THE FLOATING POUND STERLING OF THE NINETEEN-THIRTIES: AN ECONOMETRIC STUDY*

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In contrast to the "clean" floating of the 1920s, the 1930s saw the emergence of managed or "dirty" floating, with official stabilization funds established to intervene in gold and foreign-exchange markets in order to influence exchange rates. The era of managed floating was initiated by Britain with the establishment of the Exchange Equalization Account (EEA) in April 1932.[1] The EEA was novel in both organization and intent, its stated goal being the prevention of "undue fluctuations" in the external value of the pound.

We attempt in this paper to analyze exchange-rate behavior in an era of managed floating.[2] The model is applied to the monthly-average exchange rate between the British pound and the U.S. dollar for the months October 1931 through December 1938. October 1931 was the first full month in which the pound was floating, while the jittery months of 1939 prior to the outbreak of European war and the imposition of exchange controls are excluded as too abnormal. Our empirical results shed some light on the twin questions of the efficiency of exchange markets in the 1930s and the contribution of official intervention to exchange-rate stabilization. Although the £-$ rate was highly variable, it appears that most of this variability can be accounted for by changes in the broader economic conditions and policies impinging on foreign-exchange markets rather than as the result of febrile speculation emanating within these markets. The activities of the EEA are estimated to have had a small, though significant, effect on the inter-month variation of the exchange rate, but the lessened variability after December 1933 seems mainly to reflect more stable economic conditions and policies in Britain and the U.S.

The framework for the subsequent analysis is set out and discussed in Section I. Section II describes the empirical implementation and presents the econometric results. A brief Section III adds concluding comments and reflections and an Appendix describes the data utilized.

I. THE FRAMEWORK OF ANALYSIS

Following Hodgson's work [7] on experience in the 1920s, we use an equation for the exchange rate derived from the traditional theory of the foreign-exchange market.[3] Assume for the moment a two-country world of America (subscript a) and Britain (subscript b). Let p_a, p_b, Y_a, Y_b, r_a, r_b be the respective (own-currency) price levels, real income levels and interest rates. Let R, the

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1 The EEA became active on July 1, 1932. Prior to this, the Bank of England had undertaken some intervention (see [1]), For details on the formation and operations of the EEA see [1, 6, 10, 11, 15].

2 For other econometric studies of international finance in the 1930s see [3, 8, 12]. For background on the international monetary history of the interwar period see [4, 5, 9, 17].

3 Also see [13].

exchange rate, be the dollar price of one pound sterling. Denote net official intervention (expressed as a demand for sterling) by E, and speculators' expectation of the future exchange rate by R^s. The variable G is a shift variable allowing for the effects of the US departing from the gold standard in 1933. In this notation the reduced form is

$$(1) \quad R = f(p_b/p_a, Y_b, Y_a, r_b-r_a, E, G, R^s)$$

Assuming Marshall-Lerner like conditions are satisfied an increase in p_b/p_a tends to depress R through effects on exports and imports, as does an increase in Y_b or a decrease in Y_a. The net uncovered demand for sterling on capital account is assumed to depend positively on both r_b-r_a and R^s-R, so that R in (1) will depend positively on r_b-r_a and R^s.[4] An increase in R^s is assumed to raise R by a lesser amount due to the imperfect elasticity of speculative capital flows, our viewpoint on speculation being to regard it as primarily undertaken by a small group of well-informed individuals and institutions having limited borrowing power and aversion to risk. Finally, R is assumed to increase with the official support for sterling, E, and also with the shift, G, since the US gold devaluation of 1933–4 would be expected to appreciate the £ against the \$ through arbitrage and changes in trade patterns.

The inclusion of the shift variable G implicitly allows for third-country influences. More generally it can be shown that, due to cross-rate arbitrage, prices incomes and interest rates of third countries enter (1) similarly to American variables for countries pegged to the \$; to British variables for countries pegged to the £; and with weaker effects of ambiguous direction for countries floating free of both the £ and the \$.[5] Cross-rate and gold arbitrage can also transfer to the £-\$ market any intervention in other markets, whether by the EEA or some other exchange authority.[6] For simplicity, economic conditions in third countries are not added to (1), nor are the activities of stabilisation funds other than the EEA taken into account.[7] But the variable E should be interpreted as the net supply of £ made available to the £-\$ market, either directly by the EEA or indirectly through arbitrage induced by the EEA's activities in other markets.

For empirical implementation the variables Y_a, Y_b are assumed to enter (1) as the single ratio variable Y_b/Y_a and (1) is otherwise assumed linear. Denoting $(p_b/p_a)_t = X_t^1$, $(Y_b/Y_a)_t = X_t^2$, $(r_b - r_a)_t = X_t^3$, $E_t = X_t^4$, $G_t = X_t^5$ (where the subscript denotes the month of observation) equation (1) with a general lag structure added may be rewritten compactly as

$$(2) \quad R_t = \mu \left\{a + \sum_{j=1}^{5} \sum_{i=0}^{\infty} \alpha_i^j X_{t-i}^j\right\} + (1-\mu)R_t^s + \theta_t; \; 0 < \mu < 1$$

with θ_t a random variable. If speculators have good knowledge of the economic forces at work, their expectations will be of form

$$(3) \quad R_t^s = b + \sum_{j=1}^{5} \sum_{i=0}^{\infty} \beta_i^j X_{t-i}^j + \Psi_t$$

where the random variable Ψ_t allows for the

[4] The forward market is not incorporated explicitly into the discussion. Arbitrage is assumed to convey all uncovered capital movements to the spot market and to offset the spotmarket effects of all covered capital movements. Similar results would be obtained by following [14] in assuming interdependent spot and forward markets and obtaining a reduced-form equation for the spot rate, R. For a full development see [2]. Attempts to allow for a portfolio-reallocation element in capital movements by introducing into (1) the *change* in the interest-rate differential proved statistically unsuccessful so that this possibility is disregarded in what follows. Seasonal variation is excluded for similar reasons.

[5] See [12] for a development of the 3-country case and application to the US-UK-Canada triangle of the 1930s.

[6] Indeed, most of the EEA's interventions during the '30s were in other markets, any currency acquisitions being quickly converted into gold, and, during the earlier years, being mainly of francs rather than dollars.

[7] The major funds were the American (1934), Belgian (1935), Canadian (1935), and Swiss, French and Dutch (1936). The Canadian fund never operated at all, and the others finished up, for the most part, carrying on gold-pegging activities previously undertaken by the central bank. Only the EEA appears to have played a major discretionary role. After the Tripartite and Gold Agreements of September-November 1936, the funds acted in concert, so that additional effects on the £-\$ rate could hardly be expected.

expectational effects of particular events, both economic and non-economic. Rational expectations is a special case of (3), but we do not impose any such strong assumption. In particular, speculators might be supposed to give relatively heavier weight to recent values, thus expediting exchange-rate adjustments; or they might think in terms of "normality" and give relatively greater weight to less-recent values, thus helping to retard adjustment and damp exchange-rate fluctuations. Both interpretations are expressed in the literature, reflecting differing judgements as to what can reasonably be assumed about the sophistication of speculators' expectations, the lengths of their horizons, and the transaction cost of currency switches. Substituting (3) in (2) gives

$$(4) \quad R_t = A + \sum_j \sum_i B_i^j X_{t-i}^j + \epsilon_t$$

$$A \equiv \mu a + (1 - \mu)b;\ B_i^j \equiv \mu\alpha_i^j + (1 - \mu)\beta_i^j;\ \epsilon_t \equiv \theta_t + (1 - \mu)\Psi_t$$

In Section II this equation is estimated directly, treating ϵ_t as a (possibly autocorrelated) disturbance term with zero mean. Since the underlying parameters of (2) and (3) remain unidentified, hypotheses on the lag structure of (2) can be tested only very roughly by comparing the best-fitting lag structure in (4) with prior beliefs as to the lag structure appropriate to (3).

In the statistical work the contemporaneous price, income and interest-rate variables are omitted from (4) to avoid any risk of simultaneous-equation bias with regard to these variables. (This would be unnecessary if any feedback from the exchange rate to these variables operated with a lag.) However, a similar treatment of E is implausible since official intervention should affect the exchange rate almost instantaneously. The potential problem of simultaneous-equation bias with regard to E is evaded here by assuming that E is an exogenous policy variable.[8]

II. EMPIRICAL IMPLEMENTATION AND RESULTS

For empirical purposes the observations on real income are proxied by employment indices (1929 = 100), monthly income data being unavailable. Prices are represented by wholesale price indices (1926 = 100 for America and 1930 = 100 for Britain), while interest rates are three-month bill rates, measured in percentage points.[9] The exchange rate is measured in dollars per pound. The shift variable G assumes value zero up to March 1933 and one afterwards.

EEA activity is represented by a simple proxy. Effectively, E is assumed to take on only three values—a value of $e > 0$ when the EEA is intervening to support the rate, a value of $-e$ when it is intervening to depress the rate, and a value of 0 when it is not intervening significantly. Given linearity, there is no real loss of generality in taking $e = 1$, so that E is represented by a dummy variable with possible values $(-1, 0, +1)$. The assignment of a value to E in any month is based on a perusal of the reports relating to the month which appeared in *The Economist* and *The Commercial and Financial Chronicle*.[10] The aim was to distinguish those months in which market commentators viewed the EEA as actively intervening to raise or depress the exchange rate. There is, of course, a considerable subjectivity about such assignments, made worse by the fact that, in a given month, the EEA may have been reported as intervening in both directions. But the important fact is that the assignments were made independently of, and prior to, their use in regression studies, and are open to independent verification.[11]

[8] This bias problem, which does not seem very serious practically, is considered further in [16]. The way E is proxied below by a dummy should reduce any bias. More refined estimation may be justified when a better measure of E is obtained.

[9] These appear more satisfactory empirically than either call rates or long rates. The data sources are indicated in the Appendix.

[10] The assignments, which are detailed in the Appendix, are reproduced without change from [8] where more complicated attempts to allow for different degrees of intervention and for the operations of the American Stabilisation Fund are described.

[11] The validity of this dummy variable is confirmed in [16] by results for alternative rough measures of E based

The simplest result is obtained by merely lagging price, income and interest-rate variables by one month to get:[12]

$$(5)\quad R_t = \underset{(17.80)}{6.743} - \underset{(1.02)}{0.350}\,(P_b/P_a)_{t-1} - \underset{(4.62)}{1.177}\,(Y_b/Y_a)_{t-1} + \underset{(1.22)}{0.044}\,(r_b - r_a)_{t-1} + \underset{(3.12)}{0.086}E_t + \underset{(13.68)}{1.102}G_t$$

$\bar{R}^2 = 0.913$, D.W. $= 0.576$, $N = 86$

The coefficient of the shift variable, G, indicates a full \$1.10 rise in the price of the £ as a result of the U.S. devaluation against gold-bloc currencies. An average intervention by the EEA is estimated to have raised or lowered the exchange rate by 8.6 cents.[13]

All parameters in (5) have their expected sign but there are some unsatisfactory features. Besides strong serial correlation, there is an over-simple treatment of response lags. For while it is true that the intervention and interest-rate variables might be expected to exert their full effects quickly, an equally-rapid response to the price, income and gold-devaluation variables seems less plausible, since changes in commodity trade patterns are required. A failure to discover distributed lags could result from speculators anticipating and expediting the exchange-rate effects of changes in prices and incomes. But it is desirable to test for the non-existence of distributed lags before falling back on such an explanation.

We now develop a formulation which allows any chosen subset of variables to be subjected to the same geometric distributed-lag response. Proceeding somewhat generally, let $X_t^1 \cdots X_t^k$ be explanatory variables whose effect is to be subjected to the distributed lag. They will be called "long-term" variables. Let $X_t^{k+1} \cdots X_t^m$ be explanatory variables whose full effect is assumed to be immediate. They will be called "short-term" variables. Consider now the adjustment equation

$$(6)\quad \Delta\left(R - \sum_{i=k+1}^{m} \alpha_i X_t^i\right) = (1-\lambda) \cdot \left[\sum_{i=1}^{k} \alpha_i X_t^i - \left\{R_{t-1} - \sum_{i=k+1}^{m} \alpha_i X_{t-1}^i\right\}\right] + u_t$$

where Δ is the backward-difference operator. This formulation "purges" R of the effects of short-term variables before allowing for the distributed-lag operation of the long-term variables.[14] A constant term can be introduced by taking any one of the variables as unchanging.

If $X_t^1 \cdots X_t^k \equiv 0$, (6) reduces to the Cochrane-Orcutt case with autoregressive parameter λ, and if $X_t^{k+1} \cdots X_t^m \equiv 0$ it reduces to the standard Koyck case, and may be rewritten

$$(7)\quad R_t = \sum_{i=1}^{k} (1-\lambda)\alpha_i X_t^i + \lambda R_{t-1} + u_t$$

All intermediate cases may be estimated by modification of the Hildreth-Lu scanning procedure developed for the Cochrane-Orcutt case. This chooses λ, transforms R_t and $X_t^1 \cdots X_t^m$ into $y_t = R_t - \lambda R_{t-1}$, $x_t^i = (1-\lambda)X_t^i$ for $i = 1 \cdots k$, $x_i = X_t^i - \lambda X_{t-1}^i$ for $i = k+1 \cdots m$, and then estimates by OLS

$$(8)\quad y_t = \sum_{i=1}^{m} \alpha_i x_t^i + u_t$$

The process is repeated for different values of λ to find the minimum for $\hat{\sigma}_u^2$, the estimated variance of u_t.

on the official quarterly figures of reserves given in Reserves and Liabilities (Cmd 8354; H.M.S.O., London, 1951) and the rough indirect estimates made in [10]. We hope to extract from the archives comprehensive data on EEA activity.

[12] Estimated by ordinary least squares (OLS). Figures in parentheses are t-ratios. D.W. is the Durbin-Watson statistic.

[13] To get an idea of the order of magnitude of the price, income and interest-rate effects, note that in equation (5) a percentage point rise in r_b would raise R by 4.4 cents. A 10% rise in p_b at the sample mean value for p_b/p_a of 1.23 would depress R by 4.3 cents. A 10% rise in Y_b at the sample mean value for Y_b/Y_a of 1.28 would depress R by 15.1 cents.

[14] There is no strong *a priori* reason to suppose that u_t in (6) is not autocorrelated, but such an assumption seems empirically valid in all cases reported below. This implies (as (5) suggests) an autocorrelated disturbance term, ϵ_t, in the explicit solution of (6) into form (4) (specifically $\epsilon_t = u_t + \lambda\epsilon_{t-1}$).

In applying this procedure we imposed the a priori restriction that the same lag operate for both price and income effects and also for both interest-rate and intervention effects. Table I presents the results with $X_t^1 \cdots X_t^6$ taken as, respectively, $(P_b/P_a)_{t-1}$, $(Y_b/Y_a)_{t-1}$, G_t, $(r_b - r_a)_{t-1}$, E_t, const. These are exactly the independent variables appearing in (5). Case 1 is the Cochrane-Orcutt case with (5) re-estimated by the Hildreth-Lu procedure assuming its disturbance term satisfies a first-order autoregressive scheme. Case 2 allows the price and income variables to work with a distributed lag. Case 3 allows the price, income and gold-devaluation variables to work with a distributed lag. Finally, Case 4 is the Koyck case, directly estimated by OLS from (7).[15]

The most noticeable feature in the table is the sensitivity of the results to the treatment of the gold-devaluation shift, G. Taking this as a long-term variable considerably improves the goodness of fit (reduces $\hat{\sigma}_u^2$) but also diminishes the significance of the price, interest and income variables. This is doubtless a reflection of the fact that the full revaluation of the dollar against gold occurred only after several months of drifting following the suspension of convertibility by the USA in April 1933. The new parity was established only in January 1934. On balance, the best-fitting Case 3 seems the most accept-

[15] Cases 2 and 3 may be regarded as special cases of (6) with $m = 6$ and $k = 2$ and 3 respectively. For comparability with Cases 1 to 3, the values implied for the α_i are reported in Case 4, but the t- ratios refer to the directly-estimated $(1-\lambda)\alpha_i$. The low t- ratio for E in Case 4 is to be expected given the implausibility of supposing intervention to influence the exchange rate with the same distributed lag as other variables.

TABLE I

ESTIMATED VALUES OF α_i, λ, AND σ_u^2

(t-ratios under the null hypothesis the parameter is zero shown in parentheses)

X_i	Expected sign	Values of $\hat{\alpha}_i$ Case 1	Case 2	Case 3	Case 4
$(P_b/P_a)_{t-1}$	-	-0.686 (1.26)	2.08 (1.06)	0.586 (1.00)	0.604 (1.02)
$(Y_b/Y_a)_{t-1}$	-	-0.486 (1.44)	-3.509 (2.89)	-0.877 (2.15)	-0.830 (1.74)
G_t	+	0.443 (3.34)	0.534 (4.25)	1.379 (12.53)	1.408 (6.94)
$(r_b-r_a)_{t-1}$	+	0.023 (2.84)	0.079 (3.44)	0.026 (1.45)	0.068 (1.10)
E_t	+	0.035 (2.31)	0.032 (2.37)	0.026 (2.26)	0.060 (1.22)
$\hat{\lambda}$		0.95	0.90	0.72	0.709 (15.79)
$\hat{\sigma}_u^2$		0.0107	0.0106	0.0073	0.0078
D.W.		1.897	1.7786	2.076	1.978
N		86	86	86	86

able, indicating a significant distributed-lag effect of income, an insignificant effect of prices, a marginal effect of interest rates, and a small but significant effect from EEA intervention.

All cases in Table I suggest an average intervention effect well below the 8¢ estimated in equation (5), the smallest figure being the 2.6¢ of Case 3. The conclusion appears to be that the direct effect on the exchange rate of the EEA's activities, although discernible, remained modest.

If a typical intervention by the EEA altered the exchange rate by between 2 and 8 cents, did EEA activity contribute overall to stabilizing the exchange rate from month to month? The hypothetical exchange rate R_t^* that would have ruled in any month in the absence of EEA intervention can be estimated on the assumption of an unlagged intervention effect as

$$(9) \qquad R_t^* = R_t - \gamma E_t$$

where R_t is the actual exchange rate for the month, E_t is the actual value of the intervention dummy, and γ is the assumed intervention effect. But deciding whether R_t or R_t^* is the more stable is made difficult by the fact that R_t does not display a simple trend from which deviations might be measured. However, difficulties are mitigated for the 50-month interval November 1933 to December 1937 when the exchange rate had only a very slight trend.[16] For this interval the frequently-used procedure of comparing variances seems appropriate. The relative difference in variances is given by

$$(10) \quad \frac{\text{var}(R_t^*) - \text{var}(R_t)}{\text{var}(R_t)} = \frac{\gamma^2 \text{var}(E_t) - 2\gamma \text{cov}(R_t E_t)}{\text{var}(R_t)}$$

and is evaluated in Table II for various values of γ. Also shown in Table II is a similar calculation with R_t replaced by π_t, the deviation of R_t from its least-squares linear trend over the interval, and R_t^* replaced by $\pi_t^* = \pi_t - \gamma E_t$. This alternative eliminates trend, and is probably to be preferred conceptually. A positive value in Table 2 shows that exchange-rate variability would have been larger had the EEA not intervened. This would have certainly been true if the coefficient of E had been as large as the 0.08 reported in equation (5). On the other hand, for the γ values estimated in Cases 1 to 3 of Table I, the EEA activities appear to have actually increased the variance of the exchange rate.[17] But even with $\gamma = 0.08$, intervention is estimated to have lowered the variance of π_t only from var $(\pi_t^*) = 0.0061$ to $\text{var}(\pi_t) = 0.0043$. This represents a reduction in the standard deviation of π_t from 7.8 cents to 6.6 cents, which can hardly be described as more than modest. The reduction in the standard deviation of R_t is even less, being from 8.0 cents to 7.7 cents when $\gamma = 0.08$.

III. CONCLUDING REMARKS

Given the economic instability and political uncertainty of the 1930s, it is hardly a matter for surprise that exchange rates exhibited frequent, and often large, changes. However, the international currency experience of the 1930s is not so hopelessly confused or dominated by capital flight as to defy systematic econometric analysis. Our study suggests that much, but not all, of the variation in the £-$ rate can be accounted for by broad changes in economic conditions and policies bearing on foreign-exchange markets. In only one month, December 1931, is there a strong suggestion of severe speculative overshooting, and several distur-

[16] This interval includes 24 of the 46 months in which the EEA is viewed as intervening. The least-squares trend has $r = -0.442$ and slope -0.0023 with t-ratio 3.23. Since the means of R_t and R_t^* are virtually identical, ratios of variances are essentially equivalent to ratios of coefficients of variation.

[17] Other ways of measuring stability might give different conclusions, but a time-series chart of R_t and R_t^* makes it clear that the comparison is very delicate for small γ (say 0.02), the essential reason being a positive covariance of R and E. For large γ (say 0.08) it is clear visually that R_t^* becomes considerably more irregular than R_t.

TABLE II
RELATIVE VARIANCES FOR PERIOD NOV. 1933 TO DEC. 1937

γ	(var(R*) − var(R)) / var(R)	(var(π*) − var(π)) / var(π)
0.02	−0.0743	−0.0700
0.03	−0.0874	−0.0125
0.04	−0.0844	0.0274
0.06	0.03034	0.1733
0.08	0.08814	0.4070

bances such as the Belgian devaluation of March 1935, French changes of Ministry in June 1935, January 1936 and June 1936, Hitler's march into Rhineland of March 1936, and the U.S. "gold scare" of April-June 1937 fail to show up in large regression residuals.[18] The activities of the EEA, although they had a significant effect on the exchange rate, appear to have made only a modest contribution towards stabilization of inter-month exchange rate variations. The very existence of the EEA may have helped curb potential volatility of short-term capital movements by providing the appearance of a safer and better-controlled environment, but the existence and extent of such a reassurance effect would be hard to ascertain.

APPENDIX DESCRIPTION OF DATA

Exchange Rate—monthly average: *Federal Reserve Bulletin* (various issues).
Price Indices—wholesale prices, all items, seasonally unadjusted: *Federal Reserve Bulletin* (various issues) for US; *Statistical Yearbook of League of Nations* (Various issues) for UK.
Employment Indices—seasonally unadjusted: *Statistical Yearbook of League of Nations* (various issues) adjusted for revisions published up to 1939–40.
Interest Rates—three month bankers' acceptance rates: *Federal Reserve Bulletin* (various issues).
EEA Intervention Dummy—described in Section II above. Values of +1 in Sept., Oct. 1932; May, June, July, Aug., Nov., Dec. 1933; Feb., Apr., May, July, Sept., Dec. 1934; Jan., Feb., Oct., 1935; June, Nov. 1936; Apr. 1937; May–Oct. 1938. Values of −1 in July, Aug., Nov., Dec. 1932; Jan., Feb., Apr., May, Sept., Oct. 1933; Mar., May, Aug., Sept. 1935; Jan., Mar., Apr., July 1936; June, July 1937. Values of 0 otherwise.

[18] See [16] for a detailed consideration of residuals.

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