, although we may hope that it responds to the exchange rate with a lag, if at all, and thus is predetermined in this model. For these reasons it is appropriate to estimate (4.4) with some correction for simultaneous equation bias.

Section 2: Money demand in France and the U.S.

In this section we estimate money demand equations for France and the U.S. in order to elaborate the mechanism by which money affects the exchange rate in the model just presented. The estimated coefficients provide a basis for checking the estimated reduced form model for consistency with the monetarist interpretation, and they also give some understanding of the relationship between money and prices in the French economy. This is important because the exchange rate model is being applied to monthly data, and we might expect disequilibrium adjustment phenomena to be noticeable. We should not take it for granted that money demand is, for example, homogeneous with respect to prices from month to month.

Data and sources

The French data used are from Rogers and Sauvy. As described in chapter 1, no official data on French demand deposits are available for this period. Rogers (p.77) has assembled a series of sight liabilities for the four large Paris clearing banks for the period 1919-1927. These sight liabilities correspond roughly to demand deposits as presently defined (p. 301). He discusses the problem of inflating the series to reflect liabilities of all banks (p. 284 ff.) and concludes that simply multiplying by a factor of two is the best that can be done. We adopt this procedure. The currency series is from Sauvy (p. 525), corrected for official misreporting using the figures in Moreau (p. 6). This correction removes the discontinuity in the official series in April 1925.

The U.S. money supply series used is from Friedman and Schwartz, currency held by the public plus demand deposits adjusted (p. 16 ff.). Consumer price indexes are used as the price variable for each country; Sauvy's index (p. 501) for France and the NICB index for the U.S. (SCB, June 1926 et seq.). We use both short and long term interest rates in the estimation, the monthly average call money rate (SGF 1932, "reports sur titres, parquet") and long term government bond rate (ibid., "taux de la rente 3%") for France and the three-month prime commercial paper rate ("N.Y. market" in SCB, June 1924 et seq.) and U.S. Liberty bond yields (SCB, June 1928).

No monthly national income series is available for either country; as proxies we use industrial production indexes (Sauvy, p. 464 for France and SCB for the U.S.). The U.S. data are all for 1920-26. The French data cover 1919-27, while most of our exchange rate analysis has been for 1920-26. But because of the unexpected result obtained for the French money demand equations, they were run for the full period for which data are available, improving the performance somewhat.

It would have been desirable to estimate a money demand equation for the U.K. as well, but there is no monthly production index available to use as an income proxy. Further there is no monthly demand deposit data before 1921. This is the more unfortunate because no forward exchange rate data is available for the franc-dollar market, so that if we wish to extend the spot rate analysis to include the forward discount we must accept a less satisfactory data base.*

*) Frenkel and Clements attempt to get over the first difficulty by interpolating a monthly production series from a quarterly production index and monthly unemployment rates. In an earlier article (1976) Frenkel uses a franc/dollar forward rate computed from franc/sterling and dollar/sterling rates assuming triangular arbitrage prevails.

For 1921-26 we use the Bank of England note circulation, demand deposits for 9 London clearing banks, Ministry of Labor retail prices, and the three month money rate, all from LCES, various issues. There are a few problems with the coverage of the money supply variables, which probably put them closer to the French than to the U.S. data in quality.

Estimation

The conventional demand for money equation (4.1) has a presumptively exogenous variable, M , on the left hand side and endogenous variables on the right. Thus the errors in the equation are correlated with P , and perhaps y and r .^{*} In order to estimate the equation as it stands we must correct for simultaneous equation bias; alternatively we can rearrange the equation to obtain

$$(4.13) \quad \ln P_t = -b_0 + M_t - b_1 y_t + b_2 r_t + u_t$$

where we add the time subscripts and the error term u_t . If the right hand side variables are truly exogenous, this can be estimated using OLS. In the French case r is surely not exogenous; since there was no interest rate policy on the part of the monetary authorities, a priori there is no reason to expect a change in M to affect only prices.

Income may also respond to changes in M or P (perhaps via the trade account), although we might not expect this to be of great importance with monthly data. Finally, as discussed in chapter 1, it has been argued that the French money supply was endogenous, as depreciation and

*) An exogenous change in the nominal money supply results in a corresponding adjustment in prices (or interest rates or, less likely, income). Thus the true structural equation is (2.1), with prices the dependent variable, and P is obviously correlated with u_t .

inflation forced the government, in effect, to print more money. If consumer prices did contribute to this effect, presumably they did so with some lag, so that we can take M to be exogenous. In this chapter we present results using both OLS with the Cochrane-Orcutt correction for autocorrelation ("CORC") and an instrumental variables technique, assuming that y and r are endogenous but that M is not. We use as instruments the constant term, a time trend, and the money supply, plus the lagged values of all variables in the equation. These estimates are labelled "TSCORC".

Given that we are using consumer prices, and monthly data, and given that our earlier PPP results (see chapter 2) suggested the existence of price rigidity, we might not expect to find complete price adjustment within one time period. In particular, a change in the nominal money supply might not bring about corresponding price changes for several months. In the meantime, either interest rates would adjust to maintain equilibrium in money demand, or else the market would simply remain out of equilibrium. We can rewrite (4.13) as

$$(4.14) \quad \ln P_t = -b_0 + \sum_{i=0}^n \lambda_i M_{t-i} - b_1 y_t + b_2 r_t + u_t$$

where the weights λ_i sum to one so that in the long run prices are homogeneous with respect to money.

In principle these lagged coefficients can be estimated directly using OLS. However, it is usually the case that even if there are enough degrees of freedom in the equation to permit this, the multicollinearity in the lagged variables is so high that significant estimates of individual coefficients cannot be obtained. Therefore it is customary to impose some distribution on the lagged coefficients and estimate them subject

to this constraint. In this section we use the Almon polynomial distributed lag method to estimate (4.14), with a Cochrane-Orcutt correction for autocorrelation ("PDLCORC"). Since we are chiefly concerned with the lag structure of M , we assume that the problem of simultaneity can be safely neglected, and thus we do not combine the PDL method with an instrumental variables technique.

Empirical results--France

Figure 4.1 shows the log of the monthly French CPI and money supply for 1919-27. Both variables are measured in index form with 1913-14 as a base year, so that when the points on the graph coincide both have changed in proportion since before the war. We see that after 1921 prices and money move broadly together, although prices grow, on average, at a slightly faster rate. In 1920-21, however, there is a large cycle in prices while money is comparatively stable. This rise and fall of prices roughly coincides with the world-wide business cycle that occurred at the time. It is evident that, during this period at least, substantial price changes occurred more or less independently of changes in the money supply.

Estimating equation (4.13) for France using OLS (with Cochrane-Orcutt) we obtain:

France, 1919-27

$$\text{CORC:} \quad \ln P_t = 2.810 + .426 \ln M_t + .144 \ln y_t + .267 r_t$$

$$\quad \quad \quad (.905) \quad (.127) \quad \quad (.074) \quad \quad (1.15)$$

$$R^2 = .990 \quad \rho = .976 \quad (.021) \quad n = 106$$

The numbers in parentheses are standard errors. In this equation we use the long term government bond rate for r_t ; overall this gave slightly more plausible results than the call money rate, although neither has any

Figure 4.1: French money supply and consumer prices, 1919-27, monthly.

1913/14 = 100 (log scale)

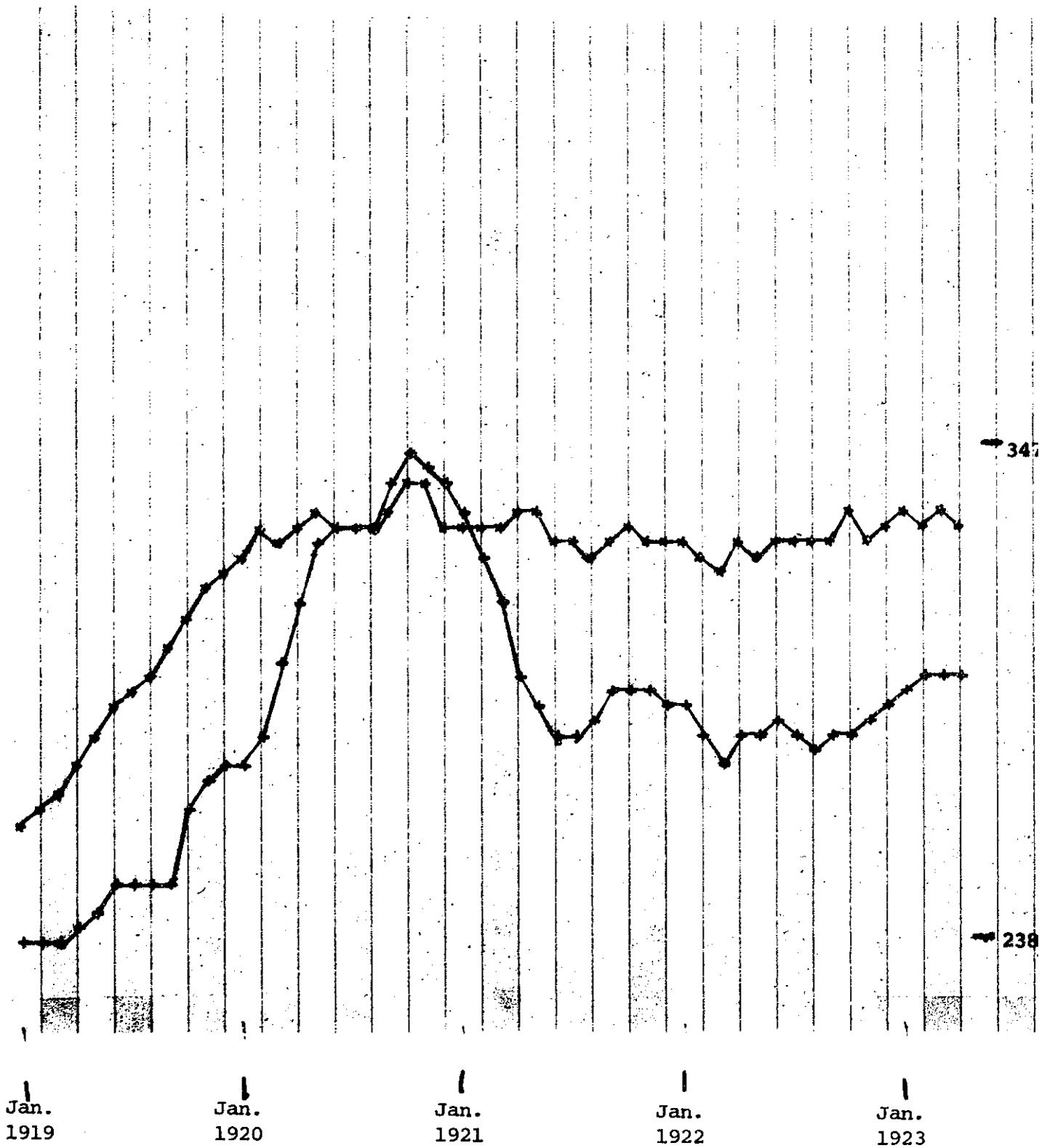
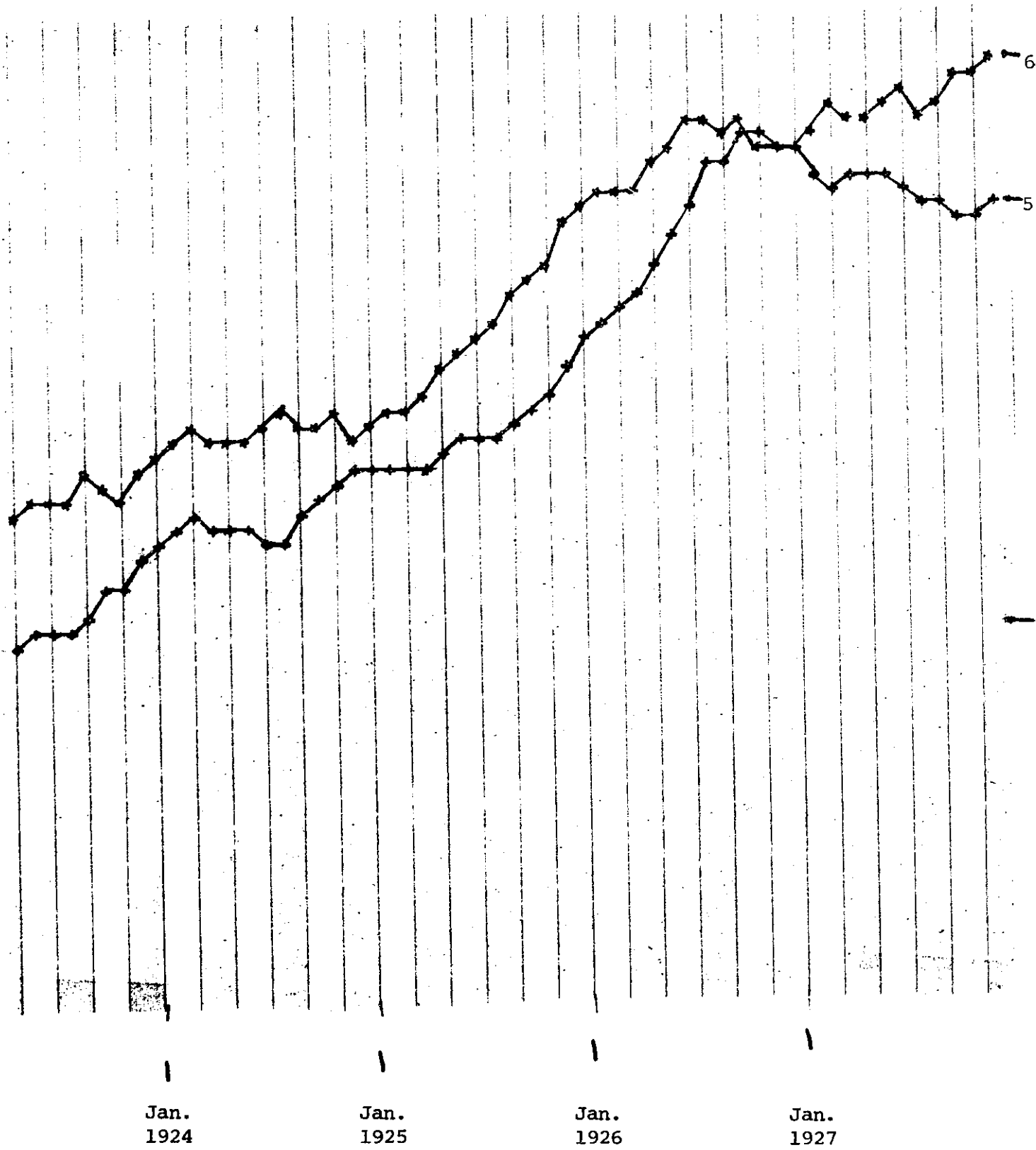


Figure 4.1, continued



great significance in the equation.

We observe that the coefficient on M has the expected sign but is significantly less than one, which is consistent with the existence of sticky prices. The coefficient on income is significantly perverse: an increase in income, which raises the demand for real balances, results in a higher price level and hence in a lower real money supply. The coefficient on r has the expected sign, but is not significantly different from zero. If we estimate the same equation using two stage least squares, we obtain

France, 1919-27

$$\text{TSCORC: } \ln P_t = 2.788 + .219 \ln M_t + .616 \ln y_t - 16.7 r_t$$

(2.175) (.279) (.276) (12.1) t

$$R^2 = .967 \quad \text{rho} = .948 \text{ (.031)} \quad n = 106$$

This is not a material improvement. The coefficient on M becomes insignificant, and the interest rate now has a perverse, but insignificant, effect. Income has a stronger effect on the price level, again in a way inconsistent with the money demand equation.

To try to account for price rigidity we estimate a distributed lag on the money supply (equation 4.14). The equation is estimated for 1920-27, with the lag on M extending back into 1919.

France, 1920-27

$$\text{PDLCORC: } P_t = -4.845 + .0993 y_t + .277 r_t + .178 M_t + .193 M_{t-1}$$

(1.667) (.0669) (.985) t (.105) t (.066) t-1

$$+ .201 M_{t-2} + .205 M_{t-3} + .202 M_{t-4} + .194 M_{t-5}$$

(.503) t-2 (.057) t-3 (.059) t-4 (.055) t-5

$$+ .181 M_{t-6} + .162 M_{t-7} + .137 M_{t-8}$$

(.049) t-6 (.063) t-7 (.106) t-8

$$R^2 = .991 \quad \text{rho} = .989 \text{ (.015)} \quad n = 95 \quad \text{SSR} = .03870$$

sum of lagged coefficients = 1.652 (.251)

mean lag = 3.81 (.81) months

The variables are measured in logs; the lag structure was approximated by a second degree polynomial. (Changes in the length of the lag or the degree of the polynomial had only minor effects on the sum of the lagged coefficients.)

All of the lagged coefficients on M are significantly positive except the last; the effect of M on the current price level extends over three quarters. With this specification the money supply dominates the equation--the coefficients on y and r are no longer significantly different from zero. The impact of the money supply rises considerably--the sum of the lagged coefficients is now significantly greater than one, so that an increase in the money supply is more than compensated for in the long run by price adjustment.

This last phenomenon seems likely to be due to the influence of the 1920-21 price cycle referred to above, during which prices clearly outstripped changes in the money supply in both directions. To test this possibility we estimate the same equation for two separate periods: 1920-23 and 1924-27.* The estimated lag structures are similar to the one shown for the full period; for the sake of clarity we present only the summed coefficients (long run impact) for M in the short period equations. We obtain

*) The choice of the dividing line between periods is largely arbitrary; presumably any structural change occurred gradually, so that no precise boundary exists. We end the first period in Dec. 1923 largely as a matter of convenience.

France, 1920-23

$$\text{PDLCORC: } \ln P_t = -20.19 + 4.283 \ln \bar{M} + .133 \ln y_t - 1.24 r_t$$

(3.84) (.636) (.078) (3.41)

$$R^2 = .955 \quad \rho = .902 \quad n = 47 \quad \text{SSR} = .02046$$

(.063)

$$\text{mean lag} = 3.64 \text{ (.75) months}$$

France, 1924-27

$$\text{PDLCORC: } \ln P_t = -.794 + .988 \ln \bar{M} + .160 \ln y_t + .281 r_t$$

(1.20) (.190) (.097) (.752)

$$R^2 = .993 \quad \rho = .944 \quad n = 48 \quad \text{SSR} = .00878$$

(.048)

$$\text{mean lag} = 3.28 \text{ (1.11) months}$$

where the coefficients on \bar{M} are the summed coefficients over nine periods.

In the first period we find a very large coefficient for \bar{M} , much greater than one, which is consistent with our casual inspection of Figure 4.1. In the second period the coefficient on \bar{M} is very close to 1.0, which is what we would expect in a conventional money demand equation. In neither period is the interest rate significant, but in both there is an income effect which is marginally significantly positive, and hence perverse.

The difference between the periods is statistically significant. The SSR's for the constrained and unconstrained equations are given above; the number of observations is 95 and the number of coefficients is 7 (including rho and the three PDL variables). Using the conventional Chow test we compute

$$F(88,7) = (.03870 / (.02046 + .00878) - 1) ((95-7)/7) = 4.067$$

The value of $F_{.99}(60,7)$ is 2.95, so we can reject the null hypothesis of no change between periods at the 99% confidence level.

Interpretation

These results show that it is inappropriate to assume that a conventional money demand function holds for French monthly data in this period. Two anomalies are readily established. First there is no significant relationship between the interest rate and the price level, either for the call money rate or the government bond rate. This is not particularly surprising: given our earlier discussion of the undeveloped nature of the French money market, it seems reasonable to conclude that the opportunity cost of holding cash instead of short term bills was not a major factor in determining money demand. Long term interest rates also function in the money demand equation as an indicator of expected inflation; evidently expectations about future prices are also relatively unimportant.

The second result is that there is a small but significant positive correlation between industrial production and the price level. This could be due to some type of Phillips curve effect, or it could be due to the interaction between income, prices, and the trade balance. An increase in output requires, ceteris paribus, a larger trade surplus and hence an exchange depreciation to maintain aggregate demand, as described in section 1 above. The exchange depreciation causes an increase in the domestic price level (or vice versa), perhaps with a lag. In the French case this effect apparently dominates the effect of a change in income on demand for real money balances.

Finally, we consider the relationship between the price level and the nominal money supply. From 1924 onward this is conventional enough, if we take into account a lag in adjustment. But for 1920-23 we find

that changes in M are in the long run much more than offset by changes in prices, with the result that there are substantial changes in the level of real money balances. We are forced either to reject the entire concept of the demand for money in this case, or to conclude that disequilibrium in the monetary sector persists from month to month.

Nevertheless there remains a highly significant relationship between prices and money in the early period. It seems clear enough that the econometric results here are dominated by the cycle in prices from February 1920 to June 1921, which was unaccompanied by significant changes in the money supply. If we grant for the sake of argument that money demand was in equilibrium the rest of the period we have only to explain this event. This price cycle was associated with a world-wide business cycle--we can perhaps assume that in this case prices were exogenous to the French economy. Plainly the money supply did not change greatly in response, but the effect of the change in real balances on output and interest rates was (for some reason) negligible. During the rest of the whole period (1919-27) changes in prices were presumably due not to world events but the French monetary expansion, and we observe a more conventional coefficient on M.

Results for the U.S.

The estimated money demand equations for the U.S. are more conventional. For equation (4.13) we obtain

U.S., 1920-26

CORC:
$$\ln P_t = 3.264 + .311 \ln M_t + .023 \ln y_t + 1.576 r_t$$

$$(.560) \quad (.103) \quad (.016) \quad (.553)$$

$$R^2 = .979 \quad \rho = .944 \quad n = 83$$

$$(.036)$$

The coefficient on M is significantly less than one, the effect of income is insignificant altogether, and the interest rate has the expected sign.

The small coefficient on M is consistent with the hypothesis of price rigidity, but unlike in the French case, we cannot find a significant lagged impact of M on the price level. Another possible explanation of the low coefficient is that the consumer price index used is simply too rigid to reflect changes in the true price level--early CPI data are noticeably less good than WPI data, which were more readily available.* Reestimating (4.13) using the U.S. WPI (BLS data in SCB), we get

U.S., 1920-26, wholesale prices

CORC:
$$\ln P_t = .614 + .745 \ln M_t + .0715 \ln y_t + 1.380 r_t$$

$$(1.08) \quad (.199) \quad (.0300) \quad (1.062)$$

$$R^2 = .982 \quad \rho = .952 \quad n = 83$$

$$(.034)$$

Estimating with 2SLS gives a significant coefficient on r:

TSCORC:
$$\ln P_t = .047 + .778 \ln M_t + .132 \ln y_t + 4.061 r_t$$

$$(1.22) \quad (.215) \quad (.065) \quad (1.618)$$

$$R^2 = .978 \quad \rho = .941 \quad n = 82$$

$$(.037)$$

In the second equation all the coefficients except the constant are significantly positive; that on M is not significantly different from 1.0.

*) This argument cannot be used to explain the French results--inspection of Figure 4.1 above and Figure 1.2 in chapter 1 shows that consumer prices are frequently more volatile than the money supply, so that it is not a question of price rigidity, and further that the WPI moves even further from M than does the CPI.

The interest rate effect is normal, but as in the French case we have a perverse effect of income; the explanation is probably the same. With this exception, the U.S. demand for money can be regarded as well behaved.

To facilitate comparison with the following section, in which we estimate the reduced form spot rate equation, we reestimate equation (4.13) for France using the interest rate variable (call money) and the period (1920-26) used in the exchange rate equations.

France, 1920-26

$$\text{CORC:} \quad \ln P_t = 2.554 + .490 \ln M_t + .134 \ln y_t - .181 r_t$$

$$\quad \quad \quad (1.027) \quad (.149) \quad \quad \quad (.083) \quad \quad \quad (.273)$$

$$R^2 = .983 \quad \rho = .979 \quad n = 83$$

$$\quad \quad \quad \quad \quad (.022)$$

Using 2SLS raises the coefficient on income substantially:

$$\text{TSCORC:} \quad \ln P_t = -.365 + .434 \ln M_t + .810 \ln y_t - .524 r_t$$

$$\quad \quad \quad (2.42) \quad (.214) \quad \quad \quad (.378) \quad \quad \quad (.631)$$

$$R^2 = .968 \quad \rho = .982 \quad n = 82$$

$$\quad \quad \quad \quad \quad (.021)$$

The results are not greatly different from those presented above.

Section 3: The reduced form spot rate equation

In this section we present estimates of the spot rate equation derived in section 1. The basic equation (4.4) is repeated here for convenience:

$$\begin{aligned}
 (4.15) \quad \ln s_t &= \ln P_t - \ln P_t^* \\
 &= b_0 + b_1 \ln M_t - b_1^* \ln M_t^* - b_2 \ln y_t + b_2^* \ln y_t^* \\
 &\quad + b_3 r_t - b_3^* r_t^*
 \end{aligned}$$

where the notation is the same as before except that the coefficients b_i have been renumbered to include a constant term and explicit coefficients on M and M^* . The first equality in (4.15) is simply the PPP equation, while the second substitutes for prices the money demand equations from section 2. Using these estimates we can infer what results should be obtained for (4.15) if the monetarist approach is correct and the spot rate is in fact determined by the interaction of PPP and the demand for money.

We have established that the contemporaneous impact of money on the price level is small, so that b_1 and b_1^* are both less than one. Because prices are sticky, a change in M will have only a small immediate impact on the exchange rate, but will have a larger effect over time. Thus we would expect to find that s_t is influenced by the lagged money supply. We recall from the PPP discussion that the coefficient on prices, particularly on consumer prices, is greater than one; this will to some extent offset the low coefficient on the money supply in the money demand equation. Thus

$$(4.16) \quad \ln s_t = \gamma \{ \ln P_t - \ln P_t^* \} = \gamma \{ b_1 M_t - b_1^* M_t^* + \dots \}$$

and our estimate of γb_1 might be close to 1.0, or indeed have any value. We can estimate γb_1 using our earlier results, as a consistency check, but we cannot readily construct a confidence interval for this estimate.

That $\gamma \neq 1$ is assumed to be due to relative changes in traded and nontraded goods prices, which would be hard to reconcile with the monetarist model in which the domestic price level is affected by the domestic money supply and not by the exchange rate itself. To maintain the monetarist interpretation in the French case we must argue that there were substantial price rigidities but that nonetheless prices (or some of them), and not interest rates or income, changed to preserve equilibrium in the monetary sector. This may seem unlikely, but we cannot reject the general monetarist approach solely on the basis of a non-unitary coefficient on the money supply.

We have established in section 2 that income is positively correlated with prices in the money demand equation; thus we expect to find positive coefficients on y and y^* in (4.15). This is not to argue that the income elasticity of money demand is perverse, but rather than in practice it is dominated by the effect of income changes on the trade balance and terms of trade (there is an identification problem here). If this is so, we should also find the effect in the spot rate equation.

We found no significant interest elasticity of money demand in France, presumably due to the special characteristics of the French economy. A conventional interest elasticity was obtained for the U.S. Thus we might expect to find a difference in the interest rate effects between the two countries. The other coefficients are broadly of the same size

for France and the U.S., at least to the extent of our statistical ability to separate them, except for the lag structure on the money supply. These lags differ greatly both between France and the U.S. and between periods in the French case.

Figure 4.2 plots the franc-dollar exchange rate and the ratio of the French to U.S. money supplies for 1920-26. Both variables are expressed as the log of an index with 1913/14 = 100, so that where the points coincide on the graph the exchange rate and relative money supplies have both changed in the same proportion since before WWI. For much of the period we see large fluctuations in the exchange rate which do not appear to be associated with changes in relative money supplies. In particular, the depreciation from mid-1922 through the end of 1923 was accompanied by relatively stable money. Only starting in 1925 is there an obvious correlation between a rising (relative) money supply in France and a continuing depreciation. This suggests that again we might look for evidence of structural change during this period.

We estimate equation (4.15) as it stands, with the addition of an error term, using the data sources described earlier. Our discussion of simultaneity in section 2 also applies here: we can take M as exogenous, but we assume that real income and interest rates are determined simultaneously with the price level and hence the exchange rate. Results are presented using both the OLS and IV methods described above--in fact the results are very similar for the two methods.

The basic equations using the franc/dollar rate are all run for 1920-26, the franc/sterling equations for 1921-26 due to various limitations

Figure 4.2: Franc/dollar exchange rate and relative money supplies, 1920-26, monthly.

solid line = exchange rate (log scale, 1913/14 = 100)

broken line = $M_{\text{France}}/M_{\text{U.S.}}$ "

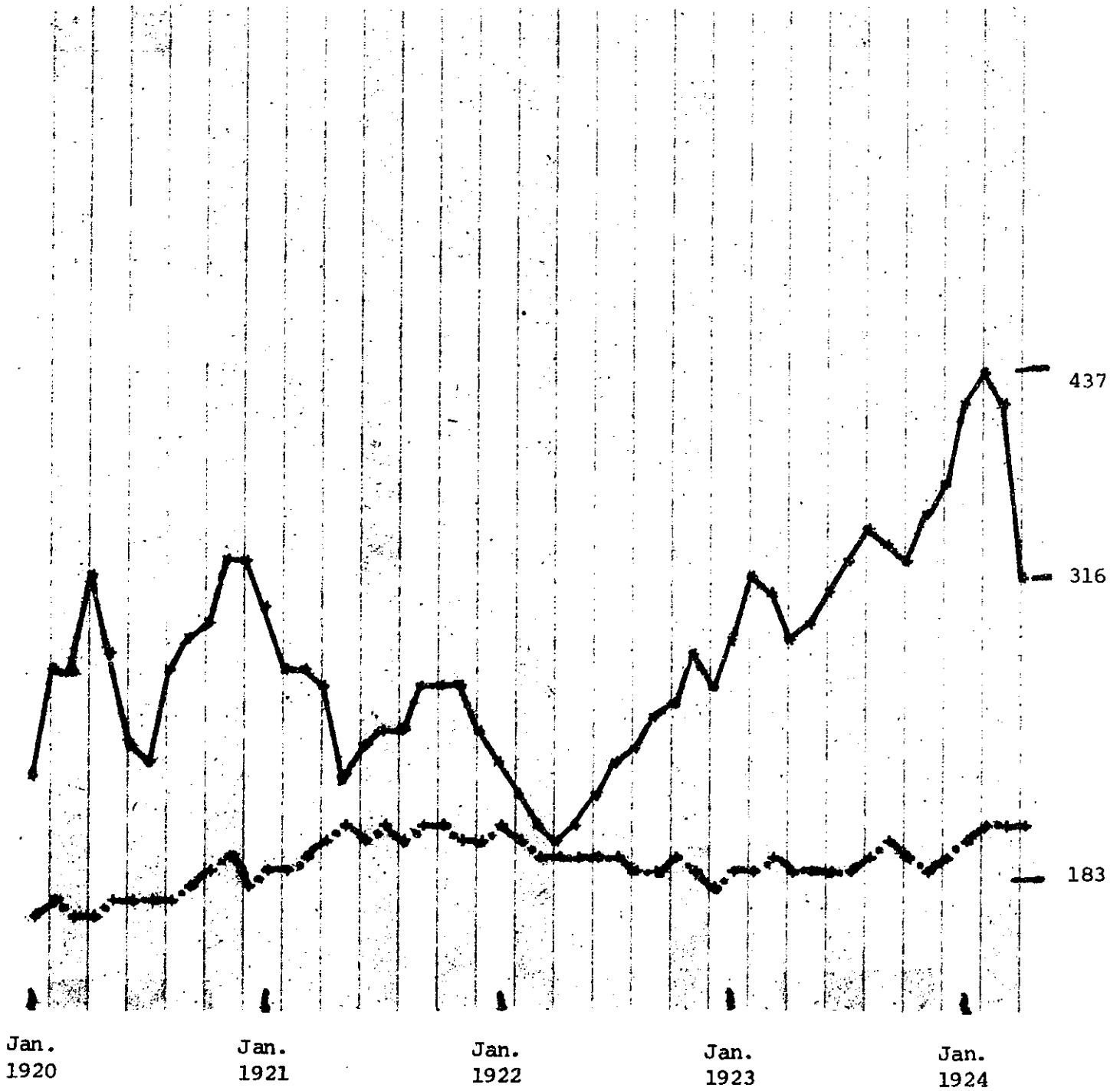
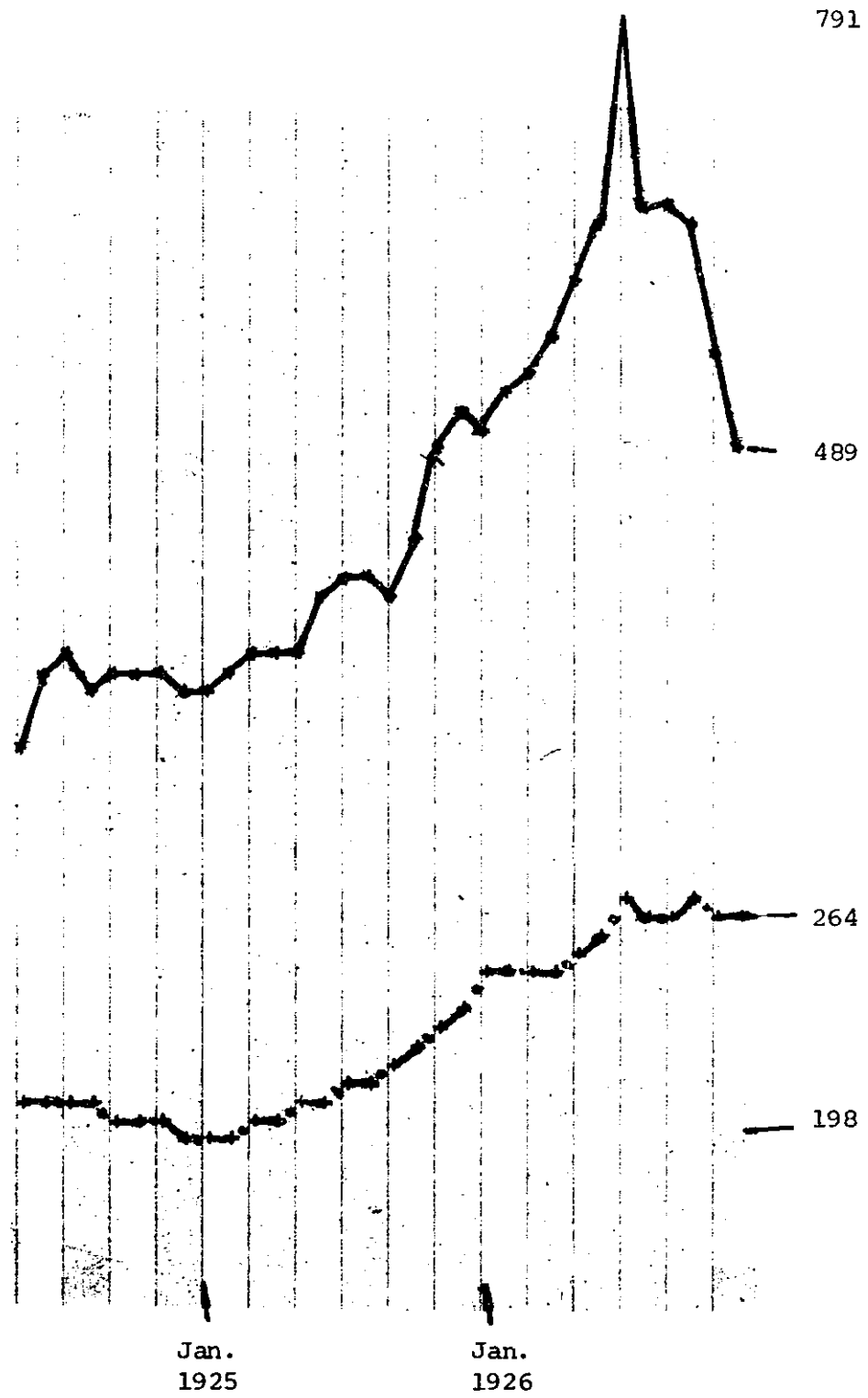


Figure 4.2, continued



on the data. The periods when the French government intervened in the foreign exchange markets are omitted, so the sample ends in July 1926 and includes a dummy variable for April 1924 ("D424"). The rationale for excluding these periods is that the interventions consisted of direct FX operations, which produced large changes in s without any immediate change in M or Y , or even in r . Presumably these variables must adjust to the shock in time, but the lags need not be the same as when the rate floats freely; we choose not to tax the model by asking it, in effect, to explain the interventions.

Empirical results

Estimating (4.15) as it stands we obtain

Franc/dollar, 1920-26

$$\begin{aligned} \text{CORC:} \quad \ln s_t = & -4.693 + 1.604 \ln M_t - .245 \ln M_t^* + .527 \ln y_t \\ & (1.981) \quad (.272) \quad (.536) \quad (.168) \\ & - .109 \ln y_t^* + 1.104 r_t + 5.172 r_t^* - .161 D424 \\ & (.104) \quad (1.002) \quad (2.573) \quad (.053) \\ R^2 = & .955 \quad \rho = .729 \quad n = 78 \quad \text{SSR} = .27819 \\ & (.078) \end{aligned}$$

The coefficients on M and M^* both have the expected sign, but that on M^* is not significantly different from zero. The coefficient on the French money supply is much larger than in the price equation, where the one period coefficient was only .490; an increase in the money supply depreciates the exchange rate more than in proportion. Even if we allow for PPP failure and take γ in (4.16) to be say, 2.0*, this seems an overly

) See chapter 2, section 3. It is possible that multicollinearity between M and M^ offsets some of the apparent impact of M on s ; this problem is eliminated in the constrained equations below.

strong response to the money supply to be explained by the behavior of prices.

The coefficients on income are about as expected, given the results from section 2; an increase in French income causes the exchange rate to depreciate. The coefficient on y^* is not significant. The coefficient on r is insignificant, also as expected, but the coefficient on the U.S. interest rate is significantly positive at the 99% confidence level. This is a surprise because while the interest rate was significant in the U.S. money demand equation, this effect is in the opposite direction: a higher U.S. interest rate causes the French franc to depreciate. This result is predicted by the M-F model, but not by the monetarist approach.

Using 2SLS to correct for possible simultaneous equation bias we get:

Franc/dollar, 1920-26

$$\begin{aligned} \text{TSCORC: } \ln s_t = & - 1.754 + 1.458 \ln M_t - 1.478 \ln M_t^* + 1.235 y_t \\ & \quad (2.656) \quad (.333) \quad \quad \quad (.725) \quad \quad \quad (.314) \\ & - .080 y_t^* - .218 r_t + 15.07 r_t^* - .251 D424 \\ & \quad \quad (.290) \quad (2.38) \quad (4.23) \quad (.079) \\ R^2 = & .937 \quad \rho = .744 \quad n = 77 \quad \text{SSR} = .38600 \\ & \quad \quad \quad (.076) \end{aligned}$$

These results do not lead to greatly different conclusions. The coefficient on M falls enough that we cannot now reject the hypothesis that it (and also the coefficient on M^*) are 1.0. The coefficients on y and r^* remain significantly positive, so that they cannot be explained away by simultaneous equation bias.

If we allow for a lag on the French money supply we obtain

Franc-dollar, 1920-26

$$\begin{aligned}
 \text{PDLCORC: } \ln s_t = & - 5.075 + 2.068 \ln \bar{M} - .694 \ln M_t^* + .531 \ln y_t \\
 & (2.472) \quad (.373) \quad (.590) \quad (.183) \\
 & - .111 \ln y_t^* + .229 r_t + 5.427 r_t^* - .167 D424 \\
 & (.099) \quad (.906) \quad (2.859) \quad (.046) \\
 R^2 = & .967 \quad \text{rho} = .805 \quad n = 73 \\
 & \quad \quad \quad (.069)
 \end{aligned}$$

mean lag on M = 1.509 (1.061) months

where the coefficient on \bar{M} is the sum of the coefficients on the French money supply lagged over 6 periods using a second degree polynomial. Taking into account the lag, the impact of the French money supply on the exchange rate is even larger; this is broadly consistent with our money demand and PPP results. It is possible that some of this impact is due to the unusual behavior of prices (and hence, presumably, the exchange rate) during 1920-21 that we discussed earlier. Rather than pursue this problem using the polynomial lag approach, we turn to an analysis of the constrained version of the spot rate equation.

A test of the monetarist hypothesis

Another way in which the monetarist approach can be investigated is simply to specify a priori the expected values of the coefficients in (4.15) and set up these expectations as constraints on the regression of (4.15). The data are then used to test whether the constraints can be rejected.* The prior constraints are not based on econometric estimates of the structural equations in the model; rather they follow from theoretical considerations.

Here we test the most obvious and perhaps the most believable of these constraints, that the coefficients on M and M* are both equal to 1.0.

*) This is the approach used by Bilson (1978) and Frenkel and Clements (1978), and discussed in chapter 1, section 3.

We focus on this constraint because it can be taken directly from the model, without, for example, the need to specify a priori a range of acceptable values for the other elasticities. The role of money is surely at the heart of the monetarist approach--the theory can be modified to allow for insignificant or perverse coefficients on r or y without sacrificing the central place of the demand for money in determining the exchange rate. To test this hypothesis, we rewrite the basic equation in the following form:

$$(4.17) \quad \ln s_t = b_0 + b_1 \ln (M_t/M_t^*) - b_2 \ln(y_t/y_t^*) + b_3 (r_t - r_t^*) + u_t$$

Rather than constrain b_1 to be 1.0 we simply test the constraint using a t - test. The coefficients on foreign and domestic income and interest rates are constrained to be equal (with opposite signs) largely for convenience; the errors on the separate coefficients in each pair are large enough that we cannot reject the hypothesis that they are equal. Estimating (4.17) yields:

Franc/Dollar, 1920-26

$$\begin{aligned} \text{CORC:} \quad \ln s_t &= 5.300 + 1.159 \ln (M_t/M_t^*) + .193 \ln (y_t/y_t^*) \\ &\quad (.439) \quad (.385) \quad (.010) \\ &\quad + .229 (r_t - r_t^*) - .169 D424 \\ &\quad (.902) \quad (.049) \end{aligned}$$

$$R^2 = .949 \quad \rho = .977 \quad n = 78 \quad \text{SSR} = .31338 \quad \text{SER} = .0655$$

(.024)

This result in general supports the monetarist approach. The coefficient on M/M^* is very close to 1.0 in magnitude, and is not significantly greater than one. The interest rate coefficient has the right sign, although it is not significant; only the income effect is significantly perverse.*

*) As in the unconstrained case, the IV estimates of this equation are not greatly different. Since the object of this test is the money supply, which is presumed exogenous, we present only the OLS estimates.

raises the SSR by 16%, but this is not enough given the number of variables in the equation. But it does seem evident that the coefficient on M/M^* really does change from one period to the next, and we can test this directly using a t - test.*

The procedure is to run a single regression for the full period but with separate coefficients for each subperiod for each variable. This is accomplished by creating a set of dummy variables, e.g.:

$$\begin{aligned} (M/M^*)_A &= \ln (M_t/M_t^*) && \text{for 1920-23} \\ &= 0 && \text{for 1924-26} \\ (M/M^*)_B &= 0 && \text{for 1920-23} \\ &= \ln (M_t/M_t^*) && \text{for 1924-26} \end{aligned}$$

and similarly for the other variables in the regression. Estimating this equation for the full period we obtain

Franc/dollar, 1920-26

$$\begin{aligned} \text{CORC: } \ln s_t &= 5.529 C_A + 4.243 C_B + .332 (M/M^*)_A + 2.336 (M/M^*)_B \\ &\quad (.351) \quad (.206) \quad (.479) \quad (.249) \\ &+ .205 (Y/Y^*)_A + .008 (Y/Y^*)_B + .764 (r - r^*)_A \\ &\quad (.107) \quad (.230) \quad (1.27) \\ &+ .863 (r - r^*)_B - .247 D424 \\ &\quad (1.41) \quad (.065) \end{aligned}$$

$$R^2 = .997 \quad \rho_A = .903 \quad \rho_B = .544 \quad n = 78 \quad \text{SSR} = .25297 \\ \text{SER} = .06055$$

where C_A and C_B are constants for period A (1920-23) and period B (1924-26)

) The reason this could succeed where the Chow test fails is that the latter forces us to consider the possibility that constraining the other variables, not M/M^ , could have led to the worsened fit. The coefficients on these variables are so imprecisely estimated in either case that they contribute greatly to the SSR in both the constrained and unconstrained regressions. This dilutes the impact of the improvement in the SSR that should (presumably) be attributed to the removal of the constraint on M/M^*

and the other variables are similarly defined. We can use the standard errors to test the null hypothesis that the coefficients on $(M/M^*)_A$ and $(M/M^*)_B$ are equal; for this test we obtain a value of $t = -3.710$, so that we can reject the hypothesis at the 99% confidence level.

We can draw two main conclusions from this result. One is that the monetarist approach does not explain everything. We have a contrast between the two periods: in one the money supply is irrelevant and income is a significant explanatory variable, while in the other income is irrelevant and money is a key variable. Thus, sometimes the real sector dominates the exchange market and sometimes the monetary sector does.*

On further consideration, we see that while the money supply itself obviously dominates the second period equation, this does not support the monetarist model of the exchange market. The coefficient on M/M^* in the second period is significantly greater than two, much less one, and this extraordinary impact is not consistent with the view that the spot rate is determined by price changes resulting from changes in M through the demand for money equation. This is true whether we judge using a priori standards (i.e., $b_1 = 1.0$) or the estimated empirical relationship between money and prices, and prices and the spot rate.

Thus the simple monetarist model presented above explains neither period of the French case. The apparent acceptance of the hypothesis that the coefficients on M and M^* are equal to one for the full period is a statistical artifact, resulting from the combination of two distinctive

*) It must be admitted that the explanatory power of the early period equation comes almost entirely from the autocorrelation coefficient. Excluding the dummy and ρ , the R^2 in the early period is only .066, while in the later period it is .906. Nonetheless the coefficient on income is significantly positive; the obvious misspecification of the exchange rate equation for the early period in itself refutes the universal applicability of the monetarist model.

episodes into one.

Interest rate behavior

The Mundell-Fleming model suggests that an increase in the nominal supply of money instead of affecting s through higher prices and PPP simply results in a capital outflow which causes exchange depreciation. The proximate cause of the outflow is a fall in the domestic interest rate, creating an interest differential in favor of foreign capital markets; thus we would expect to find a negative correlation between s and $(r - r^*)$ if the model is correct. In the short run the elasticity of the spot rate with respect to the money supply can have any value. In this part we investigate whether the results just obtained can be attributed to the M-F model.

In the three equations just estimated the interest differential $(r - r^*)$ is always insignificant. This is true for a variety of periods, interest rate variables, and estimation techniques. Thus on the face of it we cannot support the M-F interpretation of the role of interest rates. However, there are several ways in which this result might be reconciled with the M-F model.

It is possible that if the money supply influences the exchange rate solely through the interest differential that M/M^* and $(r - r^*)$ will be so highly correlated that significant estimates of their separate coefficients cannot be obtained. We can test for this by finding the correlation coefficient between the two variables, or simply by omitting M/M^* from the exchange rate equation. In fact, the correlation is only .18 and omitting money does not improve the interest rate coefficients, so we can neglect this problem.

A second possibility is that the long run and short run effects of interest rate changes are being obscured by the inclusion of only one interest rate variable.* If we reestimate (4.17) including a term for the interest differential on government bonds we obtain

Franc/dollar, 1920-26

$$\begin{aligned} \text{CORC: } \ln s_t = & 5.276 + 1.171 \ln (M_t/M_t^*) + .194 \ln (Y_t/Y_t^*) \\ & (.459) \quad (.391) \quad (.100) \\ & + .181 (r_t - r_t^*)_{ST} + 1.060 (r_t - r_t^*)_{LT} - .170 D424 \\ & (.917) \quad (3.114) \quad (.049) \\ R^2 = & .949 \quad \text{rho} = .976 \quad n = 78 \quad \text{SSR} = .31291 \\ & (.024) \end{aligned}$$

Neither the short nor the long term interest rate differential is significant. The 2SLS results do not differ substantially, and again we cannot support the M-F interpretation.

Finally, we consider the unconstrained equation presented at the beginning of this section, where a significantly positive sign was found on the U.S. interest rate, but the French rate was not significant. It seems clear that the results on the interest differential are insignificant because we have constrained the two rates to have opposite signs and because the French rate contributes so little to the equation.

The sign on the U.S. rate is consistent with the M-F hypothesis-- a higher rate abroad attracts a flow of funds out of France seeking a higher return, resulting in depreciation of the franc. But why doesn't a change in the French interest rate have a similar effect? The numbers suggest that some asymmetry exists in the two capital markets. Recall that the dollar was tied to gold during this period. Thus, an increase

*) This is J. Frankel's argument, referred to above.

in the U.S. interest rate would be taken by investors not as a sign of incipient inflation in the U.S. but as an opportunity to realize a higher return guaranteed in terms of gold. On the other hand, a higher interest rate in France might reflect further inflation, government weakness in the face of depreciation (e.g., raising the discount rate in lieu of fundamental reform), or even an excess demand for French currency.

Given all this, it is not surprising that the estimates of interest rate coefficients give contradictory and insignificant results. But while some support is given to the M-F view of capital markets and the exchange rate, there seems to be little ground for believing that the large effect of the French money supply on the spot rate operated through this mechanism.

The forward discount and the spot rate

The reduced form spot rate equation is sometimes estimated by substituting the forward discount on FX for the interest rate differential:*

$$(4.18) \quad \ln s_t = b_0 + b_1 \ln (M_t/M_t^*) + b_2 \ln (y_t/y_t^*) \\ + b_3 (\ln f - \ln s) + u_t$$

This form of the equation is of interest to us because it brings expectations explicitly into the model; in the following chapter we explore various assumptions about the formation of the forward discount. In order to estimate (4.18) we must switch to the franc/sterling rate and to a shorter period. For purposes of comparison we first estimate (4.17) using this new data base:

*) Bilson (1978) and Frenkel and Clements (1978) adopt this approach.

Franc/sterling, 1921-26

$$\begin{aligned} \text{CORC: } s_t &= 5.287 + 1.575 \ln (M_t/M_t^*) + .414 \ln y_t + .941 (r_t - r_t^*) \\ &\quad (.700) \quad (.198) \quad (.126) \quad (.822) \\ &\quad + .020 D324 - .137 D424 \\ &\quad (.050) \quad (.051) \\ R^2 &= .979 \quad \rho = .755 \quad n = 66 \quad \text{SSR} = .17242 \\ &\quad (.081) \end{aligned}$$

Note that y^* is omitted because no data is available. This biases the coefficients on the other variables to the extent that they are correlated with y^* . Since the other variables are expressed as the ratio of domestic to foreign values we may hope that this problem is not too serious. D324 is a dummy variable for March 1924 needed in connection with the use of the forward premium.

The result is similar to that for the franc-dollar rate above. The interest differential is insignificant, and the coefficient on French income is positive. The higher coefficient on M , which is significantly greater than one, is doubtless due to the shorter period. Estimating (4.18) we obtain:

Franc/sterling, 1921-26

$$\begin{aligned} \text{CORC: } \ln s_t &= 5.061 + 1.393 \ln (M_t/M_t^*) + .424 \ln y_t + 8.01 (\ln f_t - \ln s_t) \\ &\quad (.616) \quad (.185) \quad (.109) \quad (2.83) \\ &\quad - .126 D324 - .136 D424 \\ &\quad (.067) \quad (.048) \\ R^2 &= .981 \quad \rho = .722 \quad n = 66 \quad \text{SSR} = .15587 \\ &\quad (.085) \end{aligned}$$

The coefficient on the forward discount has the sign predicted by the monetarist model--it is significantly greater than zero. However, the impact of the forward discount is much too large to be explained by the model; the forward discount cannot simply be reflecting changes in interest

rates due to changes in money demand.*

Thus while estimates of equation (4.18) provide apparent confirmation of the monetarist approach we can in fact demonstrate an inconsistency. Similar results are obtained using 2SLS; the effect is not due to simultaneous equation bias.

This leads us to suspect the existence of some other link between the forward discount and the spot rate. It seems likely that the impact of $(f - s)$ comes not because in equilibrium it is equal to $(r - r^*)$ which is a measure of expected inflation differentials and hence affects prices and hence the spot rate. Rather $(f - s)$ is a direct, if imperfect, measure of expectations about the spot rate itself, and a higher forward discount encourages a capital outflow and hence exchange depreciation. This confirms one part of the M-F story. Equilibrium in domestic and foreign capital markets requires

$$(4.19) \quad r = r^* + (\ln f - \ln s)$$

A rise in $(\ln f - \ln s)$ has the same effect as a rise in r^* : it raises the return on FX and encourages a flow of funds abroad. What the evidence shows is that the influence of the interest rates, particularly r , is not statistically significant, but that changes in the forward discount are. Thus, if anything, the results using the forward discount in the exchange rate equation provide support more for the M-F than for the monetarist models.

*) The difference between the two equations is significant at the 95% level.

Conclusion

The behavior of the French franc in the 1920's shows that the monetarist model is right in assigning central importance to the money supply, at least after 1923, but wrong (in this case) about the mechanism by which money affects the exchange rate. The results overall tend to favor the more Keynesian M-F model, but with a major qualification about the role of interest rates. We consider three areas of conflict between the two approaches.

Prices

The monetarist model relies on rapid price adjustment, while the M-F approach assumes sticky prices, or in some cases an exogenous price level. Here the evidence supports the neo-Keynesians; both the PPP and money demand equations provide evidence consistent with sticky prices and inconsistent with models assuming complete adjustment.

Incomes

The models differ in their prediction of the effect on the exchange rate of an increase in income. In our case the M-F effect predominates--the real sector is more important than the monetary. The implicit argument is that an increase in income creates excess aggregate supply, requiring a larger trade balance and hence a depreciated exchange rate. In the monetarist model this second step does not follow because PPP requires that the terms of trade be constant. It was shown in the conclusion to chapter two that the terms of trade are demonstrably nonconstant, thus supporting the M-F model.*

*) A complete test of this proposition would include establishing that the trade balance, and income, actually responded to the change in the terms of trade with the appropriate sign.

Money

The idea that the nominal money supply affects the exchange rate simply through the domestic demand for money equation is refuted in this case; money has too large an impact on the spot rate to be explained in this way. The M-F model seems to be on the right track: changes in the money supply affect the spot rate by creating an international capital flow which directly affects the foreign exchange market. However, the model seems to be wrong in suggesting that this capital flow is the response of the market to interest rate differentials which result from changes in the nominal money supply; at least the evidence does not support this conclusion.

Rather, an increase in the domestic money supply appears to have a direct effect on the demand for foreign exchange which is outside the scope of either model. It may be that this is simply a portfolio balance effect, as investors seek to maintain some ratio between domestic and foreign assets. Or it may be that changes in money directly affect expectations about future exchange depreciation, with the result that investors change their desired holdings of foreign exchange, for speculative or other reasons. This last possibility is attractive, but untestable. If the forward discount is a good measure of expectations, then including it in the spot rate equation should eliminate the effect of money. It does not, so either theory is wrong or expectations are unobservable, and all the investigator can do himself is speculate.

Section 4: A dynamic model of the exchange rate

In this section we use the reduced form model to evaluate two interpretations of the floating franc found in the historical literature, and discussed in the introduction. One is that the government's monetary and fiscal policy was such that the money supply was affected by the exchange rate. This supposedly occurred because investors redeemed bonds in large numbers as the exchange rate depreciated, forcing the government to borrow from the central bank in order to maintain the real level of spending, and resulting in a larger money supply. The other argument is that expectations about future depreciation were based simply on the previous behavior of the franc, rather than on some assessment of its equilibrium value and its probable path toward that level; this is one formulation of the much-discussed "destabilizing speculation" problem.

We test these hypotheses by regressing the money supply and the forward discount on the lagged spot rate. This gives us a dynamic model: the spot rate depends on the current money supply and discount (through the reduced form equation), and these in turn depend (we suppose) on the lagged spot rate. We simulate the path of the spot rate using this model, and attempt to answer three questions:

- i) What would have happened to the franc if the government had not intervened in March 1924 and July 1926?
- ii) What would have happened to the franc if the government had stabilized the money supply starting in 1924?
- iii) What was the impact of the forward market on the path of the franc?

We simulate these events using the dynamic model, and use the results to characterize the stability of the exchange market. We do not attempt

a formal test of (or definition of) destabilizing speculation or any other stability criterion; rather we show the results of some specific experiments and let the reader form his own conclusions about what constitutes a stable exchange rate.

Endogeneity of money and the forward discount

We postulate that the lagged impact of the spot rate on the money supply and the forward discount may be written as follows:

$$(4.20) \quad \ln M_t = \alpha_0 + \sum_{i=1}^n \alpha_i \ln s_{t-i} + u_t$$

$$(4.21) \quad d_t = \beta_0 + \sum_{i=1}^n \beta_i \ln s_{t-i} + u_t, \quad d_t = (\ln f_t - \ln s_t)$$

We do not attempt to estimate the impact of the current spot rate on the money supply or the forward discount--this cannot be identified apart from the effect of money and the discount on the spot rate itself. In effect we assume that the government and investors react to recent history, but not to current events. This permits us to estimate (4.20) and (4.21) using OLS without worrying about simultaneous equation bias. The lag structure is estimated using the Almon polynomial method, with a correction for autocorrelation.

We estimate the equations using data for the franc/sterling market for June 1924-July 1926. This period is chosen because the phenomena we are looking for are generally described as being more acute after, say, 1923--we wish to examine the strongest possible case for dynamic instability, so we deliberately select an extreme period. Further, we are only safe in assuming that the forward discount represented expectations after 1923, when the discount consistently exceeded the interest differential. We have already established the existence of some structural change during the period, so we do not formally test this again. The intervention months

at the end of 1926 were excluded since presumably the government asserted control of the money supply at this time.

For the money supply equation we obtain

Franc/sterling, 1924-26

$$\begin{aligned} \text{PDLCORC: } \ln M_t = & 3.936 + .1263 \ln s_{t-1} + .0790 \ln s_{t-2} + .0488 \ln s_{t-3} \\ & (.706) \quad (.0328) \quad (.0230) \quad (.0251) \\ & + .0357 \ln s_{t-4} + .0396 \ln s_{t-5} + .0607 \ln s_{t-6} \\ & (.0258) \quad (.0249) \quad (.0344) \end{aligned}$$

$$R^2 = .988 \quad \rho = .963 \quad (.048) \quad n = 31$$

$$\text{sum of lag coefficients} = .3902 \quad (.1101)$$

$$\text{Mean lag} = 1.9 \quad (.43) \text{ months}$$

The lag structure was approximated by a second degree polynomial.

This equation shows that there is in fact a significant impact of the lagged exchange rate on the current money supply. All but the third and fourth individual lag coefficients are significant at the 95% level, and their sum is significantly positive. In the long run, the elasticity of the money supply with respect to the exchange rate is .39, although a priori it is hard to put any particular interpretation on this magnitude.

We note that the estimated autocorrelation coefficient (.963) is not significantly different from one. One possible explanation of this is that the true model is in first difference form, in which case the errors in (4.20) would be perfectly correlated. This does not matter for econometric purposes (since the equation is transformed into difference form using ρ before the coefficients are estimated), but it does make intuitive sense. The implicit model behind (4.20) is that an increase in the price of foreign exchange lowers confidence, raises bond redemptions, and forces an increase in the money supply; therefore the true structure is in difference form. The data are consistent with this model, and thus

confirm the endogeneity of the money supply.

Estimating the equation for the forward discount we obtain

Franc/sterling, 1924-26

$$\begin{aligned}
 \text{PDLCORC: } \ln d_t = & -.3455 + .0162 D324 - .0043 D424 \\
 & (.129) \quad (.0029) \quad (.0032) \\
 & + .00932 \ln s_{t-1} + .01242 \ln s_{t-2} + .01330 \ln s_{t-3} \\
 & (.00839) \quad (.00506) \quad (.00481) \\
 & + .01196 \ln s_{t-4} + .00840 \ln s_{t-5} + .00263 \ln s_{t-6} \\
 & (.00508) \quad (.00522) \quad (.00722) \\
 R^2 = & .801 \quad \rho = .945 \quad (.059) \quad n = 31 \\
 \text{sum of lag coefficients} = & .0580 \quad (.0206) \\
 \text{mean lag} = & 2.1 \quad (5.3) \text{ months}
 \end{aligned}$$

The lag structure was approximated by a second degree polynomial; the dummy variables are for the intervention in 1924.

This equation shows some evidence that the forward discount is influenced by the lagged spot rate. The second, third, and fourth lag coefficients, and their sum, are all significant at the 99% level. Again, the interpretation of the results is not entirely obvious--the sum of lag coefficients is most easily understood with reference to the steady state values of the spot rate and the discount, when the discount ought always to be zero. Thus it is not surprising to find that a change in the steady state level of the spot rate produces only a miniscule change in the forward discount rate.

However, if the discount depends on the past behavior of the spot rate it is presumably the first and second derivatives, not the levels, that determine the current discount. This results in an equation of the form of (4.21), but we cannot readily interpret the pattern of the coefficients. As in the money equation, the autocorrelation coefficient

suggests that the true model is in first difference form.

This evidence provides some support for the school of thought which held that there was something inherent in the continued depreciation of the franc. (See, for example, the quotation from Nurkse discussed in the introduction.) But it is not immediately obvious whether these effects are of economic, as opposed to statistical, significance. In order to assess the actual effect they had on the exchange market we combine equations (4.20) and (4.21) with an equation for the current spot rate.

A dynamic model

We can write the reduced form spot rate equation in a form consistent with the two dynamic equations just given:

$$(4.22) \quad \ln s_t = b_0 + b_1 \sum_{i=1}^n \lambda_i \ln M_{t-i} - b_1^* \ln M_t^* - b_2 \ln y_t \\ + b_2^* \ln y_t^* + b_3 d_t + u_t$$

We include a distributed lag on the domestic money supply, as indicated by the empirical results above. Since we wish to include the forward discount d_t we must use the franc/sterling data, and the y^* term must be omitted.

Combining these three equations gives a recursive dynamic model in which M_t and d_t are determined by lagged values of s . The current spot rate, s_t , is in turn a function of M_t and d_t . In period $t+1$, M and d respond to the new exchange rate s_t and the process continues. The dynamic behavior of the model can be analyzed by using the estimated coefficients for all three equations to simulate the path of the spot rate over time. This allows us to simulate the effects of various assumptions about the behavior of money and the forward discount.

Estimating (4.22) we obtain

Franc/sterling, 1924-26

$$\begin{aligned}
 \text{PDLCORC: } \ln s_t = & -13.234 - .0239 D324 - .111 D424 + .868 \ln M_t^* \\
 & \quad (6.509) \quad (.0689) \quad (.046) \quad (.907) \\
 & + .519 \ln y_t + 4.692 d_t + 1.694 \ln M_t + .3275 \ln M_{t-1} \\
 & \quad (.485) \quad (2.526) \quad (.430) \quad (.1844) \\
 & - .4345 \ln M_{t-2} - .5920 \ln M_{t-3} - .1448 \ln M_{t-4} \\
 & \quad (.2683) \quad (.2818) \quad (.2529) \\
 & + .9070 \ln M_{t-5} \\
 & \quad (.5103)
 \end{aligned}$$

$$R^2 = .977 \quad \text{rho} = .570 \quad n = 31 \\
 \quad \quad \quad \quad \quad \quad (.148)$$

$$\text{sum of lag coefficients} = 1.757 \quad (.375)$$

$$\text{mean lag} = .93 \quad (1.6) \text{ months}$$

The lag structure is approximated by a second degree polynomial; dummy variables are included for the intervention periods. The results are similar to those obtained in section 3 above, although we note that the coefficient on French income is insignificantly positive.

Simulation of the model

We simulate the model dynamically; that is, we use equations (4.20) and (4.21) to calculate \hat{M}_t and \hat{d}_t for the first sample period (January 1924) using the actual lagged values of s . Then \hat{s}_t is calculated using equation (4.22) with the values of \hat{M}_t and \hat{d}_t and the actual values of the exogenous variables. (Income is assumed to be exogenous for purposes of this experiment.) Then the process is repeated for the next period. In this procedure no allowance is made for the error in the previous period--the errors accumulate throughout the simulation period. This allows us to compare simulations of alternative policies for which the

true results are in fact unknown. The model is simulated only within the sample period--no actual prediction is attempted.

Figure 4.3 shows the simulated path of the exchange rate plotted against the actual path. This gives us an overall measure of the performance of the model, and a benchmark against which the other simulation results can be compared. The basic simulation period is for January 1924-July 1926, with a dummy variable for the intervention in March-April 1924. The variables are all measured in logs (of an index with 1914 = 100). Overall the fit is acceptable, although we note the existence of persistent errors. The model does not track short term fluctuations very well, but the trend throughout the period is followed closely. The simulated franc depreciates somewhat too much right after the 1924 intervention, but if anything it understates the rate of the franc's fall in 1926.

As a first exercise we consider what would have happened if the government had not intervened in the exchange markets in 1924 and 1926. To model this we simulate the model without the dummy variables for 1924, letting it run through the end of 1926, by which time stabilization had occurred. Figure 4.4 shows the simulated and actual paths of the spot rate.

Two results emerge. One is that the simulation shows that the franc would have fallen slightly in March and April of 1924 regardless of the government action. This is an intriguing result, although perhaps it should not be overemphasized. It may merely be a statistical artifact--as noted, the model does not track month to month changes very well.

Figure 4.3: Dynamic simulation of exchange rate model,
Jan. 1924 - July 1926.

above: simulated value (log scale, 1914=100)
below: actual value "

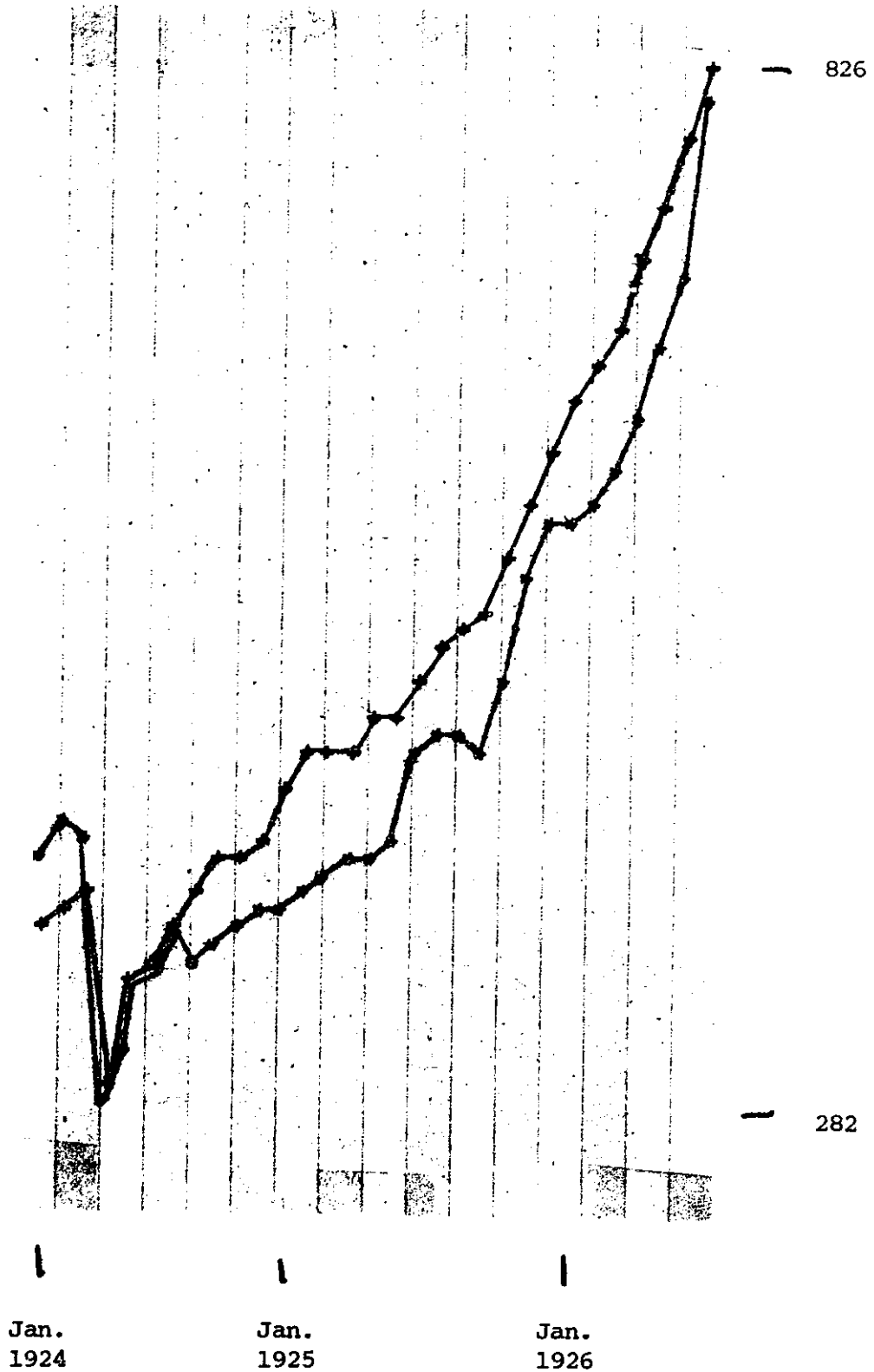
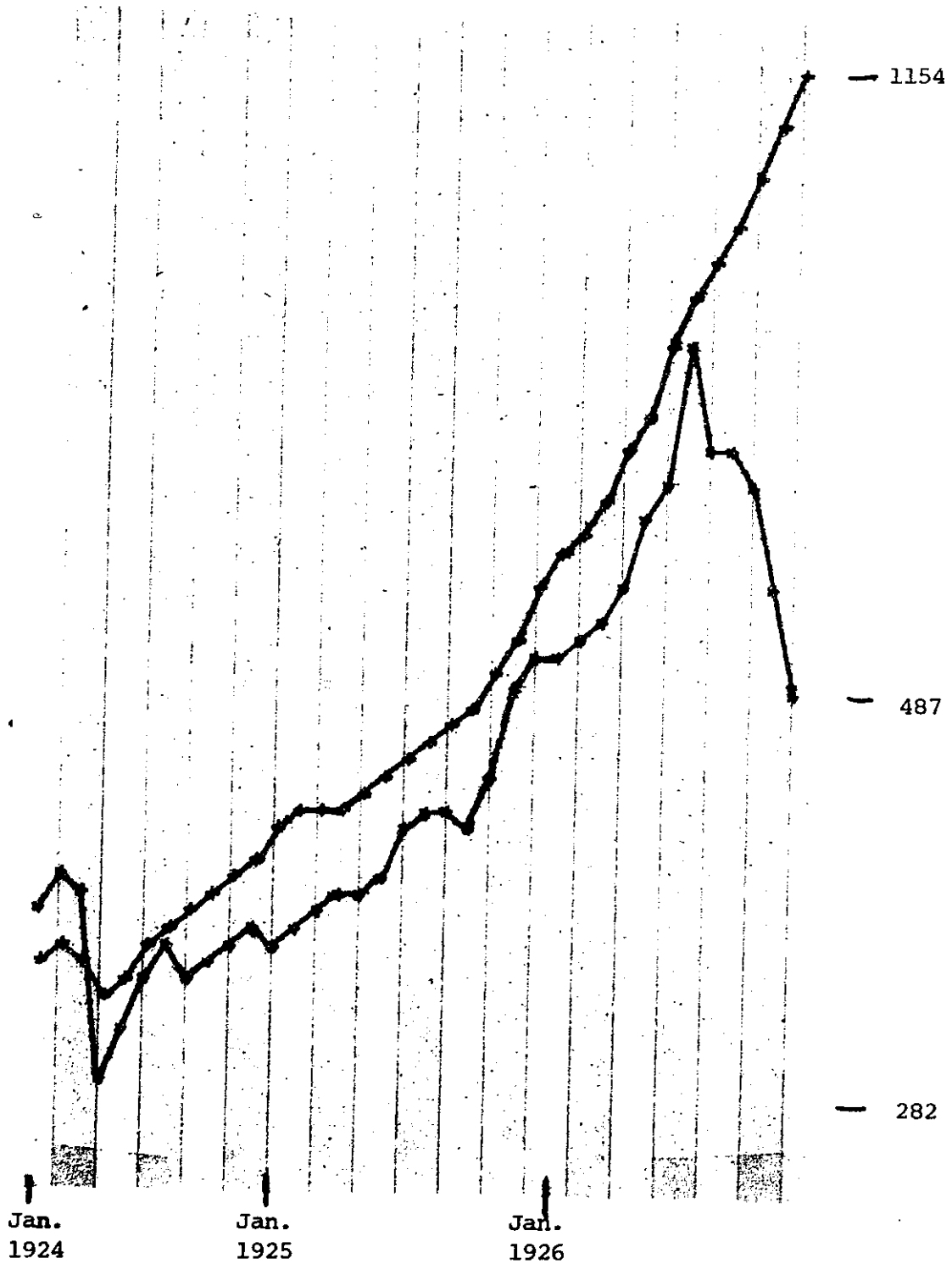


Figure 4.4: Simulated path of exchange rate given no government intervention, Jan. 1924 - December 1926.

above: simulated value
below: actual value



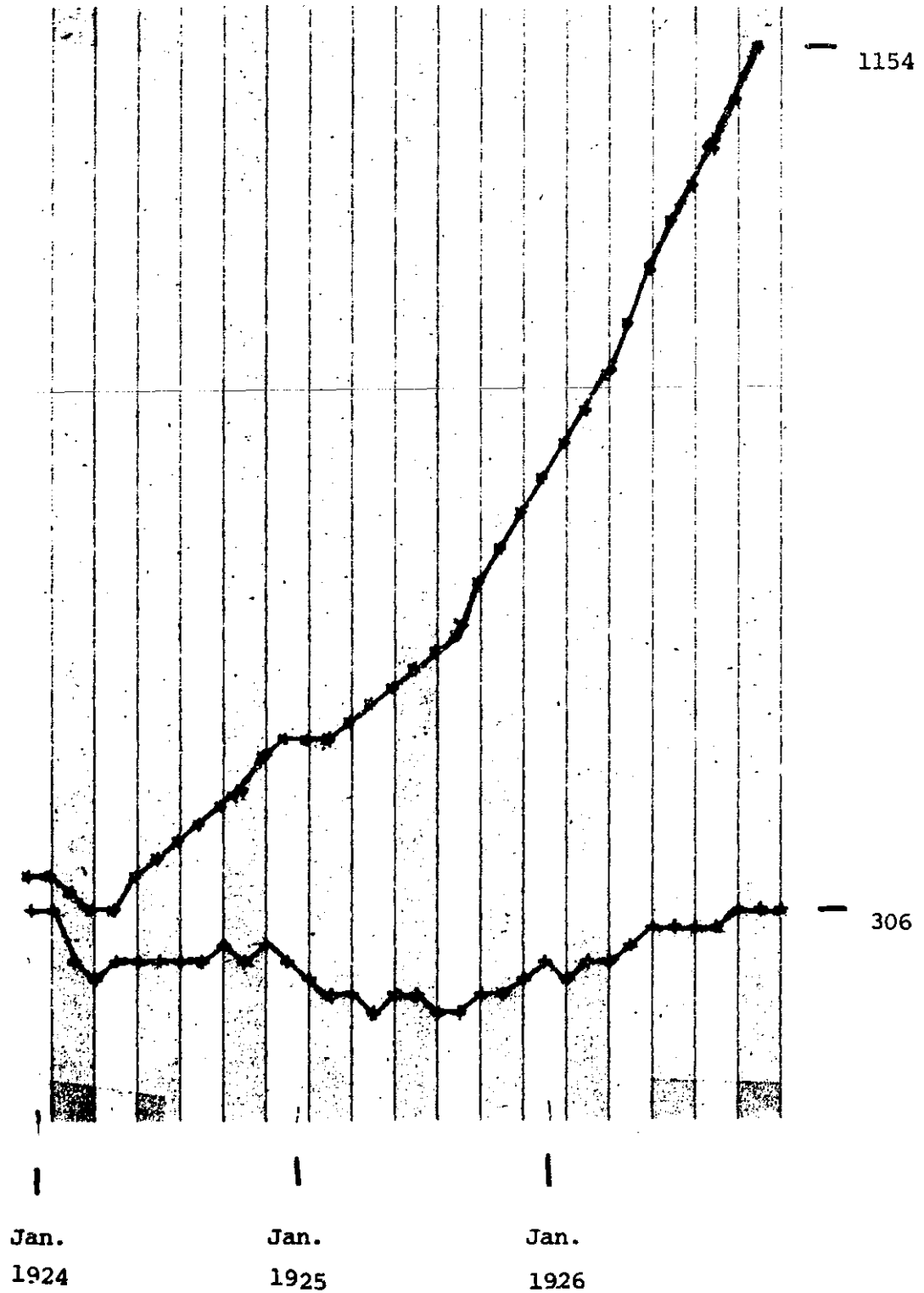
Or it may be that one of the exogenous variables (French income or U.K. money) was in fact influenced by the intervention. In any event, the drop is much less than actually occurred. The 1924 intervention had little effect on the long term path of the exchange rate--by July 1926 the simulated exchange rate is only 1.6% higher in the absence of intervention than it is if the intervention dummy is included.

Secondly, we note that after July 1926 the simulated rate keeps on rising steadily. This demonstrates that continued depreciation would have taken place in the absence of intervention, due largely to the reaction of the money supply and the forward discount to previous depreciation. This simulation was extended for three years past the end of the sample (1927-29) assuming that the exogenous variables remained constant at their December 1926 values. The franc continued to depreciate along a virtually straight line after 1926; the rate of depreciation fell only slowly, from 6 1/2 percent to 5 1/2 percent per month over the last three years.

The second experiment we perform is to simulate the exchange rate assuming that the French money supply was held constant beginning in January 1924. Figure 4.5 shows the simulated rate with constant money plotted against the simulated rate in Figure 4.4. The difference is dramatic--while the exchange rate does not become constant, it remains relatively stable and at the end of the period remains lower than at the beginning. This supports Milton Friedman's contention that the depreciation in the franc was in some sense the fault of the monetary authorities. While we may not accept the monetarist view of how money affects the exchange rate, it seems clear that an appropriate monetary policy

Figure 4.5: Simulated path of exchange rate given a constant French money supply, Jan. 1924 - Dec. 1926

above: simulated path with actual money supply
below: simulated path with constant money supply



would have satisfactorily restrained the franc in this period.*

In Figure 4.6 we show the simulation of the model assuming that the forward discount was zero throughout the simulation period, 1924-26. This path is plotted against the simulated path of the actual rate including the forward market (but excluding intervention). It is evident that the franc depreciates more if the forward discount is included. This can be construed as evidence that investors' expectations affected the path of the franc; whether this constitutes destabilization is another matter. But is it clear from Figure 4.5 that in the absence of the endogenous monetary policy the impact of the forward market on the exchange rate is not great.

Finally, in Figure 4.7 we simulate the model assuming an additional 10% fall in the franc in December 1923. This shock might, for example, be due to a wave of selling by foreign speculators, as described by Schuker. It is clear from the figure that this shock does not result in any further depreciation; instead the franc converges slowly to the path it would have taken in the absence of the shock.

However, it remains true that the government did not in fact pursue a sensible monetary policy while the franc floated, and this leaves room to argue that the floating franc was, in some sense or other, actually unstable. Nurkse's argument was not that floating rates were unstable as a logical necessity, merely that in practice they worked out that way. It is perhaps worth pointing out that in the French case the government did not attempt anything in the way of a managed float--the choice seems to have been perceived as one of complete stabilization or

*) Of course, this is evident merely from the fact that it was successfully stabilized.

Figure 4.6: Simulated path of exchange rate given a zero forward discount, Jan. 1924 - Dec. 1926.

above: simulated path with actual forward discount
below: simulated path with zero forward discount

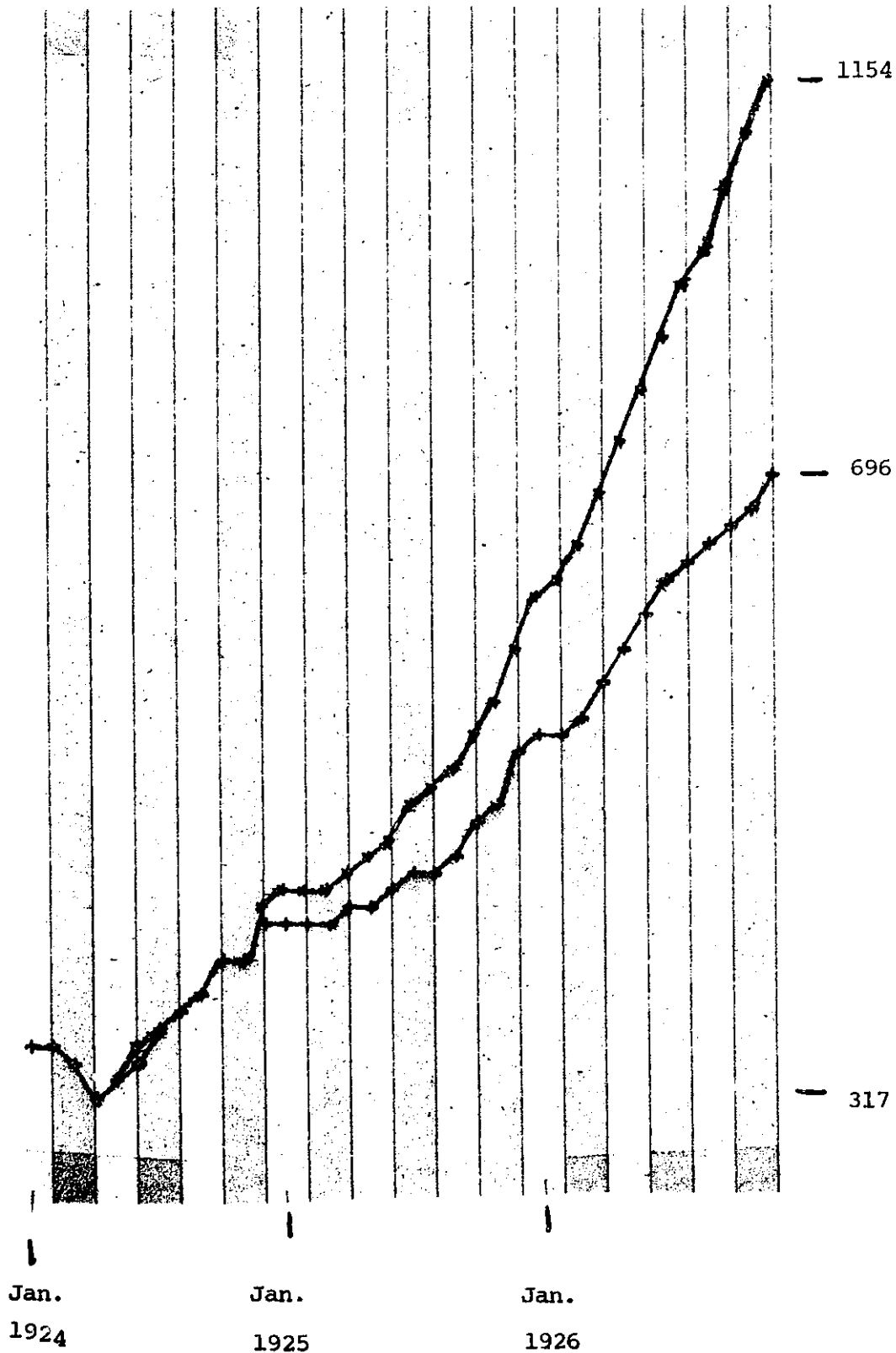
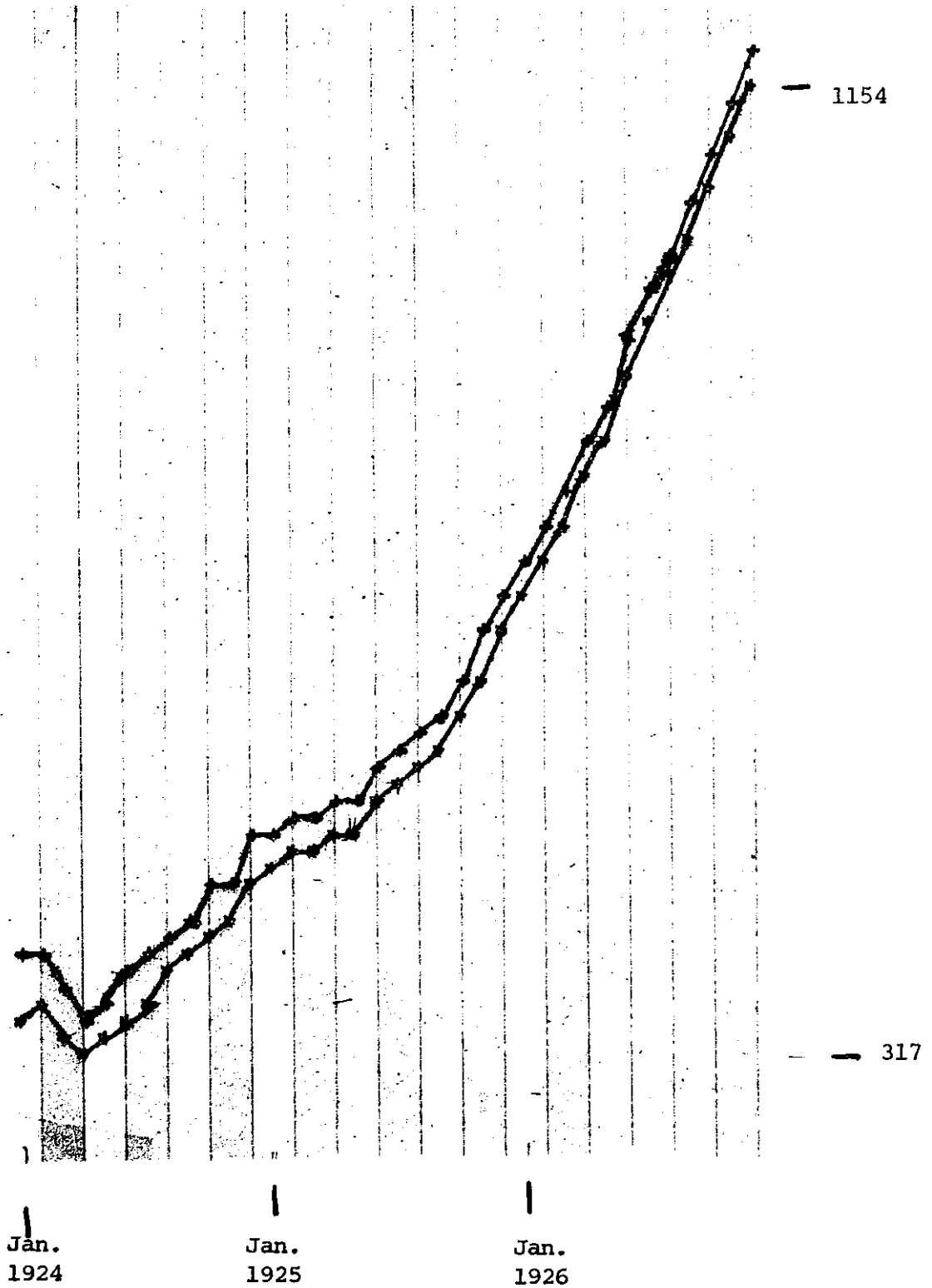


Figure 4.7: Simulated path of exchange rate given a 10% devaluation in December 1923.

above: simulated path given shock
below: simulated path with no shock



chaos. But while the response of investors to the continuing depreciation can be measured empirically, the evidence shows that it was the behavior of the government, not of investors and speculators, that caused the instability in the franc.

Chapter Five

Conclusion

The preceding four chapters have presented some detailed empirical studies of the floating franc. We have examined the relationships between goods prices and the exchange rate, between the forward price and the spot price of foreign exchange, and between the money supply and the exchange market. In this conclusion we attempt to pull together these econometric results and provide some answers to the general questions about the franc that were posed in the introductory chapter. We start by reviewing the major findings, and then turn to an analysis of them. Following the pattern of the whole work, we consider both problems in the general theory of exchange rate determination and specific questions about the behavior of the franc in the 1920's.

In chapter 2 we established that the PPP hypothesis does not hold in the French case, whether for consumer or wholesale prices, whether from month to month or with a lag for price adjustment. If we fit the equation

$$(5.1) \quad \ln s_t = b_0 + b_1 \ln (P_t/P_t^*)$$

we obtain estimates of b_1 significantly greater than 1.0, indicating that monthly changes in the exchange rate typically exceed simultaneous changes in the relative price ratio. If we assume that prices are merely sticky,

and require some months to respond to exchange rate changes, we can rewrite the PPP hypothesis as

$$(5.2) \quad \ln (P_t/P_t^*) = c_0 + \sum_{i=0}^n \lambda_i s_{t-i}$$

Estimating this equation we obtain values for the sum of lagged coefficients which are significantly less than one, showing that even after a six month lag, a change in the exchange rate will exceed the change in the price ratio.

Equation (5.1) was reestimated using various groups of traded goods for France and the U.K. For imported goods prices an estimate close to 1.0 was obtained for b_1 , while for certain exports the estimated coefficient was much smaller. After considering the impact of different weighting patterns between countries, we concluded that the observed failures of PPP are consistent with a model in which most traded goods prices equalize across countries, but nontraded goods prices do not.

This suggests that the exchange rate is exogenously determined with respect to prices, which respond stickily to changes on average: prices of tradables adjust relatively quickly and prices of nontradables much more slowly, if at all.* The assumption of PPP as a structural equation in monthly exchange rate models is thus shown, in this case at least, to be inappropriate. However, this is a much stronger form of the PPP hypothesis than is conventionally used; it may still be true that PPP holds for annual data, or across countries at any given time.

*) It is also possible that relative price changes (between traded and nontraded goods) within each country are exogenously determined by real sector events, and that the exchange rate moves with the price of tradables. Given the large magnitude of the exchange rate fluctuations in France this seems unlikely.

In chapter 3 we examined the rational expectations hypothesis using forward exchange market data, and found that the hypothesis could be rejected in the French case. Estimating the equation

$$(5.3) \quad (\ln s_t - \ln s_{t-1}) = b_0 + b_1 (\ln f_{t-1} - \ln s_{t-1})$$

we obtain an estimate of $b_1 = 7.3$ after the periods of government intervention are excluded. The estimate of b_1 is significantly greater than 1.0, and we conclude that the forward market systematically underestimated the actual depreciation of the franc, by a factor of seven.

One interpretation of this result is that expectations about the future were in fact biased; another is that the forward price of foreign exchange for one reason or another does not reflect investors' actual anticipations about the future, and that the correlation observed in (5.3) has some other meaning, and may even be a statistical artifact. This question cannot be conclusively answered, since the actual behavior of investors is unobservable, although in chapter 3 we argued that the result was probably not due merely to statistical problems. As shown in Figure 3.3, from 1924 onward the percentage forward discount on the franc is always greater than the France-U.K. interest differential, often by a substantial margin. From this one might conclude that since the discount is not being determined simply by interest rate arbitrage, it does reflect investors' expectations about the future.

In chapter 4 we estimated a monetarist equation for the spot rate itself:

$$(5.4) \quad \ln s_t = b_0 + b_1 \ln (M/M^*)_t - b_2 \ln (y/Y^*)_t \\ + b_3 (r - r^*)_t$$

which was obtained by solving conventional money demand equations for P and P^* and substituting the results into the PPP equation (5.1). The estimates of (5.4) showed that there was significant evidence of structural change if the sample was divided into two periods, 1920-23 and 1924-26. In the early period the coefficient on money b_1 is small and insignificant, while in the second period it is significantly greater than one. The coefficient on income is positive (perverse) in the early period and insignificant in the latter, while interest rates have no measurable impact on the spot rate in either period.

The positive coefficient on income can readily be attributed to the effect of changes in income on the trade balance, which overwhelm the effect of changes in income on the demand for money. A higher level of real income requires a higher trade surplus in order to maintain aggregate demand, and this requires a depreciated exchange rate. This offsets the fact that a higher real income raises demand for real money balances, requiring lower prices and hence, by PPP, an appreciated exchange rate. On this point the evidence clearly supports the Keynesian, Mundell-Fleming, point of view instead of the monetarist approach. But we cannot conclude from the evidence whether exogenous changes in income drive the exchange rate, or the reverse; all we can say is that there is an empirically significant relationship between the two variables.

The coefficients on the money supply are more puzzling. It is true that the existence of deviations from PPP means that we should not expect to find $b_1 = 1.0$ exactly; this also follows from our finding that money demand is not perfectly homogenous with respect to prices. However, the actual estimate of b_1 in the second period is too large to be explained

in this way, given the PPP results. That is, a unit change in the money supply simultaneously creates a more than proportional change in the spot rate, and this cannot satisfactorily be attributed to the effect of the change in real money balances on the price level and thence on the exchange rate. This result implies the existence of some other link between the money supply and the exchange rate, one which is omitted from the monetarist model.

The Mundell-Fleming view is that in the short run the spot rate is determined by capital flows generated by interest rate changes. If changes in the money supply change not prices but interest rates, the result should be a capital flow affecting the price of foreign exchange. This interpretation seems to be ruled out by the fact that the coefficient on the interest differential, b_3 , is completely insignificant. However, if we substitute the forward discount on francs for the interest differential in estimating (5.4) we obtain a large positive coefficient. This suggests that the forward discount is a better measure of the return to holding foreign exchange than is the interest rate differential. This is consistent with Mundell-Fleming in that an increase in the discount on francs raises the return to foreign exchange, creates a capital outflow, and thus causes depreciation of the franc (a rise in s_t).

But this does not provide the whole answer, because we still find a very strong impact of money even when the forward discount is included in equation (5.4). If the impact of money is through interest rates or the forward discount there should be substantial multicollinearity between the two variables, and we do not find this. Thus the money supply seems to be affecting the spot rate in some way besides through the price level

or the rate of return as measured by the interest rate and the forward discount.*

One explanation is that when the public has excess holdings of domestic money it merely exchanges domestic for foreign (and gold-denominated) currency. Another is that domestic money creation results in expected depreciation, and hence in a capital outflow, but that we cannot observe these expectations. The expected return is correlated with the forward discount, but not perfectly, so that including the discount in (5.4) gives the right sign but does not eliminate the effect of money. It may also be true that money affects the spot rate in both ways, through the price level and capital outflows.

The safest conclusion seems to be that neither the Mundell-Fleming nor the monetarist model gives a complete picture of the process determining the franc in this period. This should not be surprising, since each represents an extreme position: that either monetary or real sector variables are of no (empirical) importance. What we have shown is that not only can we measure real and monetary effects in the French case, but we can at least infer the existence of a phenomenon that is explained by neither model. It would clearly be helpful at this point to have an explicit portfolio model of investors' behavior, but since we lack the data to estimate one if we did we must conclude that much of

*) We should note again that this result has not been established in any formal statistical sense; but it does seem to be the logical implication of the results we have obtained.

speculative behavior is essentially unobservable.*

Before turning to a discussion of the historical issues we take note of some methodological findings that were obtained in the course of this work. The PPP analysis showed that by using the best available data sources for the full period of the franc float the PPP hypothesis can be rejected even if simultaneous equation bias is considered; this contradicts the results of several earlier investigations. In the chapter on the forward market it was shown that one conventional test of rational expectations led to a spurious acceptance of the hypothesis in this case. And in the tests of the monetarist spot rate equation we demonstrated that while certain specifications lead to acceptance of the prior expectations about the coefficients implied by the monetarist model, these hypotheses can be rejected for the French case. This can be shown by splitting the period to account for structural change over time, or by estimating the structural equations in the model and thus testing the priors directly.

As discussed in the introduction, several early studies concluded that the depreciation of the franc could not be explained using conventional economic variables. The behavior of the franc was thought to be governed by noneconomic (political or psychological) factors, which precluded successful economic modelling. This view can confidently be rejected on the basis of the spot rate equation estimated in chapter 4, which has an

*) We are in something like the position of an astronomer who has a telescope strong enough to observe that a planet is not where he thought it would be, but not strong enough to find the second planet which must be altering the path of the first.

excellent fit overall. Uncertainty may remain as to the exact structure which determines the spot rate, but there is no doubt that a satisfactory explanation based on economic variables exists. The depreciation of the franc can be attributed to the relative increases in the money supplies and incomes that occurred during the period.

The major issues outstanding have to do with the way in which these variables determine the spot rate. In particular, the literature is concerned with the overall stability of the process and with the role of speculation and expectations in it. In the last section of chapter 4 we analyzed a dynamic model of the franc, and we can use the results to shed some light on these questions, although we do not always reach definitive conclusions.

It has long been argued that the inflationary French budget policy was caused in part by the continuing depreciation of the franc. We tested this hypothesis above by regressing the money supply on the lagged exchange rate, and obtained significant coefficients. This confirms the historical view that continuing depreciation forced the government to borrow from the central bank instead of from the public, resulting in more depreciation. This phenomenon seems to have been of great importance: if we simulate the path of the franc holding the money supply constant we find it to be much more stable. (This does not necessarily imply that the government actually had the capability, political or technical, to pursue such a course.)

Does this result imply that the franc was in some sense unstable? Only in a rather limited sense is this true. Our first simulation exercise showed that in the absence of intervention, depreciation would

have continued at a rapid rate for some time. Thus the franc was unstable in the sense that it did not, and would not, settle down to some equilibrium value and stay there within any (politically) reasonable time period. However, the franc does seem to have been relatively stable about this path.

The system is stable about its steady state over a period of three years, and the intervention simulation shows that a relatively sharp shock in one period has little effect on the path of depreciation. (See Figure 4.7.) This is hardly a conclusive stability analysis, but it suggests that the underlying process was one of fairly steady depreciation.

This suggests that Schuker's scenario is not particularly apt. It is perfectly possible that speculators intervened in the forward market late in 1923 in an attempt to start a continuing depreciation--we have no new evidence on this. And the reduced form equation (5.4) shows that sudden changes in the forward discount would have a substantial impact on the spot rate. But we cannot make the last step, and say that a sudden fall in the franc would promptly trigger an ongoing depreciation; the system does not seem to be very sensitive to short-term disturbances. Rather we have the impression of a certain inevitability in the process--given the behavior of the money supply, depreciation occurred regardless of other events.

We now consider whether the presence of speculators can have exacerbated whatever depreciation was caused by the money supply; this is the familiar problem of destabilizing speculation. One of the most obvious ways in which expectations could be "destabilizing" is if the anticipated rate of

future depreciation is equal to some multiple of actual past depreciation:

$$(5.5) \quad \ln {}_t s_{t+1}^e - \ln s_t = c (\ln s_t - \ln s_{t-1})$$

We assume that the actual future rate is equal to the expected rate plus an error term, so

$$(5.6) \quad \ln s_{t+1} - \ln s_t = c (\ln s_t - \ln s_{t-1}) + u_{t+1}$$

We can think of u_t as embodying all non-speculative influences on s_t , so that it need not be perfectly random. The effect of speculation is (arbitrarily) considered as a distinct influence on the spot rate.

This system can be defined as unstable in at least two ways. If $c > 1$ or $c < -1$, the equation for s_t is explosively unstable and s will blow up if it is shocked (unless the forces summarized in u_t eventually bring it to equilibrium). If $1 > c > -1$, s_t will converge to some new equilibrium if shocked, but it still can be said that speculation has affected the equilibrium path--this is what is sometimes meant by destabilizing speculation. This formulation does not cover all possible definitions of destabilizing speculation,* but it has the twin virtues of simplicity and testability.

We estimated a version of (5.5) in chapter 4, using the forward rate as a proxy for ${}_t s_{t+1}^e$ and a polynomial distributed lag on the spot rate on the right hand side. The results showed a small, but statistically significant, impact of the lagged spot rate on the current forward discount.

*) For example, we have assumed that in the absence of exogenous forces speculative activity would somehow cause the future spot rate to have the value that was earlier anticipated for it. If this is not the case there is an added source of instability, as defined. This type of destabilizing speculation is difficult to test for, since it requires that we observe u_t , which can only be done under some very strong assumptions about the determinants of the exchange rate.

If we accept that the forward rate is a good measure of expectations, this result can be taken as evidence of destabilizing speculation. However, we might further ask whether the effect is large enough to have any economic importance. Since the mathematical form of the equation is difficult to analyze we use the simulation results to address this problem.

The simulation in which the money supply was held constant allowed the forward rate to respond to the lagged spot rate as before (implicitly assuming that investors did not recognize the new monetary policy). The franc depreciated rapidly in the months leading up to the start of the simulation in January 1924, so that if the behavior of the forward discount tended to destabilize the system we might reasonably expect it to do so in this experiment. But as was described above, the path of the franc under a stable monetary policy shows little fluctuation. Since some of this was due to changes in the exogenous variables, we conclude that destabilizing speculation, while perhaps a theoretical possibility, was not an important factor in this case.*

We close by examining the Nurkse-Friedman debate, which has been the impetus for this and many other studies of the French franc and floating exchange rates in general. There are two real issues here. One is whether fluctuations in floating exchange rates are due solely

*) We note in passing that the Tsiang-Aliber criterion for destabilizing speculation, the existence of deviations from PPP, does not apply because we have attributed these to the weighting of traded and non-traded goods prices. Aliber's analysis of the forward discount is rendered suspect by his correction for the interest differential, as discussed in the introduction.

to changes in exogenous variables, or whether they are inherent in any floating rate regime. The second is whether the presence of speculation in a floating rate system improves or worsens ("stabilizes" or "destabilizes") variations that would have occurred anyway.

About the second problem little can be said. It is conceptually difficult--defining what the equilibrium value of a floating exchange rate would be in the absence of all speculation comes close to being a contradiction in terms. Further, there is little evidence on which to test such a proposition, once defined. The test we did perform showed no substantial effect--we conclude that no unambiguous statement is possible about the qualitative effect of speculation on the exchange rate.

We can however infer the existence of some effect; the analysis of the reduced form spot rate equation suggests (unsurprisingly) that expectations about the exchange rate played some role; the monetarist model, in which the spot rate is determined in a mechanical fashion by the price levels, is inadequate. It is evident that changes in the money supply have their effect on the spot rate by affecting expected depreciation in some fashion, but we cannot say anything about the stabilizing properties of this phenomenon. It is at least not demonstrably destabilizing.

Thus neither side has any empirical support for arguing that expectations do or do not stabilize the exchange rate. But implicit in Friedman's argument is the view that the behavior of the franc was a normal response to changes in the money supply, and this interpretation receives support from the evidence. The money supply played the major role in causing the depreciation of the franc in 1924-26, as is evident from the simulation

of the franc with a constant money supply. Money is indeed the key explanatory variable in this case, as the monetarist approach predicts, although the effects of income changes and price rigidities are large enough to be measured.

However, two qualifications to this endorsement must be noted. Ceteris paribus, the franc depreciated much more than in proportion to changes in the money supply; it is open to question just how "normal" was the response of the market to the money stock. We can safely say that the market response of investors was highly volatile, whether or not destabilizing, and that is perhaps all that matters.

And finally, it is clear that the money supply was not in fact exogenous, and that depreciation was thus built into the system. Nurkse seems to have been wrong in attributing this instability to investors rather than to the government, but he was right in saying that such instability was inherent in the French case. Given the political realities and the technical ability of the French treasury staff it seems likely that a managed float was an impossibility at the time--the choice lay between complete stabilization (but only after the lesson had been learned) or no control at all. It remains uncertain to what extent Nurkse was justified in generalizing from this episode to all floating exchange rate systems, either retrospectively for the 1920's or looking ahead to what is now the present day.

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