Central Bank Intervention and Properties of the 1920s Currency Markets

by

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Abstract

The 1920s currency markets represent one of the earliest recorded periods of central bank intervention. This paper uses a relatively new set of daily data for four currencies and finds the exchange rate returns have the widespread long memory property that is also consistent with today's post Bretton Woods era. This paper quantifies the duration of the effectiveness of the very heavy intervention by the Bank of France on four 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 a time dependent risk premium.

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1. Introduction

The currency markets of the 1920s provide important information on one of 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 that time. This paper uses a relatively new set of daily data for four currencies vis a vis the British pound. The exchange rate returns are found to exhibit the widespread long memory property in both their conditional variances and also their absolute returns; and hence are extremely similar to exchange rate returns in today's post Bretton Woods era. The extreme turbulence in the markets is also seen to induce the heavy tailed, undefined variance of unconditional returns phenomenon, as studied by Koedijk, Schafgens and de Vries (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 a depreciation in excess of 50% of the French franc against the British pound. For this reason, the events 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; either through a portfolio balance effect, or through changing the risk premium.

The plan of the rest of this paper is as follows: section 2 discusses some of the background literature on central bank intervention in the recent floating period and in relation to the history of the 1920s and their unusual institutional features, including the circumstances surrounding the massive intervention by the Bank of France in March, 1924. Section 3 then reports estimates of some long memory ARCH, or FIGARCH models on the spot return series, which are found to provide a good description of the volatility process of the returns series. Confirmatory evidence from a semi parametric Local Whittle estimator is also given.

Section 4 presents the econometric evidence on the effects of the intervention by the Bank of France in 1924. 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. These findings are in direct contrast with the apparent effects of intervention in the 1980s and 1990s as reported by Goodhart and Hesse (1993), Baillie and Osterberg (1997), Chang and Taylor (1998) and others. Section 4 also discusses the dynamics of the intervention process and shows that the intervention in March, 1924, failed to have any long run impact, and that within a year, the French franc had depreciated to approximately one third of its pre intervention level. Section 4 also reports estimates of the impact of the level of intervention on the deviation of the nominal exchange rate from uncovered interest rate parity. This model is in accord with the portfolio balance approach and also the model of the time varying risk premium developed by Baillie and Osterberg (1997). 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 5 then provides a brief conclusion of the results in the paper.

2(i). Intervention in the Post Bretton Woods Era

Central bank intervention is taken to explicitly refer to the buying and selling of foreign currency in order to influence an exchange rate. In the recent post Bretton Woods era, intervention has typically been intended to move the level of a nominal exchange rate to a target level, or to “calm disorderly markets”, i.e. reduce volatility. Both intentions have been articulated at the Plaza Agreement in September, 1985 and at the Louvre Accord of February, 1987. Intervention is assumed to be sterilized, so that the purchase (sale) of foreign currency is exactly offset by a corresponding sale (purchase) of domestic government debt to eliminate the effects on domestic money supply.

As reported by Humpage (1988, 1997) and other authors, studies in the modern period have generally found a “leaning against the wind” phenomenon, with a bank buying currency, being associated with that currency depreciating. Hence the policy endogeneity aspect obscures any direct relationship between the bank changing supply and demand conditions in the foreign exchange market. Subsequent theories to understand the transmission mechanism of intervention have typically focused on the portfolio balance effect, which is motivated by mean-variance optimization, where agents are concerned with their terminal wealth, which is composed of domestic and foreign currencies and bonds. The theory requires domestic and foreign bonds as imperfect substitutes, and the absence of Ricardian equivalence. Then sterilized intervention will affect the exchange rate through agents re-adjusting their portfolios of domestic and foreign denominated bonds. This approach has been pursued by Dominguez and Frankel (1993), while critiques have been provided by Humpage (1988), Obstfeld (1989) and Ghosh (1992).

An alternative view of intervention is that it is a signal of the central bank's future monetary policy. This implies that a sterilized purchase of foreign currency is expected to lead to a depreciation of the exchange rate if the foreign currency purchase is assumed to signal a more expansionary domestic monetary policy. However, Klein and Rosengren (1991) find no consistent relationship between intervention and monetary policy, while Kaminsky and Lewis (1996) report that the impact of intervention on exchange rates has sometimes been inconsistent with the implied monetary policy.

A further transmission mechanism has been proposed by Baillie and Osterberg (1997), who extended a model of Hodrick (1989), to a situation incorporating the effects of intervention. The model consists of a two country inter-temporal asset pricing set up, with a two country world where consumers and governments face cash in advance constraints, and the total stock of each currency is divided between private and government holdings, with each country holding foreign currency for intervention purposes. Baillie and Osterberg (1997) find supporting empirical evidence for their theory, since purchases of dollars by the Federal Reserve System were associated with excess $ denominated returns over uncovered interest rate parity for the freely floating DM-$ and Yen-$ in the recent floating period. Also, consistent with a number of other studies, they find that intervention increased rather than reduced exchange rate volatility.

2(ii). Intervention in the 1920s Market

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 currency 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. Einzig (1937, 1962) has documented many of the main economic and political events of this period and their impact on the currency markets. The period beginning in early 1924, witnessed speculative attacks on the French franc and several other European currencies; especially the Begian franc. This led the French government to use 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, who 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 $100m; and banks acting as agents for the French government began to buy francs heavily in an over sold market. 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 60c. 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), Einzig (1937, 1962) and other observers at the time, 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 FF, 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 FF 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.

It is important to note that the currency markets were far less technologically sophisticated than today's markets, and also lacked the highly developed derivative markets. Furthermore, due to the limited cross border capital movements, the total daily trading volume would have been extremely small in comparison with today’s markets. The total trading volume in the foreign exchange market on a typical trading day in 2001, has been estimated as being $1,300bn, with only approximately 1% of this volume, being motivated by the trade of goods and services, as opposed to capital movements. According to The Economist (1997), the volume was only about $100bn in 1983 and it seems as if the volume of foreign exchange transactions has grown exponentially since 1973 and subsequently again in March, 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 seems there was a very low level of capital movements and arbitrage. Hence, the total volume of foreign exchange market transactions 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. This fact alone, distinguishes the 1920s from the post Bretton Woods era.

3. Models of Daily Currency Returns

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 (BL), France (FR), Italy (IT), and the U.S. (US) vis a vis the British pound. 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, McFarland and McMahon (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. 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 spot returns.

The time series realizations of the spot exchange rates for the daily FF, BF, IL and US are plotted in figures 1(a) through 1(d). The autocorrelation function of the daily returns, squared returns and absolute returns for these currencies are then plotted in figure 2(a) through 2(d).

While the spot returns are close to being uncorrelated after the first lag, the autocorrelations of the squared returns and absolute returns exhibit the slow, hyperbolic rate of decay that is typical of freely floating nominal spot exchange rates in the post Bretton Woods era; for example see Anderson and Bollerslev (1998) and Baillie, Cecen and Han (2000). A model that is consistent with the stylized statistical facts above is to specify that the spot returns y_t, follow the MA(1) - FIGARCH (Fractionally Integrated Generalized Autoregressive Conditional Heteroskedastic) process, of Baillie, Bollerslev and Mikkelsen (1996). Hence,

$$y_t = 100.\text{Äln}(S_t) = \text{ì} + \text{å}_t + \text{èå}_{t-1}, \qquad (1)$$

$$\text{å}_t = z_t\text{ó}_t, \qquad (2)$$

$$\text{ó}^2_t = \text{ù} + \text{âó}^2_{t-1} + [1 - \text{â}L - (1 - \text{ö}L)(1 - L)^{\text{ä}}]\text{å}^2_t , \qquad (3)$$

where z_t is i.i.d.(0,1) and the conditional variance process ó^2_t, in equation (3), is a FIGARCH(1,ä,1) process. When ä = 0, p = q = 1, then equation (3) reduces to the standard GARCH(1,1) model; and when ä = p = q = 1, then equation (3) 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,

$$\text{ó}^2_t = \text{ù}/(1 - \text{â}) + \text{ë}(L)\text{å}^2_t,$$

where ë_k 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 < ä < 1, it is sufficiently flexible to allow for intermediate ranges of persistence. Analogous behavior in the conditional mean of exchange rates has been considered by Cheung (1993). The simpler FIGARCH(1,δ,0) process is of the form,

$$\sigma^2_t = \omega + \beta\sigma^2_{t-1} + [1 - \beta L - (1 - L)^{\delta}]\varepsilon^2_t,$$

and has corresponding impulse response weights, $\sigma^2_t = \omega/(1 - \beta) + \lambda(L)\varepsilon^2_t$; and for large lag k, λ_k $[(1-\beta)/\Gamma(d)]k^{d-1}$. The equations (1) through (3) are estimated by using non-linear optimization procedures to maximize the Gaussian log likelihood function,

$$\ln(L) = -(T/2)\ln(2\pi) - (1/2)\Sigma_{t=1,T}[\ln(\sigma^2_t + \varepsilon^2_t\sigma^{-2}_t)], \qquad (4)$$

Since most return series are not well described by the conditional normal density in (4), subsequent inference is consequently based on the Quasi Maximum Likelihood Estimation (QMLE) technique of Bollerslev and Wooldridge (1992), where

$$T^{1/2}(\hat{\theta}_T - \theta_0) \quad N\{0, A(\theta_0)^{-1}B(\theta_0)A(\theta_0)^{-1}\}, \qquad (5)$$

and A(.) and B(.) represent the Hessian and outer product gradient respectively; and θ_0 denotes the true parameter values.

Results of the estimated models for the daily 1920s spot exchange rate returns are presented in table 1. The estimate of the long memory parameter, δ, for daily data is in the range of .65 to .92 for the four currencies. Table 1 also shows that the estimates of δ are statistically significant at the .01 percentile, with a robust Wald test of the stationary GARCH(1,1) null hypothesis versus a FIGARCH(1,δ,1) alternative being overwhelmingly rejected. Hence there is strong evidence that currency returns in the 1920s possessed the long memory property in their absolute values and conditional variance process, which reveal temporal dependencies that are very similar in nature to today's markets. Also, given the extreme turbulence that occurred in the market, the estimated models in table 1 have relatively little excess kurtosis, (especially when compared with recent period high frequency data), in the standardized residuals.

The long memory parameter in the absolute spot returns series were estimated by a 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, $f(v_j)\ \ g(\ ä)\, v_j^{-2ä}$, as $v_j\ \ 0$, and for g(ä) which is some function of ä. The local Whittle estimator then minimizes the quantity,

$$R(d) = \ln[(1/m)\, Ó_{j=1,m} [I(v_j)\, v_j^{-2ä}] - (2ä/m)\, Ó_{j=1,m} [\ln(v_j)], \tag{6}$$

where $I(v_j) = (2ðT)^{-1}\ \ Ó_{t=1,T}\ \ y_t \exp(itv_j)\ \ ^2$, 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 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 1.

4. Effects of Intervention on the French franc

In order to assess the direct quantitative effect of the intervention on the spot market, it is convenient to estimate the model,

$$y_t = 100.Äln(S_t) = ì + [á_0 /(1 - ë_0L)]D_t + å_t + èå_{t-1} , \qquad (7)$$

$$å_t = z_t ó_t, \qquad (8)$$

$$ó^2_t = ù + âó^2_{t-1} + [á_1/(1 - ë_1L)]D_t + [1 - âL - (1 - L)^ä]å^2_t , \qquad (9)$$

where z_t is i.i.d.(0,1), and D_t is a dummy variable which is 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 3 reports results for when $á_1 = ë_1 = 0$, so that only the effects on mean returns are considered. In this specification the impact multiplier of the intervention is $á_0$, the total multiplier is $á_0/(1 – ë_0)$, and the mean lag is $ë_0/(1 – ë_0)$. The estimation models in table 3 indicate generally similar MA and FIGARCH parameter estimates as for table 1, and the estimated $á_0$ parameters are found to be extremely significant for all four 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 intervention against the FF, it can be seen from table 3 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. However, the intervention also led to a depreciation of the US $ as speculative funds were apparently withdrawn from the US $ to purchase the rapidly appreciating FF, BF and IL.

Table 4 shows corresponding effects of the dynamic intervention variable in the conditional variance process. While the estimated $á_0$ and $ë_0$ parameters for the conditional mean process are found to be extremely significant for all three currencies, none of the estimated $á_1$

parameters in the conditional variance process were significant at conventional levels. Hence there is no statistical evidence that the French intervention increased trading activity, or uncertainty 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 note 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 recent period.

A further specification which was investigated, was to follow the approach of Vlaar and Palm (1993) and to include a jump variable to represent the effects of intervention. This formulation introduces the term (î + òv_t) into equation (7), where ò is the jump intensity, and 0 < ò < 1, and is generated by a Poisson process, with the jump size given by the random variable v_t, which is Gaussian i.i.d. A robust Wald test failed to find any statistical support for the inclusion of the (î + òv_t) term. The jump variable process seems of particular relevance to cases of repeated intra-marginal interventions with currencies operating in target zones, rather than the case of the 1920s currency markets. For this reason the results are not reported in the tables, but are available from the authors on request.

Many theories of intervention in the post Bretton Woods period, have emphasized the effect of intervention on deviations from uncovered interest rate parity, rather than a direct effect on the spot rate. 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); implies that intervention affects the risk premium term, æ$_t$, in the model

$$(s_{t+k} - s_t) - (f_t - s_t) = (s_{t+k} - f_t) = \text{Ó}_{j=1,k}\,\text{è}_j\,\text{å}_{-j} + \text{æ}_t , \qquad (10)$$

where f_t is the logarithm of the forward exchange rate for a k period maturity time. Hence the left hand side of equation (10) 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 $æ_t$ is the risk premium and ą is a white noise process with zero mean, finite variance and is also serially uncorrelated. As noted by Phillips, McFarland and McMahon (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 (10). 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 $E_t\{(F_t - S_{t+1})/P_{t+1}\}U^{/}(C_{t+1})/U^{/}(C_t) = 0$. 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 $U^{/}(C_{t+1})/U^{/}(C_t)$ is equal to the marginal rate of substitution in terms of utility derived from current and future consumption, and $E_t(.)$ is the expectations operator conditioned on information at time t. Then $æ_t = Cov_t(s_{t+1}\ q_{t+1})$, where q_{t+1} denotes the logarithm of the inter-temporal marginal rate of substitution. Table 5 reports QMLE of equation (10), with intervention variable, D_t, again representing the risk premium term $æ_t$. The robust t statistic on the coefficient of the intervention variable, is -1.80, and 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. Similar estimations were also completed for the other three currencies and the intervention variable was found to be extremely small and insignificant in all three cases. These results are not reported for reasons of space, but are available from the authors on request.

5. 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 four currencies (Belgium, France, Italy and US) 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. Hence, although the 1920s currency markets were quite unsophisticated by today's standards, 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 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, and a small depreciation of the US dollar. 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, which may be associated with a time dependent risk premium, and is in accord with evidence on the recent floating currency markets since 1973.

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Table 1: Estimated MA(1)-FIGARCH(1,ä,1) Models for Daily Spot Returns in the 1920s

y_t = 100.Äln(S_t) = ì + $å_t$ + è$å_{t-1}$,

$å_t$ = z_t $ó_t$ where z_t is i.i.d.(0,1),

$ó_t^2$ = ù + â$ó_{t-1}^2$ + [1 - âL - (1 - öL)(1 - L)^{ä}]$å_t^2$

	Belgium.	France	Italy	USA
ì	0.0462	0.0878	0.0351	-0.0004
	(0.0223)	(0.0228)	(0.0148)	(0.0058)
è	0.0885	0.0845	0.1262	0.1386
	(0.0570)	(0.0487)	(0.0494)	(0.0483)
ä	0.9196	0.7354	0.6541	0.8644
	(0.1756)	(0.1833)	(0.1338)	(0.1728)
ù	0.0131	0.0183	0.0280	0.0043
	(0.0074)	(0.0130)	(0.0117)	(0.0014)
â	0.7331	0.6478	0.3548	0.4932
	(0.1567)	(0.2192)	(0.1319)	(0.1307)
ö	-	0.2251	-	-
	-	(0.1122)	-	-
ln(L)	-1404.226	-1301.236	-773.736	229.808
m_3	-0.331	0.252	0.347	1.088
m_4	7.540	5.224	6.207	8.923
Q(20)	19.534	23.428	26.247	24.806
Q^2(20)	16.390	22.901	9.072	7.110
$W_{ä=0}$	27.423	16.091	23.888	25.026

Key : ln(L) is the value of the maximized log likelihood function, m_3 and m_4 are the skewness and kurtosis respectively of the standardized residuals, while 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. The statistic $W_{ä=0}$ is a robust Wald test for the GARCH(1,1) model against the FIGARCH(1,ä,1) alternative. The test statistic has an asymptotic chi squared distribution with one degree of freedom.

Table 2: Local Whittle Estimation for the Long Memory Parameter in the Absolute Daily Spot Returns in the 1920s.

	Belgium.	France	Italy	USA
ä	0.7414 (0.0915)	0.7661 (0.0916)	0.6451 (0.0576)	0.8756 (0.1336)

Key: The Gaussian likelihood for an ARFIMA(0, ä, 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 and USA, where T = 966 and is the sample size.

Table 3: Estimated MA(1)-FIGARCH(1,ä,0) Models for Daily Spot Returns in the 1920s with a Dummy Variable in the Mean for France's Intervention on March 11, 1924.

y_t = 100*Äln(S_t) = ì + [á/(1 - ëL)] D_t + $å_t$ + è$å_{t-1}$

$å_t$ = $z_t$$ó_t$ where z_t is i.i.d.(0,1),

$ó_t^2$ = ù + â$ó_{t-1}^2$ + [1 - âL - (1 - L)^{ä}]$å_t^2$

	Belgium.	France	Italy	USA
ì	0.0466 (0.0221)	0.0952 (0.0239)	0.0372 (0.0030)	-0.0011 (0.0058)
á	-6.8186 (1.4279)	-9.1129 (0.5716)	-1.1892 (0.0315)	0.5405 (0.0184)
ë	0.8215 (0.1225)	0.7580 (0.0381)	0.7459 (0.3840)	0.0548 (0.0257)
è	0.0874 (0.0587)	0.0872 (0.0501)	0.1285 (0.0494)	0.1360 (0.0480)
ä	0.9183 (0.2013)	0.5581 (0.0926)	0.6508 (0.1330)	0.8684 (0.1687)
ù	0.0134 (0.0074)	0.0245 (0.0274)	0.0286 (0.0121)	0.0042 (0.0013)
â	0.7320 (0.1791)	0.2563 (0.1181)	0.3463 (0.1303)	0.4998 (0.1317)
ln(L)	-1401.358	-1292.666	-771.547	234.820
m_3	-0.339	0.270	0.367	1.077
m_4	7.562	5.461	6.194	8.945
Q(20)	18.920	22.070	25.190	24.320
Q^2(20)	16.872	35.703	9.371	6.793

Key : As for table 1, and with D_t equal to unity on March 11, 1924 and is zero otherwise.

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Table 4 : Estimated MA(1)-FIGARCH(1,ä,0) Model for Daily Spot Returns in the 1920s with Dummy Variables in the Mean and the Variance for France's Intervention on March 11, 1924.

y_t = ì + [á$_0$ /(1-ë$_0$L)] D_t + å$_t$ + èå$_{t-1}$

å$_t$ = z_t ó$_t$ where z_t is i.i.d.(0,1),

ó$_t^2$ = ù + [á$_1$ /(1 - ë$_1$L)] D_t + âó$_{t-1}^2$ + [1 - âL - (1 - L)$^{\text{ä}}$]å$_t^2$

	Belgium.	France	Italy
ì	0.0459	0.0872	0.0391
	(0.0226)	(0.0225)	(0.0151)
á$_0$	-4.7496	-8.5079	-0.9929
	(1.4972)	(0.5650)	(0.4117)
ë$_0$	0.9028	0.7944	0.8545
	(0.0661)	(0.0381)	(0.1498)
è	0.0766	0.1063	0.1266
	(0.0579)	(0.0468)	(0.0494)
ä	0.9225	0.7741	0.6416
	(0.1826)	(0.2005)	(0.1384)
ù	0.0154	0.0486	0.0284
	(0.0080)	(0.0185)	(0.0124)
á$_1$	1.6575	1.4064	0.2238
	(1.6384)	(0.8404)	(0.2705)
ë$_1$	0.9605	0.9898	0.8855
	(0.0135)	(0.0075)	(0.0376)
â	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

Key : As for table 3.

Table 5 : Estimation of the Model for the Effect of Intervention on the Deviation from Uncovered Interest Rate Parity for French franc-Pound.

$$y_{t+26} = s_{t+26} - f_t = \gamma D_t + \Sigma_{j=1,26}\, è_j\, å_{t-j}$$

$$å_t = z_t\, ó_t \quad \text{where } z_t \text{ is i.i.d.}(0,1),$$

$$ó_t^2 = ù + âó_{t-1}^2 + [1 - âL - (1-L)^{ä}]å_t^2$$

Parameter	Estimates	Parameters	Estimates
γ	-0.0258	$è_1$	0.9779
	(0.0143)		(0.0285)
$è_2$	0.8941	$è_3$	0.8816
	(0.0560)		(0.0560)
$è_4$	0.8319	$è_5$	0.8483
	(0.0702)		(0.0749)
$è_6$	0.8311	$è_7$	0.7588
	(0.0776)		(0.0816)
$è_8$	0.7128	$è_9$	0.7539
	(0.0823)		(0.0830)
$è_{10}$	0.7130	$è_{11}$	0.7457
	(0.0840)		(0.0848)
$è_{12}$	0.6927	$è_{13}$	0.7083
	(0.0895)		(0.0900)
$è_{14}$	0.6987	$è_{15}$	0.6899
	(0.0883)		(0.0868)
$è_{16}$	0.6778	$è_{17}$	0.6894
	(0.0825)		(0.0806)
$è_{18}$	0.7269	$è_{19}$	0.7403
	(0.0757)		(0.0691)
$è_{20}$	0.7158	$è_{21}$	0.7919
	(0.0644)		(0.0621)
$è_{22}$	0.7575	$è_{23}$	0.6101
	(0.0613)		(0.0672)
$è_{24}$	0.5805	$è_{25}$	0.4705
	(0.0636)		(0.0519)
$è_{26}$	0.1918	ä	0.6736
	(0.1242)		(0.1242)
ù	0.0000	â	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		

Key : As for table 1.

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

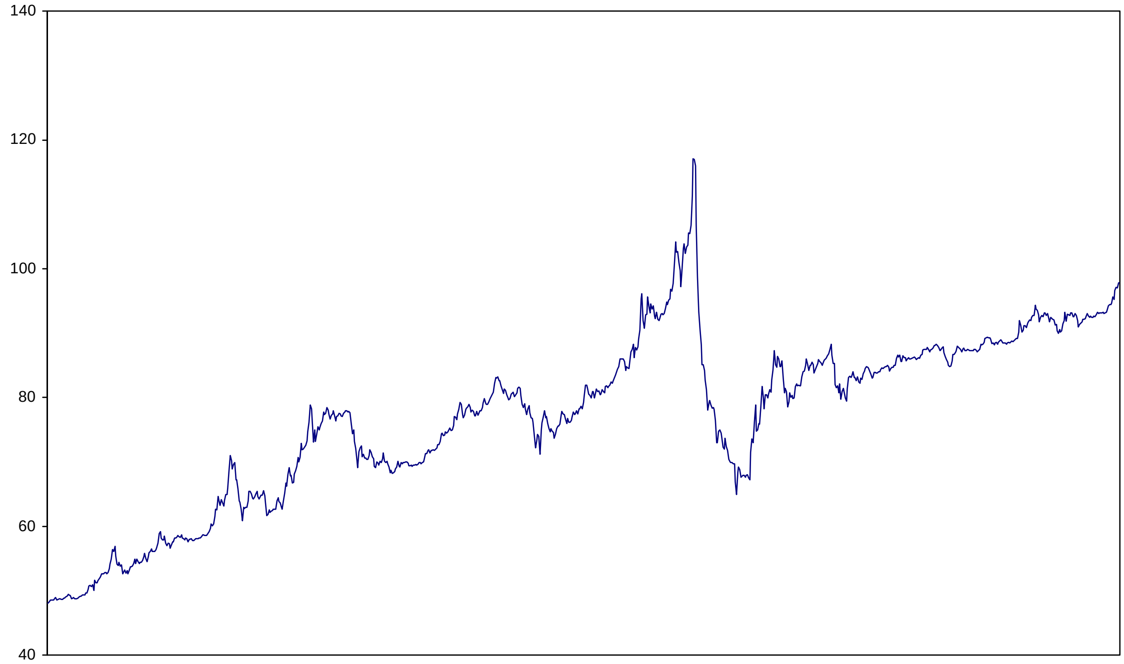

Figure 1 (b): Daily BF-BP Spot Exchange Rate from May 1, 1922 through May 30, 1925.

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

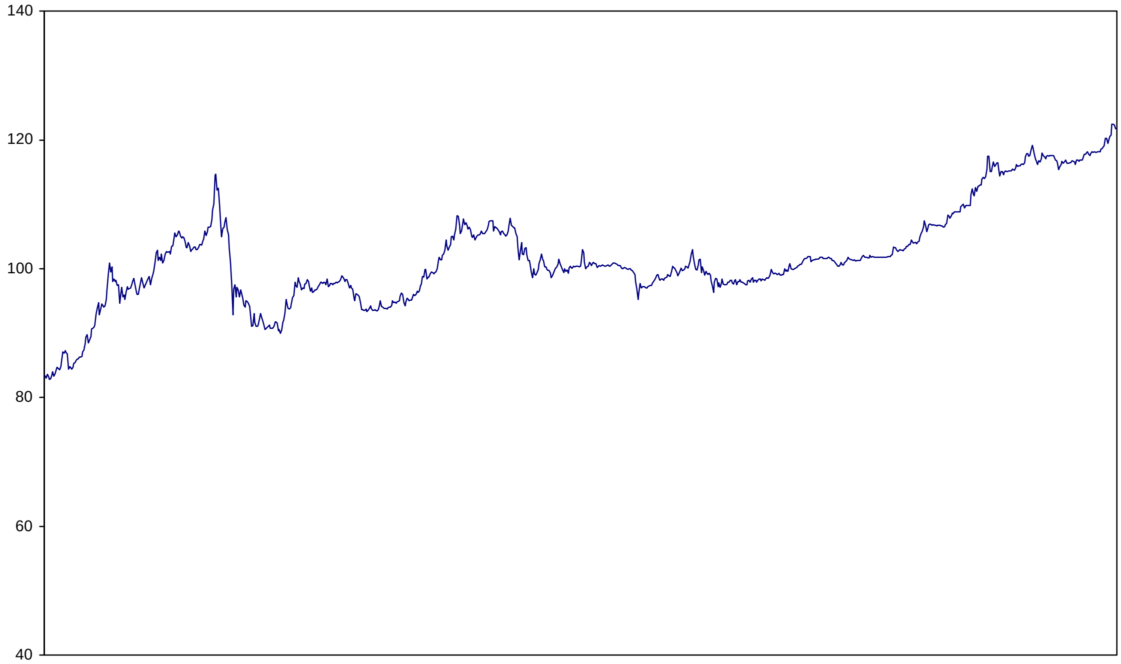

Figure 1 (d): Daily US-BP Spot Exchange Rate from May 1, 1922 through May 30, 1925.

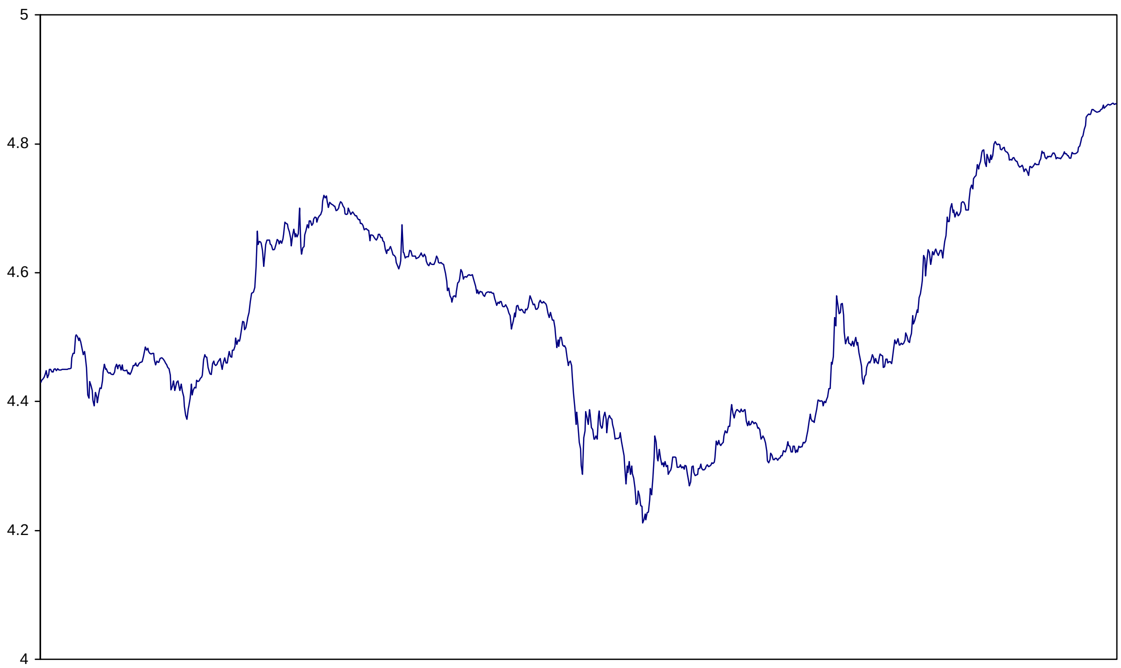

Figure 2 (a): Correlograms of Daily BF-BP Spot returns

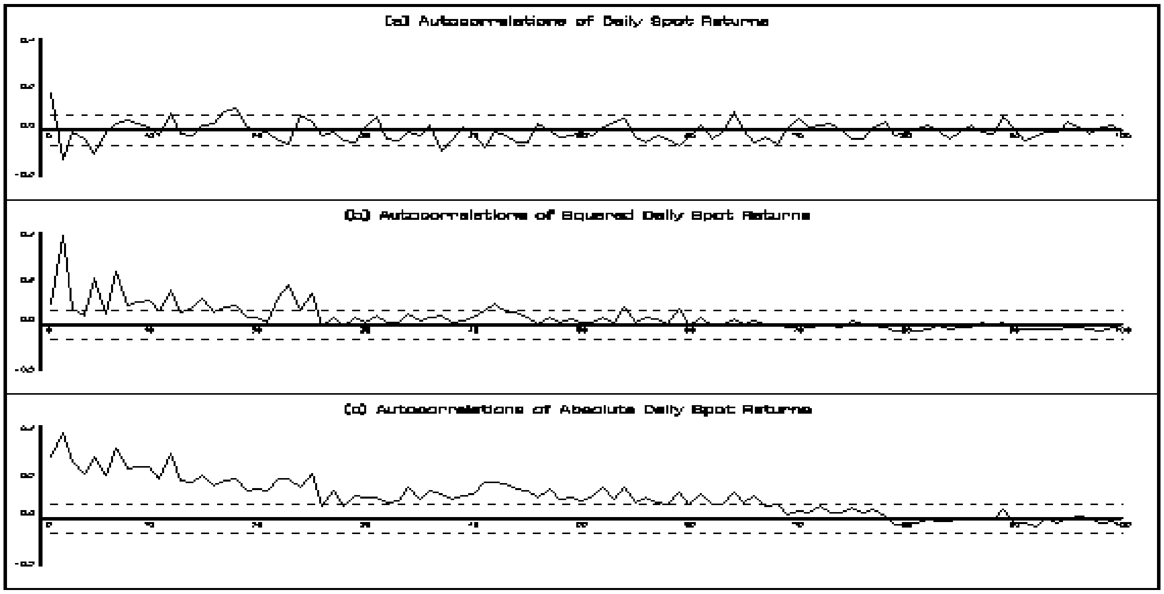

Figure 2 (b): Correlograms of Daily FF-BP Spot returns

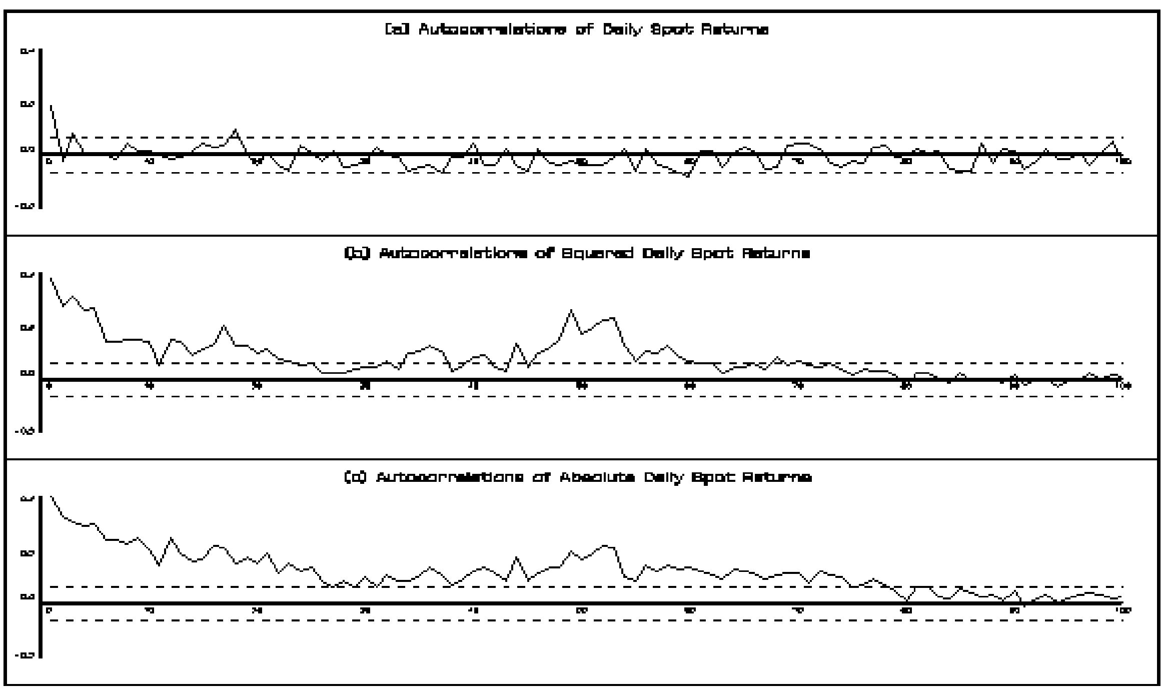

Figure 2 (c): Correlograms of Daily IL-BP Spot returns

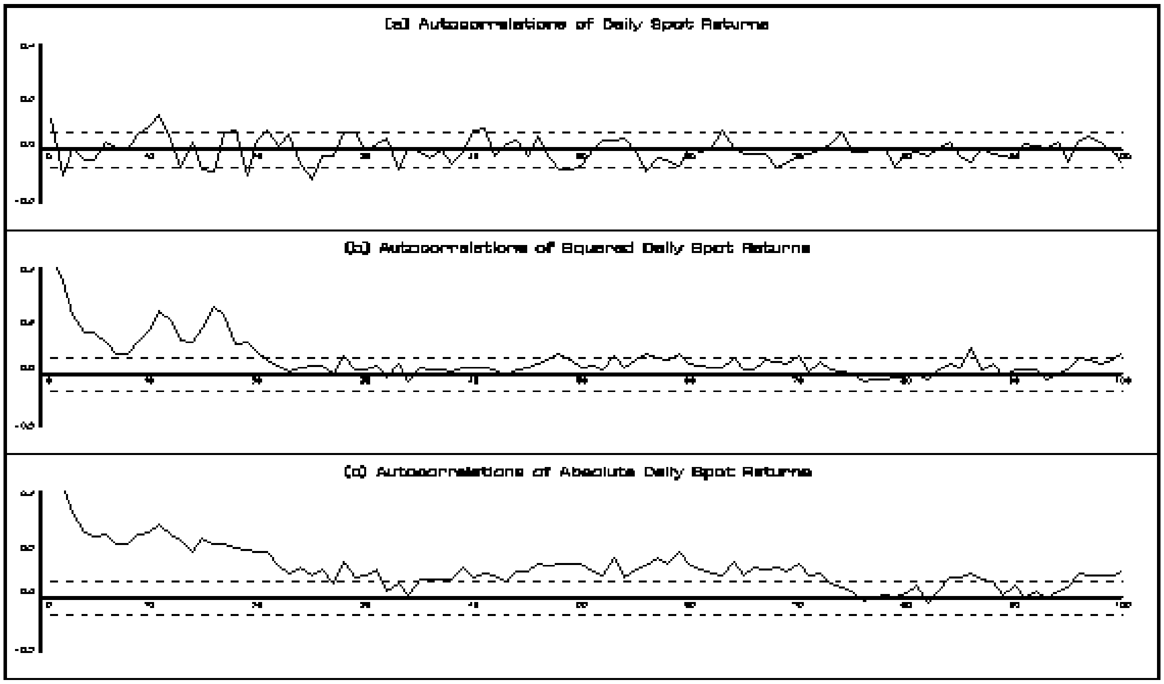

Figure 2 (d): Correlograms of Daily US$-BP Spot returns