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Long Memory Volatility, Central Bank Intervention and Uncovered Interest Rate Parity in the 1920s Exchange Markets*

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The 1920s exchange markets represent one of the earliest recorded periods of freely floating exchange rates and central bank interventions. This paper uses a set of daily exchange rate data in the 1920s for three currencies (French Franc, Belgium Franc and Italy Lira) against the British Pound, and finds the exchange rate returns have the widespread long memory volatility property that is consistent with the post Bretton Woods era. And, this paper quantifies the duration of the effectiveness of the heavy intervention by the Bank of France on three exchange rates. The intervention is found to have direct effects on the French franc spot rate, but not on market volatility. There is also some evidence that the intervention had moderate influence on the deviation from the uncovered interest rate parity in the exchange markets by Granger causing the excess returns which may be associated with a time dependent risk premium.

JEL Classification: C22, F31
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I. Introduction

The exchange markets in the 1920s provide important information on the earliest periods of freely floating exchange rates, which are remarkable for their great turbulence due to the political and economic conditions that existed in Europe at

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that time. This paper uses a set of daily data for three currencies, French Franc (FF), Belgium Franc (BF) and Italy Lira (IL) vis a vis British pound (BP). The exchange rate returns are found to exhibit the widespread long memory volatility property in both their conditional variances and also their absolute returns; and hence are extremely similar to exchange rate returns in the period of the post Bretton Woods era in which the freely floating exchange rate system was officially adopted by most of the countries in the world. The extreme turbulence in the markets is also seen to induce the heavy tailed, undefined variance of unconditional returns phenomenon, as studied by Koedijk et al. (1990).

However, the markets are also of great interest since they represent the earliest recorded sterilized intervention by a monetary authority; in this instance, by the Bank of France acting for the French government. The intervention was motivated in an attempt to thwart further speculation against the French franc, which had led over the previous year to depreciation in excess of 50% of the French franc against the British pound. For this reason, the event of the 1920s throw some light on the controversy that has existed in recent years, on the relative merits of central bank intervention. Also, there is some evidence that intervention affected excess returns over uncovered interest rate parity (UIP); either through a portfolio balance effect, or through changing the risk premium.

The plan of the rest of this paper is as follows: Section II discusses some of the background literature on the central bank intervention in the 1920s and their unusual institutional features, including the circumstances surrounding the massive intervention by the Bank of France in March, 1924. Section III then reports the estimates of long memory ARCH, or FIGARCH models on the spot return series, which are found to provide a good description of the long memory volatility process of the returns series. Confirmatory evidence from the semi parametric Local Whittle estimator is also given.

Section IV presents the econometric evidence on the effects of the intervention by the Bank of France in 1924. There is clear econometric evidence from the dummy variable model that the very heavy and unanticipated intervention on March 11, 1924 was initially highly successful; both in terms of inducing a French franc appreciation without any significant increase in volatility. And, the estimations of the Poisson jump process model are also provided to support the results. Section IV also discusses the dynamics of the intervention process and shows that the intervention failed to have any long run impact, and it reports the estimates of the impact of the level of intervention on the deviation of the nominal exchange rate from uncovered interest rate parity (UIP). As with the post Bretton Woods era, there is econometric evidence that purchases of domestic currency by the central bank are associated with excess French franc returns over uncovered interest rate parity. Section V then provides a brief conclusion in the paper.

II. The French Central Bank Intervention in the 1920s Markets

The historical origins of sterilized intervention as a policy tool is not entirely clear; although prior to 1914, the Gold Standard was in operation and intervention was not necessary. However, during WWI, the British Treasury intervened in the British pound market through J.P. Morgan and Co.; and in 1917 there were several incidents when the U.S. Treasury attempted to influence exchange rates. The European exchange market in the early 1920s experienced one of the most turbulent periods in the history of foreign exchange markets, as the markets adjusted to post war and non-Gold standard conditions. Problems associated with the hyperinflation in Germany and budget deficit in France spilled over to affect several neighboring currencies.

The period of the beginning in early 1924 witnessed speculative attacks on the French franc and several other European currencies, especially the Belgian franc. This led the French government to use apparently sterilized intervention in the hope of deterring future speculation. On March 11, 1924, the French Premier, Raymond Poincaré, launched a "bear squeeze" by negotiating secret loans from U.S. and British banks that then purchased large quantities of francs. The French government was granted a credit of £4 million by a British banking group, headed by Lazard Brothers & Co. Within a few hours, an American banking group headed by J.P. Morgan & Co. granted the French government a credit of $100 million; and banks acting as agents for the French government began to buy francs heavily in an oversold market.

From an econometric perspective, the intervention is relatively convenient since it entailed a massive purchase of French francs on only one day and hence is not associated with the policy endogeneity issue apparent when a bank engages in a continuous intervention policy in response to the changing conditions of the exchange markets. From a level of 117.00 francs to the pound on March 11, 1924, the franc then appreciated to 89.81 francs to the pound the following week. This process of attacking the franc speculators, is sometimes referred to as the "Poincare bear squeeze". By the end of April, the spot rate was 68 francs to the pound, and the forward discount for three months declined to about 60 francs. Even at that rate, however, it was undervalued compared with its discount rate parity, which shows that many traders still refused to cut their losses and were carrying their positions. Their views of the temporary nature of the recovery were justified by subsequent developments. Following the defeat of Poincare at the General Election, the franc again depreciated, and by the end of May, 1924 it was again over 84 to the British Pound.

From the information provided by Aliber (1962) and Einzig (1937, 1962), it appears that the French government intended or succeeded in sterilizing the interventions. Since the French government negotiated loans from British and U.S. commercial banks and then proceeded to buy French Franc, it seems clear the U.S. and British money stocks were unchanged. The response from the French money supply is less clear. If the French government increased its holding of French Franc, it would contract the French money stock and the intervention would not appear to be sterilized. However, the French interest rates were not changed at the time of the intervention, which strongly suggests that the interventions were sterilized. According to the papers of Einzig (1937, 1962) who has documented many of the main economic and political events of the 1920s period and their impact on the exchange markets, the French intervention was the only significant intervention in the exchange markets during the sample period in the 1920s and seemed to be the first sterilized intervention as a policy tool officially recorded in the history.

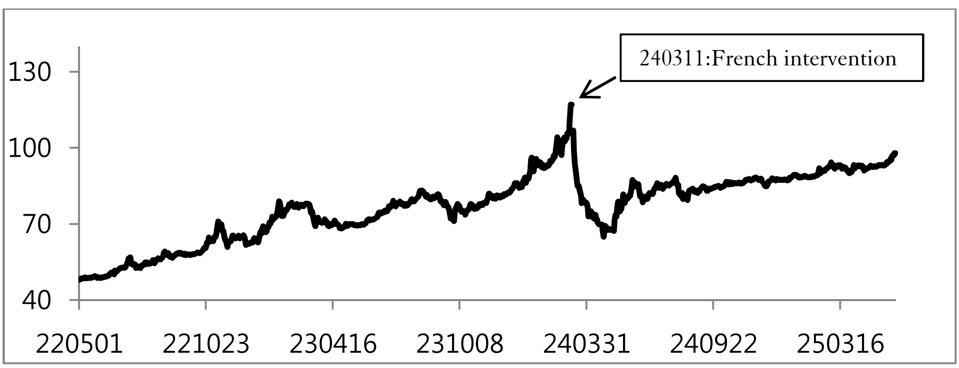
Prior to 1914, the international financial markets under the Gold Standard system were even more integrated than today and international capital movements reached the levels never matched subsequently because capital flowed across borders undeterred by currency risk or exchange controls and reinforced by the integration of labor and commodity markets (Bayoumi, 1990; Bordo et al., 1998). But, the WWI relegated the rosy state to the history's dustbin as capital controls together with tariffs and restrictions on migration were significantly proliferated and accelerated until the 1940s (Bordo et al., 1998). However, the Bretton Woods Agreement after WWII turned the trend and promoted the resumption of the capital mobility with the recovery of confidence in the benefits of economic and financial openness so that the capital mobility has trended inevitably upward in the post Bretton Woods period (Border et al., 1998).

Due to the limited cross border capital movements in the 1920s as presented by Bordo et al. (1998), the total daily trading volume would have been extremely small in comparison with the markets in the post Bretton Wood era in which it seems as if the volume of foreign exchange transactions has grown exponentially since 1973 and subsequently again in 1979 with the advent of more complete capital mobility. Although relatively little precise information is known about the extent of capital movements in the 1920s markets, it appears that there was a very low level of capital movements and arbitrage. Hence, the total volume of foreign exchange market transactions in the 1920s would have been only marginally more than the volume of trade so that the amount of currency purchased for the purposes of intervention was a relatively large percentage of the total market volume. It is also important to note that the exchange markets in the 1920s were far less technologically sophisticated and also lacked the highly developed derivative markets compared to the markets in the post Bretton Woods era. These facts distinguish the 1920s from the post Bretton Woods era.

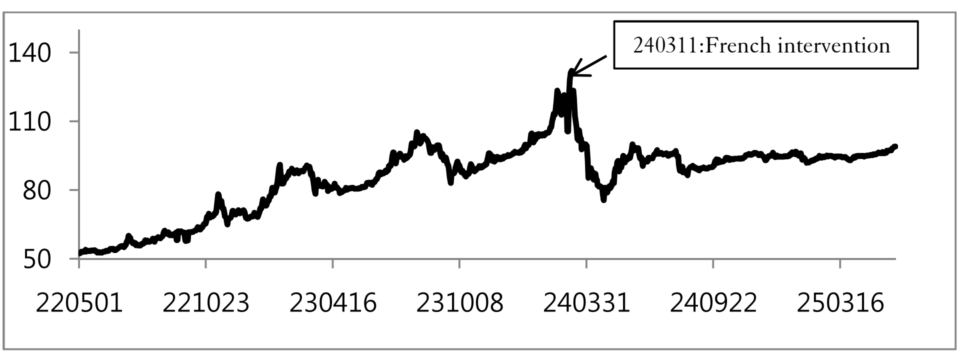
III. Long Memory Volatility Models of Daily Exchange Returns in the 1920s

This study uses daily exchange rate data from the London market, which were collected by the late Patrick McMahon from *Manchester Guardian* newspapers, and are for spot and 30-day forward exchange rates of Belgium Franc (BF), France Franc (FF), and Italy Lira (IL) vis a vis the British Pound (BP). The time series are from May 1, 1922 through May 30, 1925 and since the market was open on Saturdays, there are six observations per week and hence a total of 966 observations for this period. A previous study by Phillips et al. (1996) has used the data to test whether the forward rate is an unbiased predictor of the future spot rate. Their paper was therefore concerned with the relationship between the levels of the exchange rates and tested for cointegration with FM-LAD techniques, to deal with the presence of heavy tails in the exchange rate distributions. But, this study focuses on an entirely different econometric aspect; namely the volatility process of the daily returns data and the impact of the sterilized intervention on both the mean and volatility process of the daily returns.

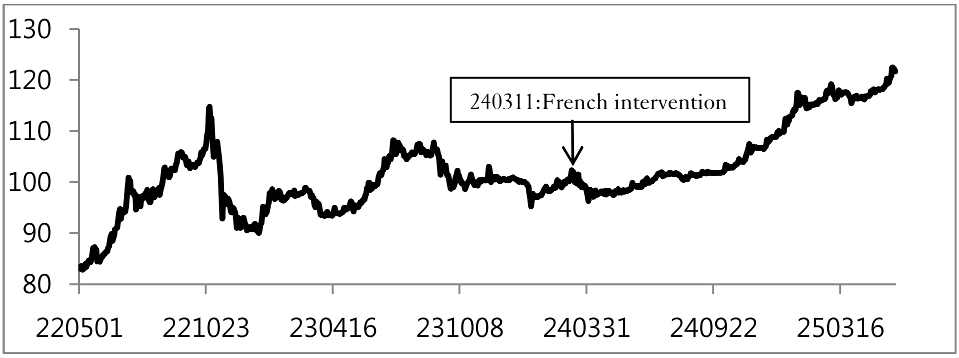
[Figure 1 (a)] Daily FF-BP Spot Exchange Rate from May 1, 1922 through May 30, 1925.



[Figure 1 (b)] Daily BF-BP Spot Exchange Rate from May 1, 1922 through May 30, 1925.



[Figure 1 (c)] Daily IL-BP Spot Exchange Rate from May 1, 1922 through May 30, 1925



For the econometric study, the time series realizations of the daily spot exchange rates are plotted in Figures 1(a) through 1(c) with indicating the specific date (240311) for the French intervention occurred on March 11, 2014. The general movements of the French Franc (FF) show that FF had depreciated against the British Pound (BP) continuously starting from 48 francs in May, 1922 up to 117 francs at the beginning of March, 1924 due to the process of attacking the franc by speculators, and the spot rate was declined to 68 francs at the end of April by the intervention of the French government. And, it is interesting to note that the movements of the Belgium Franc (BF) appeared to be quite similar to the FF indicating the very close economic relations between the two countries while the movements of the Italy Lira (IL) were different from those of the FF. In particular, this paper defines the returns data of the daily exchange rates in the conventional manner to investigate the volatility properties of the daily returns by continuously compounding the exchange rates of return and calculating as the first difference of the natural logarithm of spot exchange rates. The daily return (y_t) at day t is defined as

$$y_t = 100 * [\ln(S_t) - \ln(S_{t-1})] \tag{1}$$

where $t = 1, \ldots, 966$ and S_t is the spot exchange rate at day t.

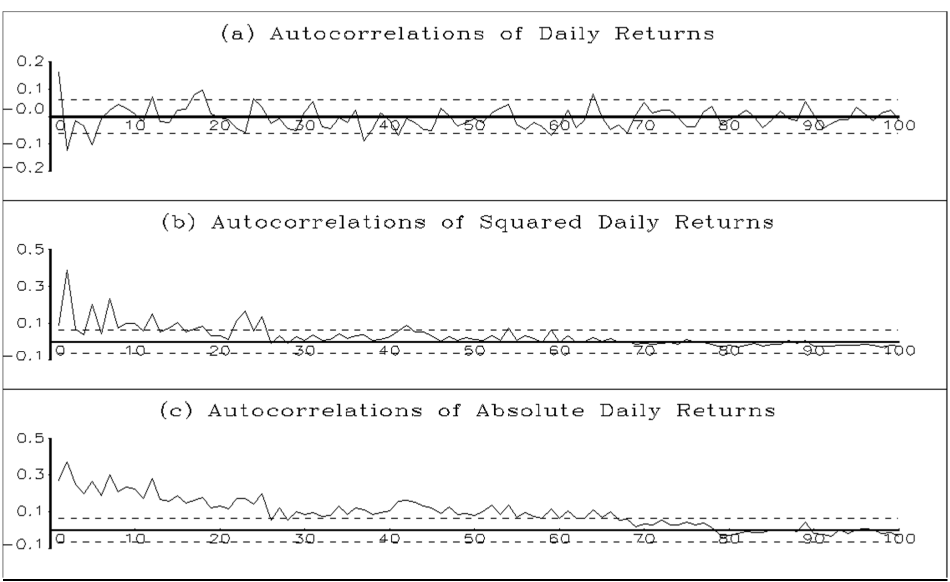
The details of the descriptive statistics for the daily returns of the FF-BP, BF-BP and IL-BP spot exchange rates are provided in Table 1. The sample means of the daily returns are generally found to be very close to zero and indistinguishable at the standard significance level and their max and min values suggesting that they are generally centered around zero implying the existence of persistent volatility clustering in the daily returns. Even though the graphs for the daily returns are not presented in this paper to reserve the space, the graphs present that the daily returns are all centered on zero and there exists persistent volatility clustering in the all series.

[Table 1] Descriptive Statistics for Daily Returns

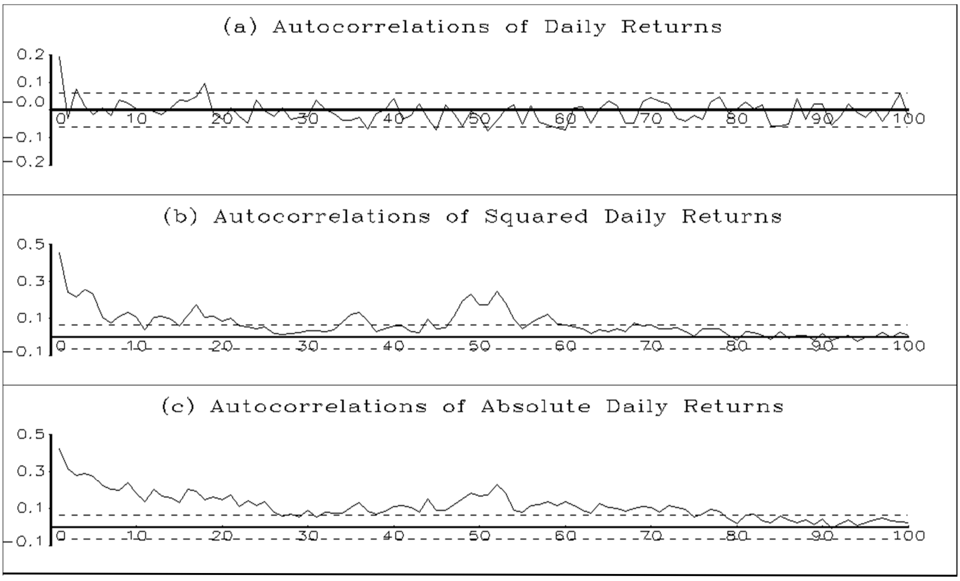
	BF	FF	IL
Mean	0.0660	0.0737	0.0392
Variance	2.3348	1.5676	0.4767
Max	15.1948	6.0953	4.1522
Min	-11.7125	-8.1930	-4.8598
Skewness	0.1386	-0.3277	-0.3561
Kurtosis	20.2925	9.0152	10.0611
ρ (1)	0.16124	0.1948	0.1179
$Q(20)$	78.2363	60.6453	90.5099
$Q^2(20)$	341.5335	580.9510	788.1585

The extremely persistent volatility clustering and turbulence across the markets are also seen to induce a heavy tailed, undefined variance of unconditional returns phenomenon as presented by Koedijk et al. (1990). And, the Ljung-Box test statistics for the test of the serial correlations, the $Q(20)$ statistics which cannot reject the null hypothesis of no serial correlation implies that the daily exchange returns do not have any serial correlations in the mean process with the small but significant values of the first order autocorrelations (ρ) which may be attributed to a combination of a small time varying risk premium, bid-ask bounce, and/or non-synchronous trading phenomena. See Andersen and Bollerslev (1997) and Goodhart and O'Hara (1996) for a description of this issue in exchange markets.

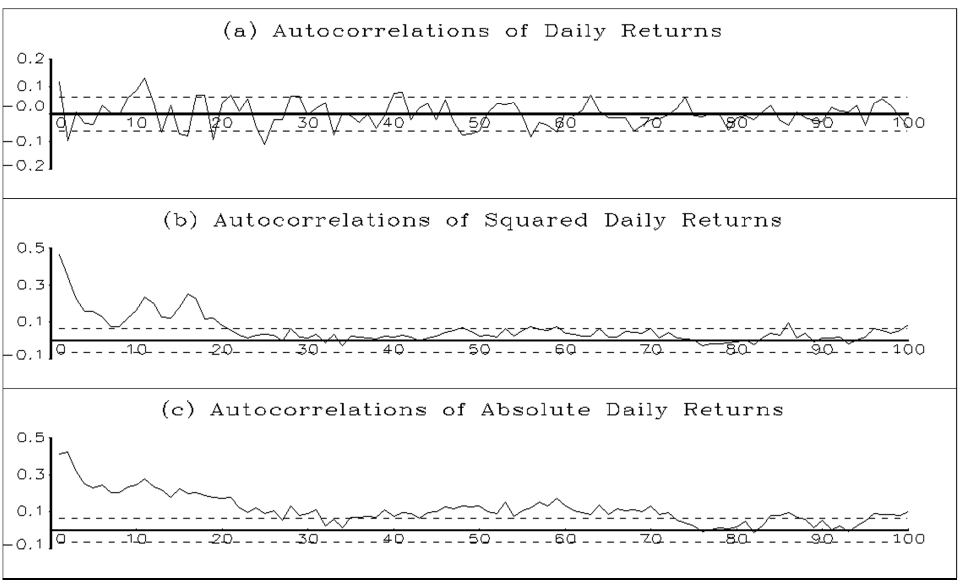
[Figure 2 (a)] Correlograms of Daily BF-BP Spot returns



[Figure 2 (b)] Correlograms of Daily FF-BP Spot returns



[Figure 2 (c)] Correlograms of Daily IL-BP Spot returns



On the other hand, the Ljung-Box test statistics, $Q^2(20)$, calculated from the squared returns of the daily exchange returns are all statistically significant indicating the existence of highly persistent autocorrelations in the volatility process of the daily returns. These finding can be confirmed by Figures 2(a) through 2(c) which plot the correlograms of the daily exchange returns which present the autocorrelation function of the returns, squared returns and absolute returns of the daily exchange rates. While the first order autocorrelation in the returns is small and significant for the daily exchange returns but the higher order autocorrelations of the raw returns are not significant at conventional levels, the autocorrelations of the squared returns and the absolute returns decay very slowly at the hyperbolic rate, which is the typical feature of the long memory property.

The long memory feature of the daily exchange returns is very significant in the autocorrelations of the squared and absolute returns of the daily returns and is more apparent in the autocorrelation functions of the absolute returns as presented by Granger and Ding (1996), which is quite similar to the long memory volatility of the freely floating nominal spot exchange rates in the post Bretton Woods era; see Anderson and Bollerslev (1998) and Baillie et al. (2000). And, the daily exchange returns appear not to be normally distributed since the values of the skewness and the kurtosis are greater than the levels of the normal distribution, and they are all statistically significant.

For the analysis of the long memory volatility in the daily returns of the BF-BP, FF-BP and IL-BP exchange rates, this paper adopts the parametric ARMA (m,n)-FIGARCH (p,d,q) model which is consistent with the basic stylized properties above. The model specification is the following;

$$y_t = \mu + \varphi(L) y_{t-1} + \theta(L)\varepsilon_t , \tag{2}$$

$$\varepsilon_t^2 = z_t \sigma_t^2 , \tag{3}$$

$$[1-\beta(L)]\sigma_t^2 = \omega + [1-\beta(L) - \phi(L)(1-L)^d]\varepsilon_t^2 \tag{4}$$

where y_t is the daily returns, $z_t \sim i.i.d.N(0,1)$, μ and ω are scalars, $\varphi(L)$, $\theta(L)$, $\beta(L)$ and $\phi(L)$ are polynomials in the lag operator, and (d) is the long memory parameter.

The parameter (d) characterizes the long memory property of hyperbolic decay in volatility because it allows for autocorrelations decaying at a slow hyperbolic rate. For $0 < d < 1$, the FIGARCH model has an undefined unconditional variance, thereby implying a long memory behavior and is strictly stationary and ergodic (Baillie et al., 1996; Baillie and Morana, 2009). However, the process does possess a finite sum to its cumulative impulse response weights. This makes the FIGARCH model different from other possible forms of the long memory ARCH models proposed by Karanassos et al. (2004). When $d = 0$, $p = q = 1$, then equation (4) reduces to the standard GARCH(1,1) model; and when $d = p = q = 1$, then equation (4) becomes the Integrated GARCH, or IGARCH(1,1) model, and implies complete persistence of the conditional variance to a shock in squared returns. The FIGARCH process has impulse response weights, $\sigma_t^2 = \omega/(1-\beta) + \lambda(L)\varepsilon_t^2$ where $\lambda_k \approx k^{d-1}$, which is essentially the long memory property or "Hurst effect" of hyperbolic decay. The attraction of the FIGARCH process is that for $0 < d < 1$, it is sufficiently flexible to allow for intermediate ranges of persistence. The simpler FIGARCH$(1,d,0)$ process is of the form, $\sigma_t^2 = \omega + \beta\sigma_{t-1}^2 + [1-\beta L-(1-L)^d]\varepsilon_t^2$, and has corresponding impulse response weights, $\sigma_t^2 = \omega/(1-\beta)+\lambda(L)\varepsilon_t^2$; and for large lag k, $\lambda_k \approx [(1-\beta)/\Gamma(d)]k^{d-1}$. The FIGARCH process is strictly stationary and ergodic for $0 \le d \le 1$, and shocks will have no permanent effect. See Baillie (1996) and Baillie et al. (1996) for the further theoretical details for the long memory process and the FIGARCH model.

The equations (2) through (4) are estimated by using non-linear optimization procedures to maximize the Gaussian log likelihood function,

$$\ln(L) = -(T/2)\ln(2\pi)-(1/2)\textstyle\sum_{t=1,T}[\ln(\sigma_t^2+\varepsilon_t^2\sigma_t^{-2})], \tag{5}$$

Since most return series are not well described by the conditional normal density in (5), subsequent inference is consequently based on the Quasi Maximum Likelihood Estimation (QMLE) technique of Bollerslev and Wooldridge (1992),

$$T^{1/2}(\hat{\theta}_T-\theta_0) \to N\{0, A(\theta_0)^{-1}B(\theta_0)A(\theta_0)^{-1}\}, \tag{6}$$

where $A(\cdot)$ and $B(\cdot)$ represent the Hessian and outer product gradient; and θ_0 denotes the true parameter values.

As presented by Baillie et al. (1996), the orders of the ARMA and the GARCH polynomials in the lag operator are chosen to be as parsimonious as possible but still provide an adequate representation of the autocorrelation structure of the daily returns. After considerable experimentations, the most appropriate specifications for the daily returns are chosen by using LR test statistics. The exact parametric specification of the model, which best represents the degree of autocorrelation in the conditional mean and variance of the daily returns are found to be the MA(1)-FIGARCH $(1,d,0)$ model for the daily returns of the BF-BP and the IL-BP exchange rates and the MA(1)-FIGARCH $(1,d,1)$ model for the daily returns of the FF-BP exchange rates.

Results of the estimated models for the daily 1920s spot exchange rate returns are presented in Table 2 with robust standard errors from equation (6) in parentheses below corresponding parameter estimates. The estimate of the long memory parameter (d) for daily data is in the range of 0.65 to 0.92 for the three currencies. Table 2 also shows that the estimates of d are statistically significant at the 0.01 percentile, with a robust Wald test of the stationary GARCH null hypothesis versus a FIGARCH alternative being overwhelmingly rejected. Hence there is strong evidence that exchange returns in the 1920s possessed the long memory volatility property in their absolute values and conditional variance process, which reveal temporal dependencies that are very similar in nature to the markets in the post Bretton Woods era. Also, given the extreme turbulence that occurred in the market, the estimated models in Table 2 have relatively little excess kurtosis in the standardized residuals.

[Table 2] Estimated MA(1)-FIGARCH(p,d,q) Models for Daily Returns

	BF	FF	IL
μ	0.0462**	0.0878***	0.0351**
	(0.0223)	(0.0228)	(0.0148)
θ	0.0885	0.0845*	0.1262**
	(0.0570)	(0.0487)	(0.0494)
d	0.9196***	0.7354***	0.6541***
	(0.1756)	(0.1833)	(0.1338)
ω	0.0131*	0.0183	0.0280**
	(0.0074)	(0.0130)	(0.0117)
β	0.7331***	0.6478***	0.3548***
	(0.1567)	(0.2192)	(0.1319)
φ	-	0.2251**	-
	-	(0.1122)	-
$\ln(L)$	-1404.226	-1301.236	-773.736
m_3	-0.331	0.252	0.347
m_4	7.540	5.224	6.207
$Q(20)$	19.534	23.428	26.247
$Q^2(20)$	16.390	22.901	9.072
$W_{d=0}$	27.423	16.091	23.888

Notes: i) Robust standard errors are in parentheses below the corresponding parameter estimates and the asterisks (***, ***, *) represent the significance level of 1%, 5% and 10%. ii) $\ln(L)$ refers to the value of the maximized log likelihood function. iii) m_3 and m_4 are the skewness and kurtosis respectively of the standardized residuals. iv) $Q(20)$ and $Q^2(20)$ are the Ljung-Box test statistics with 20 degrees of freedom also based on the standardized residuals and squared standardized residuals. v) the statistic $W_{d=0}$ is a robust Wald test for the GARCH model against the FIGARCH alternative.

The long memory volatility parameter in the absolute spot returns series were estimated by the Local Whittle estimator. If $f(v_j)$ is the spectral density of the absolute returns series, then the local Whittle estimator only requires specifying the form of the spectral density close to the zero frequency. For a long memory process, $f(v_j) \approx g(d)\,|\,v_j\,|^{-2d}$, as $v_j \to 0$, and for $g(d)$ which is some function of d. The local Whittle estimator then minimizes the quantity,

$$R(d) = \ln[(1/m)\Sigma_{j=1,m}[I(v_j)\,v_j^{-2d}] - (2d/m)\sum_{j=1,m}[\ln(v_j)], \tag{7}$$

where $I(v_j) = (2\pi T)^{-1} | \sum_{t=1,T} | y_t | \exp(itv_j) |^2$, and is the periodogram of the absolute returns series, $| y_t |$.

The local Whittle estimator appears particularly desirable in situations where the long memory dependence of a time series is compounded by very non Gaussian, fat tailed densities. Taqqu and Teverovsky (1997) report detailed simulation studies of various semi parametric estimators for long range dependence and find the local Whittle estimator to perform well in extreme non Gaussian cases. The estimator depends on the number of low frequency ordinates being used. The estimates of the long memory parameter for the absolute returns series in Table 3 are in the range of 0.65 to 0.88 and are close to the values of the estimated long memory parameter in the FIGARCH models in Table 2.

[Table 3] Local Whittle Estimation for the Long Memory Parameter in the Absolute Daily Returns

	BF	FF	IL
d	0.7414***	0.7661***	0.6451***
	(0.0915)	(0.0916)	(0.0576)

Notes: i) the Gaussian likelihood for an ARFIMA($0,d,0$) model is maximized in the frequency domain from the first m low frequency ordinates. In the above, the value of m was $T/32$ for Belgium and France, and $m = T/64$ for Italy where T is the sample size.
ii) the standard errors are in parentheses below the corresponding parameter estimates and the asterisks (***, ***, *) represent the significance level of 1%, 5% and 10%.

IV. Central Bank Intervention and Uncovered Interest Parity (UIP) in the 1920s Markets

In order to assess the direct quantitative effect of the intervention on the spot market, it is convenient to estimate the MA(1)-FIGARCH$(1,d,0)$ with a dummy variable model,

$$y_t = \mu + [\alpha_0 / (1-\lambda_0 L)] Int_t + \theta\varepsilon_{t-1} + \varepsilon_t , \tag{8}$$

$$\varepsilon_t^2 = z_t \sigma_t^2 , \tag{9}$$

$$\sigma_t^2 = \omega + \beta\sigma_{t-1}^2 + [\alpha_1 / (1-\lambda_1 L)] Int_t + [1-\beta L - (1-L)^d] \varepsilon_t^2 , \tag{10}$$

where $z_t \sim i.i.d.N(0,1)$, and Int_t is defined to be unity on March 11, 1924 when the secret interventionist policy was implemented and is zero otherwise.

The model was again estimated by QMLE as discussed in Section 3 and Table 4 reports results for when $\alpha_1 = \lambda_1 = 0$, so that only the effects on mean returns are considered. In this specification the impact multiplier of the intervention is α_0 , the total multiplier is $\alpha_0 / (1-\lambda_0)$, and the mean lag is $\lambda_0 / (1-\lambda_0)$.

[Table 4] Estimated MA(1)-FIGARCH($1,d,0$) Models for Daily Returns in the 1920s with a Dummy Variable in the Mean for French Intervention on March 11, 1924

	BF	FF	IL
μ	0.0466**	0.0952***	0.0372***
	(0.0221)	(0.0239)	(0.0030)
α	-6.8186***	-9.1129***	-1.1892***
	(1.4279)	(0.5716)	(0.0315)
λ	0.8215***	0.7580***	0.7459**
	(0.1225)	(0.0381)	(0.3840)
θ	0.0874	0.0872*	0.1285***
	(0.0587)	(0.0501)	(0.0494)
d	0.9183***	0.5581***	0.6508***
	(0.2013)	(0.0926)	(0.1330)
ω	0.0134*	0.0245	0.0286**
	(0.0074)	(0.0274)	(0.0121)
β	0.7320***	0.2563**	0.3463***
	(0.1791)	(0.1181)	(0.1303)
$\ln(L)$	-1401.358	-1292.666	-771.547
m_3	-0.339	0.270	0.367
m_4	7.562	5.461	6.194
$Q(20)$	18.920	22.070	25.190
$Q^2(20)$	16.872	35.703	9.371

Notes: As for Table 2.

The estimation models in Table 4 indicate generally similar MA and FIGARCH parameter estimates as for Table 2, and the estimated α_0 parameters are found to be negative and extremely significant for all three currencies. The model implies an immediate appreciation of the FF following the intervention of 9.1% and a total long run appreciation of 36.4%. While the intention of the French intervention appears to clearly have been to curtail speculation against the FF, it can be seen from Table 4 to have had corresponding effects on neighboring currencies. In particular, the intervention also had the effect in the short run of leading to significant appreciations of both the BF and IL. In the case of the BF, which tends to move quite closely with the FF, the appreciation was also substantial. Also it is interesting to note that in case of the daily USD-BP exchange rate which is the non-neighboring currency of the French Franc, the dummy coefficient of the French intervention is found to be positive and statistically significant (not reported) indicating that the intervention led to a depreciation of the US Dollar against the British Pound. This is because the speculative funds for the intervention were apparently withdrawn from the US Dollar to purchase the rapidly appreciating FF, BF and IL as explained in Section II.

[Table 5] Estimated MA(1)-FIGARCH(1,d,0) Model for Daily Returns in the 1920s with Dummy Variables in the Mean and the Variance for French Intervention on March 11, 1924

	BF	FF	IL
μ	0.0459**	0.0872***	0.0391***
	(0.0226)	(0.0225)	(0.0151)
α_0	-4.7496***	-8.5079***	-0.9929***
	(1.4972)	(0.5650)	(0.4117)
λ_0	0.9028***	0.7944***	0.8545***
	(0.0661)	(0.0381)	(0.1498)
θ	0.0766	0.1063**	0.1266***
	(0.0579)	(0.0468)	(0.0494)
d	0.9225***	0.7741***	0.6416***
	(0.1826)	(0.2005)	(0.1384)
ω	0.0154*	0.0486***	0.0284**
	(0.0080)	(0.0185)	(0.0124)
α_1	1.6575	1.4064	0.2238
	(1.6384)	(0.8404)	(0.2705)
λ_1	0.9605***	0.9898***	0.8855***
	(0.0135)	(0.0075)	(0.0376)
β	0.7135***	0.4335**	0.3327***
	(0.1668)	(0.2413)	(0.1334)
$\ln(L)$	-1398.274	-1276.440	-769.771
m_3	-0.320	0.268	0.387
m_4	7.847	4.514	6.239
$Q(20)$	19.199	22.898	25.802
$Q^2(20)$	18.559	21.192	8.967

Notes: As for Table 2.

Table 5 shows corresponding effects of the dynamic intervention variable in the conditional variance process. While the estimated α_0 and λ_0 parameters for the conditional mean process are found to be extremely significant for all three currencies, none of the estimated α_1 parameters in the conditional variance process were significant at conventional levels. Hence there is no statistical evidence that the French intervention increased trading activity and market volatility. This is in sharp contrast to the results reported by Chang and Taylor (1998), Baillie and Osterberg (1997) and Goodhart and Hesse (1993), who all noted the increases in volatility following intervention in the post Bretton Woods era. This is another feature of the intervention in the 1920s that distinguishes it from the post Bretton Woods period. One possible explanation may be the difference in global financial market circumstance between 1920s and post Bretton Woods era. In fact, the financial markets in the 1920s were not integrated across the markets and the governments in the 1920s did not follow the coordinated policies because each government should formulate its policies independently in order to restore their war-torn economies (Darbar et al., 1993).

Since the intervention in the 1920s was conducted in extreme secrecy and occurred on only one day, the analysis of its effects avoids the policy endogeneity issue that is apparent with intervention in the more recent post Bretton Woods era when the subsequent use of intervention as a policy tool is dependent on the state of the exchange markets. Consequently, there is clear econometric evidence that the very heavy and unanticipated intervention on March 11, 1924 was initially highly successful; both in terms of inducing a French franc appreciation, without any significant increase in volatility.

For the further investigation on the effects of the intervention on the FX markets in the 1920s, this paper follows the Poisson jump process model of Vlaar and Palm (1993) to represent the intervention in the FX markets. In practice, the jump variable process seems of particular relevance to the cases of repeated intra-marginal interventions with currencies operating in the post Bretton Woods period, rather than the case of the 1920s with only one intervention. Due to the reason, this paper briefly provides the estimation results of the jump process model and compare with the results from the dummy variable model previously.

The estimated parameters of the jump process model combined with the FIGARCH model for the three daily exchange returns series are reported in Table 6 with the model specification. The estimated Poisson jump probability (η) for the three currencies (BF, FF and IL) are all statistically significant at the conventional level implying that the jumps including the intervention are very apparent in the FX markets. And, the parameters (ν) of the BF and FF which represent the mean size of the jumps in the mean process of the daily returns are found to be negative and statistically significant indicating on average the jumps in the FX markets decrease the exchange returns by appreciating the currencies (BF and FF) against the BP even though the parameter of the IL is positive but statistically insignificant.

And, the variance size of the jumps in the volatility process (δ^2) for the BF and FF are estimated to be statistically insignificant suggesting that the jumps many not affect the market volatility at all while the parameter of the IL is found to be statistically significant so that the jumps can affect the volatility in the Italian FX market. However, the value of the parameter (δ^2) for the IL is so small that the jump may not affect the volatility significantly. Also, the long memory parameters (d) of the jump process model are found to be quite similar to the values of the dummy variable model. In general, the results of the jump process model are quite in consistent with those of the dummy variable model and support them.

[Table 6] Poisson jump process - FIGARCH $(1,d,0)$ Model for Daily Returns in the 1920s

$$y_t = \mu + (\eta * \nu) + \varepsilon_t + \theta\varepsilon_{t-1},$$
$$\varepsilon_t^2 = z_t \sigma_t^2,$$
$$\sigma_t^2 = \omega + \beta\sigma_{t-1}^2 + [1 - \beta L - (1-L)^d]\varepsilon_t^2,$$

where the jump intensity (η) follows the Poisson distribution and is forced in the (0,1) interval, and the jump size is given by the random variable which is assumed to be NID(ν,δ^2)

	BF	FF	IL
μ	0.0913***	0.0781***	0.0296**
	(0.0196)	(0.0197)	(0.0119)
η	0.0393***	0.1700***	0.1965***
	(0.0147)	(0.0713)	(0.0664)
ν	-1.8906*	-0.0997*	0.0469
	(1.0532)	(0.0591)	(0.0778)
δ^2	2.2703	1.1267	0.0431***
	(2.0931)	(0.7018)	(0.0152)
θ	0.0495	0.1091***	0.1062**
	(0.0468)	(0.0400)	(0.0469)
d	0.9022***	0.7998***	0.6518***
	(0.0165)	(0.0872)	(0.1223)
ω	0.0122	0.0124	0.0073
	(0.0116)	(0.0111)	(0.0056)
β	0.3801***	0.5086***	0.2592***
	(0.1306)	(0.1116)	(0.0787)
$\ln(L)$	-1440.193	-1271.896	-764.664
m_3	-0.936	1.197	3.003
m_4	8.859	11.167	2.292
$Q(20)$	51.995	22.752	20.739
$Q^2(20)$	27.086	20.125	24.015

Notes: As for Table 2.

Furthermore, this paper analyzes another effect of the intervention on the FX markets in 1920s in terms of the uncovered interest rate parity (UIP). Many theories of intervention in the post Bretton Woods period have emphasized the effect of intervention on deviations from the UIP rather than a direct effect on the spot rate. In particular, the portfolio balance model of Dominguez and Frankel (1993) and the risk premium model of Baillie and Osterberg (1997) who extended the model of Hodrick (1989) imply that the central bank intervention affects the risk premium term (ρ_t) in the model

$$(s_{t+k} - s_t) - (f_t - s_t) = (s_{t+k} - f_t) = \gamma\rho_t + \sum_{j=1,k} \theta_j \varepsilon_{t-j} \quad (11)$$

where f_t is the logarithm of the forward exchange rate for a k period maturity time.

Hence the left hand side of equation (11) is the forward rate forecast error, $(s_{t+k} - f_t)$, the first term on the right hand side of the equation is a MA(k) process to reflect the fact that the forward rate forecast error may be autocorrelated to lag k, while ρ_t is the risk premium and ε_t is a white noise process with zero mean, finite variance and is also serially uncorrelated. As noted by Phillips et al. (1996), for the daily 1920s data, the average maturity time of the forward contract, k is 26. They also note that the forward premium is stationary, which justifies the assumption of a stationary risk premium and the interpretation of equation (11).

It should be further noted that the above formulation arises from the discrete time, consumption based asset pricing model, with real returns over current and future consumption streams of the representative investor, leading to a corresponding Euler equation of $E_t[(F_t - S_{t+l}) / P_{t+l}][U'(C_{t+l}) / U'(C_t)] = 0$. In this formulation, upper case letters F, S and P refer to the levels of spot rate, the forward rate and the domestic price level respectively; and $U'(C_t)$ refers to the marginal utility of consumption so that $[U'(C_{t+l}) / U'(C_t)]$ is equal to the marginal rate of substitution in terms of utility derived from current and future consumption, and $E_t(\cdot)$ is the expectations operator conditioned on information at time t. Then $\rho_t = Cov_t(s_{t+l},\ q_{t+l})$, where q_{t+l} denotes the logarithm of the inter-temporal marginal rate of substitution.

Table 7 reports QMLE of equation (11) with intervention variable again representing the risk premium term (ρ_t). The estimated value of the coefficient (γ) is -0.026 with the robust t statistic is -1.80 which is only significant at the .07 level. Hence there is some moderate statistical evidence that intervention Granger causes a risk premium, or excess returns from uncovered interest rate parity. There is no evidence of intervention having a lagged effect on these excess returns. However, it is noteworthy that the parameter estimate associated with the intervention is of the same sign and order of magnitude as the model estimated by Baillie and Osterberg (1997), who reported significant results for the DM-$ and Yen-$ in the post Bretton Woods era. Again, the interpretation is equivalent with a purchase of domestic currency by the domestic central bank leading to an excess return for the domestic currency over uncovered interest rate parity. Hence the intervention appears to have a similar transmission mechanism in the 1920s compared with the post Bretton Woods era, albeit with also a direct effect on the spot market in the desired direction.

[Table 7] Estimation of the Model for the Effect of Intervention on the Deviation from Uncovered Interest Rate Parity for FF-BP

Parameter	Estimates	Parameters	Estimates
γ	-0.0258**	θ_1	0.9779***
	(0.0143)		(0.0285)
θ_2	0.8941***	θ_3	0.8816***
	(0.0560)		(0.0560)
θ_4	0.8319***	θ_5	0.8483***
	(0.0702)		(0.0749)
θ_6	0.8311***	θ_7	0.7588***
	(0.0776)		(0.0816)
θ_8	0.7128***	θ_9	0.7539***
	(0.0823)		(0.0830)
θ_{10}	0.7130***	θ_{11}	0.7457***
	(0.0840)		(0.0848)
θ_{12}	0.6927***	θ_{13}	0.7083***
	(0.0895)		(0.0900)
θ_{14}	0.6987***	θ_{15}	0.6899***
	(0.0883)		(0.0868)
θ_{16}	0.6778***	θ_{17}	0.6894***
	(0.0825)		(0.0806)
θ_{18}	0.7269***	θ_{19}	0.7403***
	(0.0757)		(0.0691)
θ_{20}	0.7158***	θ_{21}	0.7919***
	(0.0644)		(0.0621)
θ_{22}	0.7575***	θ_{23}	0.6101***
	(0.0613)		(0.0672)
θ_{24}	0.5805***	θ_{25}	0.4705***
	(0.0636)		(0.0519)
θ_{26}	0.1918*	d	0.6736***
	(0.1242)		(0.1242)
ω	0.0000	β	0.4991***
	(0.1242)		(0.1630)
$\ln(L)$	2722.085		
m_3	0.288		
m_4	4.184		
$Q(20)$	11.593		
$Q^2(20)$	26.506		

Notes: As for Table 2.

V. Conclusion

This paper has examined some of the characteristics of the foreign exchange market in the 1920s floating period and the effects of French intervention on the spot market. The spot exchange returns for the three currencies (Belgium Franc, France franc and Italy Lira) against the British Pound in this period exhibit the same long memory properties in their absolute returns and conditional variances that are apparent in the post Bretton Woods era. The long memory volatility process, FIGARCH model is found to be an appropriate description of the volatility process of the daily returns in the 1920s. Hence, although the 1920s exchange markets were quite unsophisticated, the returns on the spot market nevertheless possess remarkably similar characteristics to those of the post Bretton Woods era.

The effect of intervention by the French government is estimated to lead to an immediate appreciation of FF by 9.1% and a total long run appreciation of 36.4%. The effects of the intervention spilled over to other currencies and led to significant appreciations of the BF and IL. Similar models reveal that the intervention did not have any significant effect on market volatility, which is in contrast to previous research on the post Bretton Woods era. This is one feature of the intervention in the 1920s that distinguishes it from the recent period. Finally, there is also evidence that the French intervention Granger caused excess returns from uncovered interest rate parity (UIP), which may be associated with a time dependent risk premium, and is in accord with evidence on the recent floating exchange markets since 1973. However, this risk premium explanation could be only a partial explanation of the rejection of the UIP. Additional empirical studies on the peso problem or the irrational speculative bubbles would provide further important insights into this turbulent period of economic history.

As this paper notes above, the analysis of the 1920s exchange markets provides important collaboration of results for the post Bretton Wood era, which in turn has clear policy implications concerning the financial markets so that this could appear to be an important area for future research.

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