Bear squeezes, volatility spillovers and speculative attacks in the hyperinflation 1920s foreign exchange

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This paper examines some of the characteristics of the foreign exchange market in the 1920s floating period. Nominal returns appear to exhibit properties consistent with asset prices on modern more well-organized financial markets; i.e. they appear to be well described by martingales and possess persistent time dependent heteroscedasticity. In order to deal with the extreme kurtosis in the exchange rate series we use robust inferential methods to test for volatility spillovers and shocks that might effect subsequent mean returns. Apart from some particularly abnormal 'bear squeeze' episodes the markets appear remarkably efficient. (JEL C22, E41, E31).

Institutional and technological changes in the last decade would strongly suggest that the integration of financial markets is increasing. Indeed, a number of studies have examined different speculative auction markets, including exchange rates, stock prices and commodity prices and have found striking similarities in terms of the apparent widespread martingale property, volatility patterns and reactions to news. Also, several studies have now analyzed the reaction of volatility between and within different asset markets, either in terms of volatility spillovers across different geographical locations

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or different asset markets. In particular, Engle, Ito and Lin (1990) and Baillie and Bollerslev (1991) looked at patterns of volatility between different exchange rates and market locations. Using data over the recent free floating period, these studies suggest that, while volatility may be temporally and geographically autocorrelated, the markets appear semi-strong efficient with price changes quickly incorporating news. Hamao, Masulis and Ng (1990) have also considered volatility spillovers between different equity markets; and find very interestingly that volatility was somewhat less important in the turbulent equity markets after the October 1987 crash.

This paper considers the structure of the foreign exchange market during an equally turbulent and interesting period of history, namely the era of widespread floating exchange rates in the 1920s. The foreign exchange market in this period was clearly less well organized than in the current float beginning in 1973. In particular the 1920s foreign exchange market lacked the sophisticated telecommunications systems, the organized trading structure and the range of financial instruments, such as options and futures, that exist in today’s market place. Furthermore, the world economy was recovering from the devastating effects of World War I, with the turmoil of war reparations and hyperinflation in Germany. This also led to concerted speculative attacks on various currencies, most notably the French franc, which in turn prompted the French government to engage in a number of ‘bear squeezes’ in the hope of deterring future speculation. An interesting description of the unusual events of 1924 is available from Einzig (1937, pp. 280–281):

The speculative campaign attained its climax on March 11, when the franc touched 117 [per pound]. Then followed one of the most memorable recoveries in the history of foreign exchange. It began with rumors of the conclusion of credits abroad. These rumors were subsequently confirmed by the announcement that a British banking group, headed by Lazard Brothers & Co., had granted the French government a credit of £4,000,000 and a few hours later an American Banking Group headed by J.P. Morgan & Co. had granted a credit of $100,000,000. The banks acting as agents for the French government began to buy francs heavily in an over sold market. Before very long francs become practically unobtainable. When speculators realized that the game was up, many of them tried frantically to cover their short positions at all costs...

The process of bear covering continued through April, and by the end of the month the spot rate was under 68 and the forward discount has declined to about 60 c. for three months. Even at that rate, however, it was undervalued compared with its discount rate parity, which shows that many bears 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 M. Poincare at the General Election, the franc became distinctly weaker, and by the end of May it was once more over 84 to the £.

The analysis conducted in this paper finds that despite the severe disruptions that occurred and the relatively primitive market conditions, the 1920 foreign exchange markets were surprisingly efficient and in terms of the temporal dependencies very similar in character to today’s market. However, in contrast to the general findings it does appear that some degree of volatility spillover did occur which was consistent with news on the French and Belgian
currencies being transmitted to the Italian lire and Swiss franc. Part, but not all of this spillover effect seems to have occurred during the bear squeeze episode.

The plan of this paper is as follows. Section I provides a brief description of the foreign exchange market during this period and some of the relevant economic and political factors. Section II then discusses some of the temporal characteristics of the data, which turn out to be remarkably similar to exchange rates in the current float. While most of the spot and forward rates appear to be martingales, they also possess strong time dependence in their conditional variances which are well described by Generalized Autoregressive Conditional Heteroskedastic (GARCH) processes. Similarly to the experience following the breakdown of the Bretton Woods Agreement in 1973, the GARCH processes, examined in Section III, indicate a very high degree of persistence in the volatility process during the 1920s foreign exchange market. In Section IV the effects of exchange rate innovations and volatility between and within other currencies are examined. While several of the political and economic events of this period were associated with extreme volatility, such episodes were generally short lived and do not appear to have led to predictable changes in mean returns. This evidence of apparent efficiency in the market has remarkably similar behavior to today's foreign exchange market. Due to the extreme degree of non-normality in the returns data we rely throughout the paper on the Robust standard errors technique of Bollerslev and Wooldridge (1992). These Quasi Maximum Likelihood techniques allow for robust inference under quite general conditions.

I. The foreign exchange market in the 1920s

The early 1920s are an interesting period of history which, apart from the post-1973 era, constitute the other main source of information on the behavior of a system of floating exchange rates. This period is well documented from a data perspective and is interesting in terms of the exogenous economic and political events taking place.

The data used in this study are taken from Einzig (1937) and consist of 162 weekly Saturday observations on the London market from February 25, 1922 through March 25, 1925 on the exchange rates of Belgium (BL), Britain (BR), France (FR), Holland (HL), Italy (IT) and Switzerland (SW) vis-à-vis the US dollar. It should be noted that Einzig (1937) provides data beyond this period; however Britain, Holland and Switzerland returned to a gold standard in 1925 so all the data series are truncated at March 25, 1925 to facilitate comparability. Also, the original exchange rate data provided by Einzig (1937) was vis-à-vis the British pound but, in order to separate out news and shocks emanating on the pound we applied triangular arbitrage to obtain the exchange rates in terms of a numeraire US dollar. The qualitative nature of all of the results reported in this study are unaltered when using the pound rather than the US dollar as the numeraire currency. In particular, the results pertaining to the systematic lack of any cross country spillover appears invariant to the choice of numeraire currency.

One of the best known features of the early 1920s was the rapid depreciation of the German mark following the severe hyperinflation and explosion of the
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money supply process in Germany. In January 1922 there were approximately
800 marks to the pound; by May 1922 there were 1500 and by September
1923 the mark had depreciated to 45 million marks to the pound. At this
point the market ceased to be quoted.

Considerable, though less dramatic economic and political turbulence, was
simultaneously experienced by the six other European currencies analyzed in
this study. Following World War I the French government substantially
increased its expenditures to repair the regions of the country destroyed in
the war. Subsequent domestic French inflation was compounded by the
difficulty in collecting war reparations from Germany and finally, in the early
1920s, international confidence in the French franc began to deteriorate and
by November 1923 heavy sales of the franc occurred in the Amsterdam market,
which quickly led to similar activity in the London market. By March 1924
the French franc had depreciated almost 50 per cent and on March 11, French
Premier Raymond Poincaré launched a 'bear squeeze' by negotiating secret
loans from US and British banks, who then purchased large quantities of
francs. 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. Similar
events, leading to another bear squeeze, occurred in July 1926.

The events surrounding the French franc do not appear independent of
events in other currency zones. In particular, the Belgian franc was also
attacked by speculators in February and March 1924. This well documented
event was explained by Shepherd (1936) and Einzig (1962) in terms of the
Belgian and French francs sharing co-movements due to their similar
economic and political situations while Einzig (1937) has suggested a linkage
due to psychological factors. Also, Aliber (1962) argued that investors over
this period were influenced by purchasing power parity considerations.

II. Temporal behavior of exchange rates

Several previous studies such as Meese and Singleton (1982), Baillie and
Bollerslev (1989a, 1991) have documented the apparent existence of a unit
root in weekly, daily and hourly exchange rates in the current float. The
application of the unit root testing methodology of Phillips (1987) and Phillips
and Perron (1988) also failed to reject the null hypothesis of a unit root in
the logarithm of the 1920s exchange rates against a stationary alternative. 1
Details of these results are omitted from the paper for reasons of space, but
are available from the authors on request.

The finding of a unit root in the nominal exchange rates is a necessary but
not sufficient condition for the validity of the martingale hypothesis. On
denoting the logarithms of the spot exchange rate by \( s_t \), the martingale
property with respect to the information set \( \Omega_t \) implies that

\[
E(\Delta s_{t+1} | \Omega_t) = E_t(\Delta s_{t+1}) = 0
\]

so that the expected one period rate of return is zero and unpredictable. This
is in accord with the concept of weak form efficiency and a time invariant
risk premium. This simple martingale specification was found to be
appropriate against a range of alternative models for the conditional mean,
including own lagged returns and the lagged forward premium. Details of
these tests are postponed to later in this section, after the basic model has
been introduced.

As previously mentioned, several authors such as Shepherd (1936) and
Einzig (1962), have suggested common comovement between currencies in
the 1920s. Since all the six currencies appear to be well described as \(I(1)\)
processes, it is appropriate to examine this issue in terms of the concept of
cointegration, which allows for the possibility of long-run stationary
cointegrating relationships between the nominal rates. To that end we
implemented the trace test due to Johansen (1988, 1991) but were unable to
reject the null hypothesis of six distinct stochastic trends. Hence no evidence
of cointegration between the exchange rates in the early 1920s were discerned.
This result is contrary to the results presented by Baillie and Bollerslev (1989a)
for the 1980s, who found evidence for one cointegrating vector in a system
of seven daily spot exchange rates. Since this result could be driven by any
subset of the exchange rates, and since several of the currencies were in the
EMS, the apparent cointegration of exchange rates in the 1980s might not
be that surprising. However, the 1920s era possessed no such deliberate policy
coordination and it seems reasonable for the various currencies to be
determined by quite different sets of fundamentals.

From a statistical point of view the apparent lack of any cointegrating
relationship also justifies the specification of a set of univariate time series
models of the martingale variety. The exchange rate returns were clearly not
independent and identically distributed through time however, but were
characterized by substantial heteroscedasticity. This phenomenon was
originally noted by Mandelbrot (1963) and Fama (1965) and is consistent
with the systematic occurrence of tranquil and volatile periods that are typical
of data from modern speculative markets. The returns data also exhibits
substantial excess kurtosis which have been well chronicled for exchange rate
data in the recent float; e.g. Westerfield (1977), McFarland et al. (1982), and
Hsieh (1989). Thus in order to provide robust inference in the presence of
the extreme kurtosis, the subsequent statistics presented in the paper all rely
on the robust standard errors technique due to Bollerslev and Wooldridge
(1992), which is briefly described in the Appendix.

A number of authors including Milhoj (1987), McCurdy and Morgan
(1987), and Baillie and Bollerslev (1989b) have all found the basic ARCH
process, introduced by Engle (1982), and the Generalized ARCH (GARCH)
process of Bollerslev (1986), to be very successful in describing the time
dependent heteroscedasticity present in exchange rate returns data in the
recent float. Consequently we estimated the following GARCH(1,1) model
for all six returns series:

\[
\begin{align*}
\langle 1 \rangle & \quad 100 \Delta \varepsilon_t = \mu + \varepsilon_t \\
\langle 2 \rangle & \quad \varepsilon_t | \Omega_{t-1} \sim N(0, \sigma_t^2) \\
\langle 3 \rangle & \quad \sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2,
\end{align*}
\]

where \(N(\cdot, \cdot)\) defines the conditional normal density. All models were
estimated using the Berndt et al. (1974) algorithm along with robust Quasi
Maximum Likelihood based standard errors. From Table 1 all the exchange
rates appear to be well characterized by the above simple model, and the
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Table 1. QMLE with robust standard errors of the model:

$$100\Delta \log s_t = \mu + \epsilon_t$$
$$\epsilon_t|\Omega_{t-1} \sim N(0, \sigma_t^2)$$
$$\sigma_t^2 = \omega + \alpha \sigma_{t-1}^2 + \beta \epsilon_{t-1}^2$$

<table>
<thead>
<tr>
<th></th>
<th>Belgium</th>
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<th>France</th>
<th>Holland</th>
<th>Italy</th>
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<tbody>
<tr>
<td>$\mu$</td>
<td>0.013</td>
<td>-0.060</td>
<td>0.203</td>
<td>0.004</td>
<td>0.152</td>
<td>0.088</td>
</tr>
<tr>
<td></td>
<td>(0.129)</td>
<td>(0.049)</td>
<td>(0.143)</td>
<td>(0.022)</td>
<td>(0.083)</td>
<td>(0.034)</td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.268</td>
<td>0.076</td>
<td>0.763</td>
<td>0.014</td>
<td>0.201</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>(0.184)</td>
<td>(0.042)</td>
<td>(0.462)</td>
<td>(0.009)</td>
<td>(0.193)</td>
<td>(0.038)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.517</td>
<td>0.394</td>
<td>0.429</td>
<td>0.484</td>
<td>0.215</td>
<td>0.157</td>
</tr>
<tr>
<td></td>
<td>(0.168)</td>
<td>(0.137)</td>
<td>(0.191)</td>
<td>(0.184)</td>
<td>(0.087)</td>
<td>(0.223)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.591</td>
<td>0.473</td>
<td>0.586</td>
<td>0.533</td>
<td>0.728</td>
<td>0.721</td>
</tr>
<tr>
<td></td>
<td>(0.094)</td>
<td>(0.181)</td>
<td>(0.117)</td>
<td>(0.113)</td>
<td>(0.124)</td>
<td>(0.253)</td>
</tr>
<tr>
<td>$Q(10)$</td>
<td>12.839</td>
<td>15.218</td>
<td>7.119</td>
<td>16.043</td>
<td>7.875</td>
<td>17.627</td>
</tr>
<tr>
<td>$Q^2(10)$</td>
<td>6.979</td>
<td>10.519</td>
<td>13.045</td>
<td>6.734</td>
<td>13.821</td>
<td>40.191</td>
</tr>
<tr>
<td>$m_3$</td>
<td>0.027</td>
<td>-0.766</td>
<td>0.177</td>
<td>0.031</td>
<td>0.361</td>
<td>1.407</td>
</tr>
<tr>
<td>$m_4$</td>
<td>4.122</td>
<td>5.920</td>
<td>4.333</td>
<td>3.709</td>
<td>3.855</td>
<td>8.594</td>
</tr>
<tr>
<td>$W$</td>
<td>0.741</td>
<td>0.169</td>
<td>0.305</td>
<td>3.664</td>
<td>2.241</td>
<td>0.123</td>
</tr>
</tbody>
</table>

Key: All countries were estimated for 162 weekly observations from February 25, 1922 through March 28, 1925. Robust standard errors appear in parenthesis below corresponding parameter estimates. The statistics $m_3$ and $m_4$ are respectively the sample skewness and kurtosis coefficients of the standardized residuals. Under the assumption of normality $m_3 \sim N(0, 6/T)$ and $m_4 \sim N(3, 24/T)$ asymptotically. $Q(10)$ and $Q^2(10)$ are the Ljung Box statistic based on the first 10 lags of the autocorrelations of the standardized residuals, and squared standardized residuals respectively. The final row of the table, denoted as $W$, is a robust Wald test statistic for the inclusion of the lagged forward premium in the mean return.

Results compare closely with Baillie and Bollerslev (1989a) who report similar models estimated on weekly 1980s data. This is confirmed by the test statistics reported in the last rows of the table. The Ljung and Box (1978) statistic on the standardized residuals $\hat{\epsilon}_t \hat{\sigma}_t^{-2}$ and the squared standardized residuals $\hat{\epsilon}_t^2 \hat{\sigma}_t^{-4}$ do not indicate any misspecification of the own temporal dependencies. To further test the martingale specification Table 1 also reports Robust Wald tests on the inclusion of the lagged forward premium, $(\log f_{t-1} - \log s_{t-1})$, to explain the mean returns. None of these tests were significant.

The shocks to the conditional variances as represented by $(\alpha + \beta)$ are very persistent. Also, the standardized residuals for all of the six rates show substantial excess kurtosis, thus necessitating the robust inference procedures. In summary, though the exchange rates all exhibit substantial autocorrelation and persistence in their volatility, there is little or no evidence of any own temporal dependence in the mean of returns.
III. Cross country volatility effects of the exchange rate

This section explores the possibility of spillover effects among the currencies. Spillover effects have recently been examined in papers by Engle et al. (1990) and Baillie and Bollerslev (1991), both of which use data on several different currencies and market locations in the current floating period. Since the 1920s data are only available from one market location it is not possible to directly determine how news or volatility is transmitted from one market location to another. However, the key idea of seeing how volatility spills over from one currency to another, either contemporaneously or with a lag, remains the same.

Many authors have discussed the role of news on the behavior of exchange rates in the recent float. For example, Cornell (1983) and Ito and Roley (1987) have considered news on money supply announcements, while Ito (1987) has examined the effect of policy regime changes. We shall not attempt to explicitly model the news arrival process to the market. Instead, Table 2 contains a series of Robust Wald statistics for the hypothesis that the lagged surprise of its own and other exchange rates do not influence mean returns. It can be seen from Table 2 that there is virtually no evidence that lagged returns Granger causes mean returns, either individually or collectively for any of the currencies.

While it is reasonable for volatility to be autocorrelated across time and space, as in the 'heat wave' and 'meteor shower' hypotheses set forward in Engle et al. (1990), an efficient market should quickly incorporate volatility caused by news into its mean price. Hence, the possibility of lagged volatility Granger causing mean prices or mean returns, would violate the notion of strong form efficiency in the absence of a time varying risk premium. A test

Table 2. Robust Wald tests for causality in mean: effect of lagged innovations, \( \hat{\theta}_{jt-1} \).

\[
100 \Delta \log s_t = \mu_t + \epsilon_t + \gamma \hat{\theta}_{jt-1} \\
\epsilon_t | \Omega_{t-1} \sim N(0, \sigma_t^2) \\
\sigma_t^2 = \omega + \alpha \epsilon_{t-1}^2 + \beta \sigma_{t-1}^2
\]

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>( \hat{\theta}<em>{BL</em>{t-1}} )</td>
<td>1.000</td>
<td>0.074</td>
<td>0.314</td>
<td>0.141</td>
<td>1.586</td>
</tr>
<tr>
<td>( \hat{\theta}<em>{BR</em>{t-1}} )</td>
<td>0.050</td>
<td>0.000</td>
<td>0.880</td>
<td>0.500</td>
<td>0.000</td>
</tr>
<tr>
<td>( \hat{\theta}<em>{FR</em>{t-1}} )</td>
<td>0.169</td>
<td>0.250</td>
<td>0.088</td>
<td>0.020</td>
<td>0.911</td>
</tr>
<tr>
<td>( \hat{\theta}<em>{HL</em>{t-1}} )</td>
<td>0.427</td>
<td>0.844</td>
<td>0.017</td>
<td>0.027</td>
<td>0.013</td>
</tr>
<tr>
<td>( \hat{\theta}<em>{IT</em>{t-1}} )</td>
<td>0.391</td>
<td>0.790</td>
<td>0.496</td>
<td>0.128</td>
<td>1.235</td>
</tr>
<tr>
<td>( \hat{\theta}<em>{SW</em>{t-1}} )</td>
<td>0.238</td>
<td>0.629</td>
<td>0.045</td>
<td>1.111</td>
<td>3.104</td>
</tr>
<tr>
<td>( \sum \hat{\theta}_{jt-1} )</td>
<td>8.655</td>
<td>3.224</td>
<td>9.341</td>
<td>3.768</td>
<td>3.945</td>
</tr>
</tbody>
</table>

Key: All the elements in the first six rows have an asymptotic \( \chi^2 \) distribution under the null, while the elements in the final row are asymptotically \( \chi^2 \) distributed. The final row of the table denotes the Wald test statistic when all five other lagged conditional residuals are included in the equation for the mean returns. One asterisk denotes significance at the 0.05 level and two asterisks indicates significance at the 0.01 level.
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**Table 3.** Robust Wald tests for causality in mean: effect of conditional standard deviations $\hat{\sigma}_\mu$.

$$100\Delta \log s_t = \mu_i + e_{it} + \lambda \hat{\sigma}_\mu$$

or

$$e_{it} | \Omega_{t-1} \sim N(0, \sigma_{e}^2)$$

$$\sigma_{u}^2 = \omega + \alpha \epsilon_{u,t-1}^2 + \beta \sigma_{u,t-1}^2 + \gamma \hat{\sigma}_\mu$$

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</thead>
<tbody>
<tr>
<td>$\hat{\sigma}_{BLt}$</td>
<td>0.898</td>
<td>1.000</td>
<td>1.128</td>
<td>2.116</td>
<td>14.916**</td>
<td>9.434**</td>
</tr>
<tr>
<td>$\hat{\sigma}_{BRt}$</td>
<td>0.560</td>
<td>1.054</td>
<td>0.055</td>
<td>0.000</td>
<td>1.359</td>
<td>0.183</td>
</tr>
<tr>
<td>$\hat{\sigma}_{FRt}$</td>
<td>0.336</td>
<td>2.678</td>
<td>2.384</td>
<td>0.826</td>
<td>13.351**</td>
<td>5.556*</td>
</tr>
<tr>
<td>$\hat{\sigma}_{HLt}$</td>
<td>0.699</td>
<td>2.589</td>
<td>0.007</td>
<td>0.184</td>
<td>0.498</td>
<td>1.032</td>
</tr>
<tr>
<td>$\hat{\sigma}_{HTt}$</td>
<td>0.474</td>
<td>1.214</td>
<td>0.084</td>
<td>2.028</td>
<td>9.620</td>
<td>1.588</td>
</tr>
<tr>
<td>$\hat{\sigma}_{SWt}$</td>
<td>4.386*</td>
<td>0.286</td>
<td>0.046</td>
<td>4.054*</td>
<td>3.340</td>
<td>0.885</td>
</tr>
<tr>
<td>$\sum \hat{\sigma}_{jt}$</td>
<td>7.487</td>
<td>10.162</td>
<td>4.302</td>
<td>6.517</td>
<td>31.935**</td>
<td>15.216**</td>
</tr>
</tbody>
</table>

Key: See Table 2.

**Table 4.** Robust Wald tests for causality in variance: effect of conditional variances $\hat{\sigma}_\mu^2$.

$$100\Delta \log s_t = \mu_i + e_{it}$$

or

$$e_{it} | \Omega_{t-1} \sim N(0, \sigma_{e}^2)$$

$$\sigma_{u}^2 = \omega + \alpha \epsilon_{u,t-1}^2 + \beta \sigma_{u,t-1}^2 + \gamma \hat{\sigma}_\mu^2$$

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<th>Switzerland</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\sigma}_{BLt}^2$</td>
<td>—</td>
<td>20.25**</td>
<td>4.514*</td>
<td>0.563</td>
<td>1.000</td>
<td>0.111</td>
</tr>
<tr>
<td>$\hat{\sigma}_{BRt}^2$</td>
<td>1.250</td>
<td>—</td>
<td>0.142</td>
<td>1.591</td>
<td>8.869**</td>
<td>21.741**</td>
</tr>
<tr>
<td>$\hat{\sigma}_{FRt}^2$</td>
<td>0.0003</td>
<td>1.000</td>
<td>—</td>
<td>0.444</td>
<td>4.000*</td>
<td>0.442</td>
</tr>
<tr>
<td>$\hat{\sigma}_{HLt}^2$</td>
<td>0.857</td>
<td>1.000</td>
<td>0.028</td>
<td>—</td>
<td>9.990**</td>
<td>5.760*</td>
</tr>
<tr>
<td>$\hat{\sigma}_{HTt}^2$</td>
<td>1.700</td>
<td>0.640</td>
<td>1.846</td>
<td>0.444</td>
<td>—</td>
<td>0.000</td>
</tr>
<tr>
<td>$\hat{\sigma}_{SWt}^2$</td>
<td>3.642</td>
<td>0.016</td>
<td>0.307</td>
<td>0.009</td>
<td>1.313</td>
<td>—</td>
</tr>
<tr>
<td>$\sum \hat{\sigma}_{jt}^2$</td>
<td>4.922</td>
<td>26.542</td>
<td>8.291</td>
<td>3.476</td>
<td>14.927*</td>
<td>28.865**</td>
</tr>
</tbody>
</table>

Key: See Table 2.

for this form of market inefficiency is equivalent to testing for GARCH in the mean (GARCH-M) effects, where the lagged conditional standard deviations are used to explain mean returns. The original ARCH-M model introduced by Engle et al. (1987) is the model used for this purpose, where interest focuses on whether lagged conditional standard deviations significantly cause mean returns. Table 3 presents a series of Robust Wald statistics to test this proposition. Again the evidence is generally supportive of market efficiency and a time invariant risk premium with no systematic effects of news or volatility on one currency being useful in predicting returns on another for 30 of the 36 possible relationships. The exceptions to this are the mean returns of Italy and Switzerland that strongly react to volatility on
the Belgian and French currencies. However, a considerable amount of these significant relationships appear to be due to events around the time of the Bear Squeeze in March 1924 when volatility peaked on the French and Belgian francs. In order to isolate the degree of dependence that is due to the highly abnormal bear squeeze period we included two dummy variables in the French and Belgian conditional variance equations for the weeks of March 11 and 18, 1924 and then used these adjusted conditional standard deviations in the model presented in Table 3. For Italy, for example, the Robust Wald statistics were reduced from 14.916 to 11.304 for Belgian volatility; and from 13.351 to 11.977 for the effect of French volatility. Thus, although the bear squeeze appears to be an important factor, it is not the only occasion when news on the French and Belgian currencies was related to subsequent mean returns on the Italian and Swiss currencies.

Previous results reported in Tables 2 and 3 were concerned with tests for causation in the mean. The results in Table 4 test for similar causal relationships between the exchange rate returns variances. For the Italian and Swiss currencies, which appear from Table 3 to exhibit significant spillovers in the mean, the results in Table 4 should be interpreted carefully. Overall, however, there is little evidence of spillovers in the variance and the general conclusion emerging from the study is consistent with the study of hourly exchange rates from 1986 analyzed by Baillie and Bollerslev (1991).

IV. Conclusions

The 1920s provide an interesting experiment on the success of a floating exchange rate system. Despite the relatively primitive conditions compared with today’s markets, the 1920s exchange rate returns appear remarkably similar in pattern to today’s markets, with a highly persistent volatility process. In general little evidence is available to question the efficiency of these markets, although lagged news and volatility on the French and Belgian currencies appear to be transmitted to future returns on the Italian lira and the Swiss franc. While a certain amount of this ‘inefficiency’ appears due to the events surrounding the famous Bear Squeeze of March 1924 there are probably other periods as yet unaccounted for when this causal flow of information occurred. For the other currencies, no such departure from apparent market efficiency was evident.

Appendix

This appendix describes the robust standard error procedure developed in Weiss (1986), Bollerslev and Wooldridge (1992), and Wooldridge (1990). Let,

\[ \mu_t(\theta) = E_{t-1}(y_t) \]
\[ \sigma^2_t(\theta) = \text{Var}_{t-1}(y_t) \]

denote the conditional mean and the variance for \( y_t \) as a function of the unknown parameters \( \theta \). It is also convenient to define

\[ e_t(\theta) = y_t - \mu_t(\theta). \]

Following Bollerslev and Wooldridge (1992), if the model for \( y_t \) correctly parameterizes \( \mu_t(\theta) \) and \( \sigma^2_t(\theta) \), the Quasi Maximum Likelihood Estimator (QMLE) for \( \theta \), say \( \hat{\theta}_T \), obtained under
the auxiliary assumption of conditional normality, will under fairly general regularity conditions be \( \sqrt{T} \) consistent for the true parameters, \( \theta_0 \), and asymptotically normally distributed. Furthermore, a consistent estimate for the asymptotic covariance matrix for \( \hat{\theta}_T \) is readily available, as

\[
\sqrt{T}(A_T^{-1} B_T A_T^{-1})^{-1/2}(\hat{\theta}_T - \theta_0) \rightarrow N(0, I),
\]

where

\[
A_T = T^{-1} \sum_{t=1}^{T} \left[ \nabla_{\theta} \mu(t) \nabla_{\theta} \sigma_t^{-2}(\hat{\theta}_T) + 0.5 \nabla_{\theta} \sigma_t^2(\hat{\theta}_T) \nabla_{\theta} \sigma_t^{-4}(\hat{\theta}_T) \right]
\]

and

\[
B_T = \hat{\beta}_T^{-1} \sum_{t=1}^{T} \left[ \nabla_{\theta} \mu(t) \nabla_{\theta} \sigma_t^{-2}(\hat{\theta}_T) \psi(t) + 0.5 \nabla_{\theta} \sigma_t^2(\hat{\theta}_T) \sigma_t^{-4}(\hat{\theta}_T) (\epsilon_t^2(\hat{\theta}_T) - \sigma_t^2(\hat{\theta}_T)) \right].
\]

The limiting distribution available from \( \langle A3 \rangle \) is used to construct the robust Wald statistics used throughout this paper. It should be noted that, the expressions in \( \langle A2 \rangle \) and \( \langle A3 \rangle \) involve first derivatives of the conditional mean and variance functions only. This is particularly appealing when numerical derivatives are being used. Also, when the assumption of conditional normality is satisfied, the usual information matrix results hold true; i.e., \( E(A_T^{-1} B_T A_T^{-1}) = E(A_T^{-1}) = E(B_T^{-1}) \).

**Notes**

1. For the German mark, not analyzed any further here, the unit root hypothesis can be rejected in favor of an explosive alternative.
2. Restricting the analysis to France, Belgium and Italy in order to increase the potential power of the test does not alter this conclusion. The findings of Baillie and Bollerslev (1989a) and the implications concerning the predictability of at least one of the nominal rates have recently been challenged by Diebold *et al.* (1992) in the context of a forecasting experiment. Further analysis of the stability of the cointegrating relationship in this data is provided by Sephton and Larsen (1991).
3. An alternative to the QMLE based robust standard errors would be to estimate models with fat tailed conditional densities such as the student t density in Baillie and Bollerslev (1989b). Experience with the data in this study indicated that using robust standard errors was a more tractable procedure.

**References**


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