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THE SOURCES OF FINANCIAL CRISIS: PRE- AND POST-FED EVIDENCE*

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This paper investigates the generation and the propagation mechanism of currency demand and supply shocks before and after World War I, the structural determinants of the variability of stock prices and interest rates, and the changes introduced by the creation of the Fed on the dynamics of the system. It is shown that in the pre-1914 era external monetary shocks interacted with a seasonal demand for money to produce financial crises. The Fed helped to prevent crises by insulating the U.S. economy from external shocks. A structural VAR provides evidence for these claims.

1. INTRODUCTION

This paper addresses the following questions: What are the structural determinants of the variability of interest rates and stock prices in the U.S. before World War I? What was the propagation mechanism of currency demand and supply shocks in the U.S. before and after World War I? Was there any relevant change in the dynamics of these determinants after the Fed was created?

Several factors motivate an examination of these questions at an empirical level. First, although a large body of descriptive literature has stressed the close links existing among financial crises, movements in interest rates and stock prices and components of high-powered money (HPM) in the pre-World War I era (see e.g. Friedman and Schwartz 1963, Cagan 1965), no attempt has yet been made to examine the determinants of the variability of these financial variables.[2]

Second, the earliest literature on financial crises recognized their tendency to occur in specific seasons of the year and this fact led some authors to postulate a seasonal hypothesis of financial crises (see e.g. Andrew Piatt 1907, Kemmerer 1910 or Sprague 1910). The traditional interpretation of this phenomenon maintains that seasonal movements in the demand for currency (and/or credit) generated periods of financial stress because of the virtually inelastic supply of high-powered money.[3] A recent examination of this position contained in Miron (1986) supports the idea that seasonal fluctuations in the demand for loans or deposits may make crises more likely to occur. By examining the propagation mechanism of currency demand shocks we can provide further econometric evidence on this hypothesis.

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[2] Bordo (1965) and Gorton (1988) study banking panics and financial crises in the U.S., while Clark (1986) examines the link between interest rates and HPM but none of them address the question of the sources and the propagation mechanism of financial crises.

[3] See for example Warburg (1930), Friedman and Schwartz (1963) and Diller (1971).

Miron attributes the decreased occurrence of financial crises in the U.S. after 1914 to Federal Reserve activities. He argues that by introducing seasonality in high powered money supply, the Fed effectively eliminated the seasonal pattern existing in interest rates. Miron, Mankiw and Weil (1987) and Barsky, Miron, Mankiw and Weil (1988) examined the univariate stochastic process for prices and interest rates in the U.S. and Europe and attributed the observed changes in the process to the actions of the Fed. Since both the Fed's role in altering these stochastic processes and in reducing the occurrence of crises is still controversial,[4] this paper employs a multivariate analysis which can quantify the impact of the Fed in the experience.

The analysis of the paper proceeds in two steps: first a multivariate structural model is recovered from a weakly restricted vector autoregressive (VAR) reduced form model, the determinants of the variability of the system are identified and the dynamic propagation mechanism of structural shocks is examined. Second, the model's dynamics before and after 1914 are compared and the impact of the creation of the Fed on the system is assessed.

The approach to recover the structural shocks from the reduced form innovations is similar to Sims (1986) and Bernanke (1986) and differs from the "cointegration restriction" approach of King, Plosser, Stock and Watson (1987) or the "long-run" approach of Blanchard and Quah (1989) and Shapiro and Watson (1988). While in these studies long-run restrictions derived from economic theory are used to recover the structure of the model, here we identify behavioral equations on the basis of beliefs about the timing of the collection of information in the economy. This approach is more useful than the other two when the restrictions imposed by economic theory are controversial or there are not enough to uniquely recover the structure of the model from a reduced form.

The features of the dynamic propagation mechanism of structural shocks are examined in a Bayesian fashion, by constructing posterior distributions of the statistics of interest, in this case the variance decomposition and the impulse responses.

The results of the investigation contrast with the traditional interpretation of the experience in several respects. It is shown that unexpected movements in the availability of HPM originating from external sources have a substantial impact on the system and explain the largest portion of the variability of interest rates and stock prices before 1914. We also show that before 1914 HPM supply responds (seasonally and nonseasonally) to innovations in HPM demand. From these findings we argue that the supply of HPM was not as inelastic as was previously thought and that it was a combination of international shocks to the availability of gold in the U.S. and seasonal domestic movements in HPM demand that was responsible for the explosion of financial crises in the U.S. After 1914, we find that the importance of external shocks declined and that HPM demand and price innovations explain most of the variability of interest rates and stock prices. Since

[4] See Clark (1986) and Canova (1988) for the first issue, and Timberlake (1985) and Dewald (1972) for the second. For the experience of crises of other countries (with or without central banks) Jevons (1884) provides insights for the U.K., White (1984) for Scotland and Bordo and Redish (1985) for Canada.

the variability of external shocks did not decrease after 1914 and since the response of interest rates to HPM demand innovations was still significant and seasonal, we conclude that creation of the Fed did not help to prevent financial crises by introducing a seasonal pattern in HPM supply but rather by insulating the U.S. economy from external HPM supply shocks.

The rest of the paper is organized as follows: the next section describes the data and constructs, identifies and estimates the multivariate structural model. Section 3 describes the restrictions placed by the traditional explanation of the experience, examines the dynamics of the system and suggests an alternative interpretation of the facts. Section 4 summarizes the conclusions.

2. A STRUCTURAL VAR MODEL

In this section I employ an international vector autoregressive (VAR) model to study the propagation mechanism of currency demand and supply shocks and the determinants of the variability of interest rates and stock prices before and after the creation of the Fed.

2.1. *The Specification of the Reduced Form Model.* There are several variables which would be legitimate candidates to enter the reduced form of the system. The variables considered here are the exchange rate of New York on London, the U.K. day rate, the U.S. wholesale price index, a U.S. stock price index, the U.S. call money rate, the U.S. high powered money and a proxy for U.S. industrial production. Other variables of possible interest are excluded because of data collection problems (see Section 2.2), because their impact on the system is minimal (the case of Treasury Deposits) or because they are collinear with the included variables.

The reduced form of the system includes 13 lags of each variable and a set of seasonal dummies. Seasonal dummies are included to capture deterministic seasonals while a lag length of 13 is chosen to account for possible stochastic forms of seasonality. Since there is a great deal of controversy surrounding the treatment of trends in the variables of a VAR model, a brief discussion motivating our choice is in order.

A now standard routine to choose the specification of a VAR model is to test for the presence of unit roots and of statistical cointegrating restrictions. Conditional on the results of the tests, the VAR model is then written in a Vector Error Correction (VEC) form (see e.g. King, Plosser, Stock and Watson 1987). From a classical point of view an examination of the order of integration of each variable and of the number of unit roots existing in the system as a whole is necessary because the presence of nonstationarities in the data may make the MA representation of the system ill-conditioned and inference spurious (see e.g. Phillips 1986 or Pagan and Wickens 1989).

However, if one adopts a Bayesian point of view, inference is independent of unit roots (see Sims 1988). That is, if the VAR has normal disturbances, the prior distribution for the coefficients is normal and the prior distribution for the covariance matrix of the innovations is diffuse, then the joint posterior distribution of the coefficients of the MA representation and of the covariance matrix of the innovations is of the inverted gamma-normal type regardless of the size of the dominant roots of the system and of the number of roots on the unit circle. Therefore, inference is considerably simplified under a Bayesian point of view.

In this paper we follow the Bayesian approach and explicitly construct the joint posterior distribution of the MA coefficients using Monte Carlo methods (see Geweke 1989 for the computational issues concerning this approach). The prior on the coefficients is of the Litterman (1982) variety and is based on empirical regularities and statistical rules of thumbs found to be useful in estimation and forecasting. It features a zero mean on all coefficients except for the first own lagged coefficient (=.95) in each equation and a symmetric prior variance for the coefficients of each equation. Each prior variance is characterized by three parameters: a general tightness parameter ($\theta_1 = 0.1$), a tightness parameter on lags of variables different from the dependent one ($\theta_2 = 0.5$) and a decay parameter ($\theta_3 = 1.5$) which regulates how the prior distribution gets more concentrated around the prior mean as the lag length j increases.

Although at first glance the information contained in this prior appears to be rather restrictive or inappropriate for some of the variables of the system, it is possible to depart from this initial prior and let longer delays or cross effects have some influence. This is accomplished by choosing the dispersion associated with each prior mean, which is regulated by the parameter θ_1, to be nonnegligible.

Note also that the prior employed puts a low probability mass on the region of the coefficient space which generates unstable or explosive behavior. This choice is justified on two grounds. First, the observation that the plots of the series included in the system do not show such unstable or explosive behavior. Second, the fact that unstable roots appear in the posterior distribution of the coefficients if and only if the prior has all of its mass concentrated in the unstable region (see DeJong and Whiteman 1989 and Sims and Ulhig 1991).

No linear trend is included in the system since a 7 variable VAR system with 13 lags for each variable can account for polynomial trends up to the 91st order (see Sims 1987 for this argument). The addition of a linear trend to the system may induce collinearity at low frequencies making inference more uncertain and causing larger standard error bands around the point estimates of the variance decomposition and of the impulse response functions.

In conclusion, the reduced form of the model contains 13 lags of the level of the variables, 12 seasonal dummies and no linear trend. A weakly restrictive "Litterman" prior is imposed on the coefficients of each equation and the specification is estimated recursively with the Kalman filter in each of the two subsamples considered (1891,7–1913,12 and 1924,1–1937,1).

2.2. *The Data.* The data for the period under consideration is mostly available at monthly frequencies but presents many difficulties. First, the recording date is not homogeneous across samples. Averages over the month or the lowest value in the last week of the month are typically recorded before 1914, while end of the month values are in general reported afterwards. Second, many series measure different aggregates over time. This is the case, for example, with the bank clearing series, which measures debits of banks after 1919. Third, many financial variables have substantially different risk characteristics before and after 1914. For example, the collateral required to borrow at the time rate changed dramatically after 1915.

Finally, many series (especially banking variables) have serious gaps. The seven variables included in the model are chosen on the basis of the continuity of definition and reliability of the reported figures. The data employed measure averages over the months in both samples unless otherwise indicated.

The primary source for financial data is Macaulay (1938). We use his monthly series for the call money rate (CALL), for the U.S. Bureau of Labor Statistics' index number of wholesale price of commodities (WPI), for the index number of the prices of railroad stocks weighted by the number of share outstanding at the beginning of the year (SP)[5] and for pigiron production (PP). To maintain consistency pigiron production is used here in both samples even though a direct measure for industrial production exists after 1919.[6] The call money rate is the renewal at the desk of the New York Stock Exchange and refers to loans made for an indefinite period of time, callable with 24 hours notice and requiring a collateral deposited at the bank issuing the loan.

There are several sources for the level of high powered money (HPM) in circulation. To maintain a consistent measure of the aggregate over the two samples, we choose the data contained in Andrew Piatt (1910) up to 1905 and those contained in the Treasury Reports afterward.[7] The definition of high powered money includes gold coins and certificates, silver dollars and certificates, Treasury notes, U.S. notes and subsidiary silver outside the Treasury. After 1914 Federal notes outstanding outside the Treasury and the Fed are included. Net gold exports refer to the gold balance at the New York market and is taken from Andrew Piatt and Banking and Monetary Statistics (BMS) (1943, p. 536). Data on the exchange rate with the U.K. (EXR) is the lowest value of the last week of the month for the rate quoted in New York and is taken from Kemmerer (1910, p. 374) for the period up to 1909 and from BMS (p. 681) after 1913. Since the exchange rate is practically constant in the years before 1909 and after 1914, missing data are reconstructed using a simple spline interpolation.

The U.K. day rate (UKD) is the rate for overnight loans charged by banks in London and has risk features similar to the U.S. call rate. In the first sample it corresponds to the rate quoted on the first Friday of the month and the sources are Palgrave Inglis (1910) and Goodhart (1972). No data is available on this rate from 1918 to 1924. BMS contains monthly averages of daily figures after 1924.

2.3. *The Structural Innovations.* To provide a structural interpretation of the dynamic features of the system, it is necessary to identify behavioral disturbances. Let y_t be the 7×1 vector of variables of the system and let the reduced form be written as:

[5] Macaulay does not indicate how he constructed the SP index. Since in the 1890's only few stocks appeared in the index, there are doubts about the reliability of this measure of stock prices for the early part of the sample.

[6] In addition to consistency issues, it appears that the IP index is not a reasonable indicator of real activity. This is because it heavily weighs financial variables (like bank clearings) to obtain a proxy measure of industrial activities.

[7] The data contained in Banking and Monetary Statistics from 1915 on are end of the month figures.

$$y_t = A(l)y_{t-1} + \sum_{s=1}^{12} \beta_s D_s + u_t, \tag{1}$$

where $A(l)$ is a matrix polynomial in the lag operator, D_s are seasonal dummies, u_t are the reduced form innovations which, conditional on $H_u(t-1)$, are serially independent normally distributed random variables with covariance matrix Σ where $H_u(t)$ is the completion of the space spanned by linear combinations of u_t. Let the corresponding dynamic behavioral model be written as:

$$a(l)y_t = \sum_{s=1}^{12} b_s D_s + \varepsilon_t, \tag{2}$$

where $a(l)$ is matrix polynomial in the lag operator of the same order as $A(l)$ and ε_t, conditional on $H_\varepsilon(t-1)$, are serially independent, normally distributed disturbances with covariance matrix Ω. We assume that dim $(u) \supseteq$ dim (ε) (see King 1986) and $H_u(t) = H_\varepsilon(t)$. Comparing (1) and (2) we have:

$$\begin{aligned} A(l) &= -a_0^{-1}a(l) \; \forall \, l \\ \beta_s &= a_0^{-1}b_s \\ u_t &= a_0^{-1}\varepsilon_t. \end{aligned} \tag{3}$$

By equation (3), the covariance matrices of u_t and ε_t are linked by $\Sigma = a_0^{-1}\Omega a_0^{-1'}$. To recover the structural disturbances ε_t and to examine the propagation mechanism of structural shocks we need to identify and estimate a_0 and Ω.

Blanchard and Quah (1989), Shapiro and Watson (1988) and others have used the restriction $A(1) = -a_0^{-1}a(1)$ together with the assumption that $a(1)$ is triangular (or block triangular) and that Ω is diagonal to identify structural disturbances and to examine the propagation mechanism of shocks. The rationale for having $a(1)$ triangular (or block triangular) in their model is that economic theory predicts that shocks to the demand for goods will have no long-run effects, while shocks to the supply of goods will. However, since here we are primarily interested in currency demand and supply shocks, their identification scheme is not useful.

An alternative approach is to use theoretical cointegrating restrictions to identify the structure of the model (see e.g., King, Plosser, Stock and Watson 1987). Examples of theoretical cointegrating restrictions which could emerge in the international system under consideration are interest rate arbitrage and the homogeneity of the price level with the nominal exchange rate.[8] Unfortunately, theory does not provide enough of these restrictions to be able to identify the structural innovations and an alternative strategy is required.

The approach we use here is informational. That is, since the availability of information places restrictions on the way agents react to certain shocks, we use

[8] I would like to thank an anonymous referee for suggesting these as reasonable theoretical long-run restrictions.

these restrictions to identify their behavior. We assume that Ω is diagonal and restrict the a_0 matrix so that (3) becomes:

(4) $$u_{EXR} = \alpha_1 u_{UKD} + \alpha_2 u_{SP} + \alpha_3 u_{CALL} + \varepsilon_1$$

(5) $$u_{UKD} = \alpha_4 u_{EXR} + \alpha_5 u_{SP} + \alpha_6 u_{CALL} + \varepsilon_2$$

(6) $$u_{CALL} = \alpha_7 u_{EXR} + \alpha_8 u_{SP} + \alpha_9 u_{HPM} + \varepsilon_3$$

(7) $$u_{HPM} = \alpha_{10} u_{WPI} + \alpha_{11} u_{CALL} + \alpha_{12} u_{PP} + \varepsilon_4$$

(8) $$u_{WPI} = \alpha_{13} u_{SP} + \alpha_{14} u_{CALL} + \alpha_{15} u_{PP} + \varepsilon_5$$

(9) $$u_{PP} = \alpha_{16} u_{WPI} + \alpha_{17} u_{SP} + \alpha_{18} u_{CALL} + \varepsilon_6$$

(10) $$u_{SP} = \alpha_{19} u_{CALL} + \varepsilon_7 .$$

The rationale for this identification scheme is as follows: equations (4) and (5) represent two components of an external HPM supply function. Innovations in these equations represent international (private and public) shocks to gold flows. Implicit in (4) and (5) are the assumptions that the foreign monetary authority and the foreign private sector respond within a month to U.S. financial variables, but with a delay to other U.S. variables because of data collection and communication delays.

Equation (6) is a domestic HPM supply function and describes the behavior of the monetary authority and of the U.S. banking system. All shocks to U.S. financial variables are assumed to enter this equation, while innovations in WPI and pigiron are excluded on the grounds of data delay. Shocks in U.K. day rate are also excluded from this equation because banks and policymakers are not interested in shocks in the rate for overnight loans in London unless they affect the exchange rate or domestic financial markets.

Equation (7) is a domestic HPM demand function. It states that, within a month, shocks to the demand for money of the nonbanking public stem from shocks in the price level, in the interest rate and in domestic output. Innovations to equations (6) and (7) represent domestic shocks to the supply and the demand of HPM, respectively.

Equations (8) and (9) describe real aspects of the U.S. private nonbanking sector. They link production and price shocks to the interest rate and to stock price shocks.

Finally, equation (10) is an arbitrage relation. It assumes that shocks to stock prices are influenced by shocks to the level of interest rates within a month. Innovations in this equation represent shocks to the risk differential of the two assets. Foreign variables and U.S. monetary variables are excluded from equations (8) through (10) on the assumption that within the month they impact on the variables of this block only through the U.S. interest rate.

The above scheme identified 5 blocks of shocks (external HPM supply shocks, domestic HPM supply shocks, domestic HPM demand shocks, real and financial shocks). To transform the system into an orthogonal form, the cross equation correlations in the external HPM supply block (equations (4) and (5)) and the real block (equations (8) and (9)) are removed with an arbitrary triangularization which sets α_1, α_{16} equal to zero.[9]

2.4. *Estimation.* With this identification scheme there are 24 free parameters (17 α's and the 7 diagonal elements of Ω). Since there are 28 free parameters in Σ the system is overidentified and the simple Indirect Least Square (ILS) procedure of Bernanke (1986) does not apply. The estimation of a_0 and of the diagonal elements of Ω is undertaken here using a latent variable maximum likelihood routine. The log likelihood for the problem is given by:

$$\mathcal{L} = -\frac{T}{2} (\log |a_0^{-1}\Omega a_0^{-1'}|) - \frac{1}{2} \sum_{t=1}^{T} u_t a_0 \Omega^{-1} a_0' u_t'. \tag{11}$$

The trace of the second element is given by $\Omega^{-1/2} a_0 \Sigma a_0' \Omega^{-1/2'}$. Maximizing (11) with respect to Σ and concentrating the likelihood yields:

$$\bar{\mathcal{L}} = -\frac{T}{2} \operatorname{tr} (\Omega^{-1/2} a_0 \hat{\Sigma} a_0' \Omega^{-1/2'}) - \frac{T}{2} \left(\sum_{k=1}^{7} \sigma_k^2 \right) + T \log |a_0^{-1}|, \tag{12}$$

where $\Omega = \operatorname{diag}(\sigma_k^2)$, $k = 1, \ldots, 7$, tr (Z) indicates the trace of the matrix Z, $\hat{\Sigma}$ $1/T * \Sigma_{t=1}^{T-1} \hat{u}_t \hat{u}_t'$ and where $\hat{u}_t$ are the estimated VAR residuals obtained from (1).

The estimation procedure used here therefore involves two steps: first, from the estimation of the VAR coefficients we retrieve $\hat{u}_t$ and $\hat{\Sigma}$ Then, given $\hat{\Sigma}$, we seek a decomposition $\hat{\Sigma} = a_0^{-1} \Omega a_0^{-1'}$, where Ω is diagonal and a_0 is given by (4) through (10), which maximizes (12). A necessary condition for this two step procedure to be asymptotically correct is that the information matrix of the problem is block diagonal (see Durbin 1970). When estimates for the free parameters of a_0 and Ω are found, the variance decomposition and the impulse response function of the structural model can be computed by substituting (3) into the MA representation obtained from (1).

Table 1 presents the estimated correlation matrices of the reduced form innovations for the system in the two samples. A "*" indicates that the null hypothesis of zero correlation is asymptotically rejected at the 10 percent confidence level.[10]

The estimated values for the free parameters in the two samples are reported below with approximate standard errors in parenthesis.[11]

[9] An earlier version of the paper showed that this arbitrary choice is innocuous for the results of Section 4, i.e. alternative triangularization schemes in each of the two blocks do not alter the conclusions. Also, two other identification schemes, employed to check the robustness of the results, produced conclusions which are very similar to the ones reported in this paper and are available on request from the author.

[10] Table 1 indicates that, among other things, the contemporaneous correlations between HPM, the call rate and pigiron innovations are small in both samples and have a negative sign. This agrees with the evidence found by Litterman and Weiss (1985) for the post-WWII U.S. economy.

[11] The code employed to maximize (12) employs iterative methods, is based on a BFGS updating algorithm and was written by Chris Sims. The approximate standard errors are based on the second order derivative accumulated during the search. Convergence is independent of initial conditions and was obtained in about 20 steps.

Sample 1891,7–1913,12

$$u_{EXR} = \underset{(.003)}{-.0001} \times u_{SP} \; \underset{(.00005)}{-.0004} \times u_{CALL} + \varepsilon_1$$

$$u_{UKD} = \underset{(17.88)}{-7.54} \times u_{EXR} \; \underset{(.77)}{-1.56} \times u_{SP} \; \underset{(.01)}{-.03} \times u_{CALL} + \varepsilon_2$$

$$u_{CALL} = \underset{(.32)}{-.40} \times u_{EXR} \; \underset{(1.19)}{+.10} \times u_{SP} \; \underset{(.26)}{-.05} \times u_{HPM} + \varepsilon_3$$

$$u_{HPM} = \underset{(.038)}{-.06} \times u_{WPI} \; \underset{(.0002)}{.0002} \times u_{CALL} \; \underset{(.009)}{+.01} \times u_{PP} + \varepsilon_4$$

$$u_{WPI} = \underset{(.01)}{-.07} \times u_{SP} \; \underset{(.0005)}{-.00004} \times u_{CALL} \; \underset{(.014)}{+.003} \times u_{PP} + \varepsilon_5$$

$$u_{PP} = \underset{(.07)}{.05} \times u_{SP} \; \underset{(.001)}{+.003} \times u_{CALL} + \varepsilon_6$$

$$u_{SP} = \underset{(.0008)}{.0009} \times u_{CALL} + \varepsilon_7$$

Sample 1924,1–1937,1

$$u_{EXR} = \underset{(.03)}{-.10} \times u_{SP} \; \underset{(.002)}{-.001} \times u_{CALL} + \varepsilon_1$$

$$u_{UKD} = \underset{(1.009)}{-.11} \times u_{EXR} \; \underset{(.371)}{+1.33} \times u_{SP} \; \underset{(.04)}{-.006} \times u_{CALL} + \varepsilon_2$$

$$u_{CALL} = \underset{(5.18)}{17.7} \times u_{EXR} \; \underset{(2.75)}{+6.83} \times u_{SP} \; \underset{(5.07)}{+30.64} \times u_{HPM} + \varepsilon_3$$

$$u_{HPM} = \underset{(.23)}{-.04} \times u_{WPI} \; \underset{(.006)}{-.01} \times u_{CALL} \; \underset{(.008)}{-.009} \times u_{PP} + \varepsilon_4$$

$$u_{WPI} = \underset{(.001)}{-.03} \times u_{SP} \; \underset{(.001)}{-.002} \times u_{CALL} \; \underset{(.003)}{-.008} \times u_{PP} + \varepsilon_5$$

$$u_{PP} = \underset{(.34)}{-.70} \times u_{SP} \; \underset{(.04)}{-.05} \times u_{CALL} + \varepsilon_6$$

$$u_{SP} = \underset{(.04)}{-.08} \times u_{CALL} + \varepsilon_7$$

The Estimated Diagonal Elements of Ω

Sample 1891,7–1913,12	Sample 1924,1–1937,1
$\sigma_1^2 = 2.20E-06$	$\sigma_1^2 = 1.84E-04$
$\sigma_2^2 = 0.208$	$\sigma_2^2 = 3.64E-02$
$\sigma_3^2 = 2.437$	$\sigma_3^2 = 0.307$
$\sigma_4^2 = 4.725$	$\sigma_4^2 = 2.18E-04$
$\sigma_5^2 = 1.40E-04$	$\sigma_5^2 = 3.61E-05$
$\sigma_6^2 = 2.19E-03$	$\sigma_6^2 = 3.12E-02$
$\sigma_7^2 = 7.18E-04$	$\sigma_7^2 = 3.20E-03$

The 90 percent posterior probability bands for the variance decomposition of the structural system at the 60-month horizon and for the structural impulse responses appear in Table 2 and Figures 1 and 2 respectively.[12] The bands are computed by approximating the posterior distribution of these statistics using Monte Carlo methods. The procedure employed simplifies the one of Kloek and Van Dijk (1978) by directly drawing 100 samples from the posterior distribution of the VAR coefficients and the covariance matrix. For each sample the impulse response and

[12] The impulse responses are scaled to be percentage of the largest absolute value of the response of each variable, i.e., the graphs are comparable by rows, not by columns.

TABLE 1
CORRELATION MATRIX OF INNOVATIONS

Sample 1891, 7–1913, 12

	exrate	ukday	wpi	stoprice	callmony	money	pigiron
exrateuk	.26E-05	−.01	.10	−.02	−.39*	−.007	.16*
ukday		.21*	.07	.08	.10	.08	−.03
wpi			.14E-03	.16*	−.001	.11*	−.01
stoprice				.71E-03	−.05	.15*	−.02
callmony					2.42	−.03	−.10
money						.48E-04	−.12*
pigiron							.002

Sample 1924, 1–1937, 1

	exrate	ukday	wpi	stoprice	callmony	money	pigiron
exrateuk	18E-03	−.05	.11	.19*	−.20*	−.29*	.02
ukday		.04	−.09	−.30*	.004	.29	−.10
wpi			.42E-04	.26*	.15*	−.05	.27*
stoprice				.0022	.01	−.36*	.14*
callmony					.14	.008	.05
money						.16E-03	.03
pigiron							.03

Note: The variances are on the main diagonal. A "*" indicates correlations which are significantly different from zero.

the variance decomposition are computed. At the end of the exercise the statistics are ordered and the 90 percent band extracted.

Table 3 shows the 90 percent posterior probability band for the variance decomposition in seasonal bands. This measure decomposes the average (over frequencies) forecast error variance of each variable in each seasonal band into a sum of components associated with a set of orthogonal innovations. The measure is therefore useful to assess the impact of certain shocks at seasonal frequencies. Its derivation is as follows. Let the MA representation for the structural system be:

$$y_t = B(l)\left(\sum_{s=1}^{12} b_s D_s + a_0^{-1}\varepsilon_t\right), \tag{13}$$

where $B(l) = A(l)^{-1}$. Let $x_t = y_t - B(l)\Sigma_{s=1}^{12} b_s D_s$. Since by construction cov $(\varepsilon_{t,i}, \varepsilon_{t,k}) = 0\ \forall\ i, k$, the variance of $x_{t,i}$ is the sum of orthogonal components associated with $\varepsilon_{t,k}$, $k = 1, \ldots, 7$. Therefore, for all $\omega \in [-\pi, \pi]$

$$F_{x_i}(\omega) = \sum_{k=1}^{7} |B_{i,k}(\omega)|^2 \times \frac{\sigma_k^2}{2\pi} \qquad i = 1, \ldots 7, \tag{14}$$

where F_{x_i} is the spectral density of $x_{t,i}$ and $B(\omega)$ is the Fourier transform of $B(l)a_0^{-1}$. Let $m_{i,k}(\omega_0)$ be the percentage of the variance of x_i at frequency ω_0 explained by innovations in x_k, i.e.:

TABLE 2
VARIANCE DECOMPOSITION AT 60 STEPS: 90 PERCENT CONFIDENCE BAND

Variance of	EX R	UK D	WPI	SP	Call	HPM	PP
Sample 1891, 7–1913, 12							
Explained by							
Foreign Shock 1	[57–98]	[54–96]	[48–91]	[67–99]	[60–99]	[62–99]	[58–97]
Foreign Shock 2	[0–2]	[0–3]	[0–1]	[0–1]	[0–1]	[0–1]	[0–1]
Price	[0–4]	[0–3]	[4–26]	[0–1]	[0–2]	[0–1]	[0–2]
Stock Price	[0–1]	[0–3]	[0–2]	[0–4]	[0–4]	[0–2]	[0–2]
Monetary Policy	[0–1]	[0–1]	[0–2]	[0–1]	[0–2]	[0–1]	[0–1]
HPM Demand	[0–16]	[1–5]	[1–8]	[3–18]	[1–16]	[1–10]	[2–9]
Production	[0–0]	[0–1]	[0–1]	[0–0]	[0–1]	[0–1]	[0–2]
Sample 1924, 1–1937, 12							
Explained by							
Foreign Shock 1	[13–38]	[7–20]	[3–21]	[7–28]	[3–19]	[5–17]	[2–11]
Foreign Shock 2	[0–2]	[0–2]	[0–3]	[0–2]	[0–1]	[0–1]	[0–1]
Price	[14–45]	[47–63]	[58–73]	[14–31]	[54–73]	[25–41]	[28–44]
Stock Price	[0–8]	[0–4]	[1–5]	[9–22]	[1–4]	[2–7]	[3–10]
Monetary Policy	[0–1]	[0–1]	[0–1]	[0–2]	[0–1]	[0–1]	[0–1]
HPM Demand	[22–54]	[18–39]	[24–42]	[31–57]	[8–22]	[40–68]	[33–59]
Production	[0–1]	[0–1]	[0–0]	[0–1]	[0–1]	[0–1]	[1–3]

(15)
$$m_{i,k}(\omega_0) = \frac{|B_{i,k}(\omega_0)|^2}{F_{y_i}(\omega_0)} \times \frac{\sigma_k^2}{2\pi}.$$

Define:

(16)
$$M_{i,k} = (\|\Gamma\|)^{-1} \int_\Gamma m_{i,k}(\omega)\, d\omega,$$

where $\Gamma = [\omega_0 - \delta, \omega_0 + \delta]$, $\|\Gamma\|$ is the length of Γ. $M_{i,k}$ is the average percentage of the variance of y_i in the band Γ explained by y_k. Table 3 reports the 90 percent posterior band for $M_{i,k}$. There $\omega_0 = h\pi/6$, $h = 1, \dots, 6$, δ includes three spectral ordinates and $\|\Gamma\| = 7$.

3. THE RESULTS

3.1. *The Standard Hypothesis.* Some of the existing literature (see e.g. Miron 1986, Miron, Mankiw and Weil 1987, Barsky, Miron, Mankiw and Weil 1988, and Barro 1989) has suggested that:

(a) the supply of HPM was inelastic before 1914, that U.S. interest rates moved in response to (seasonal) fluctuations in currency demand and that

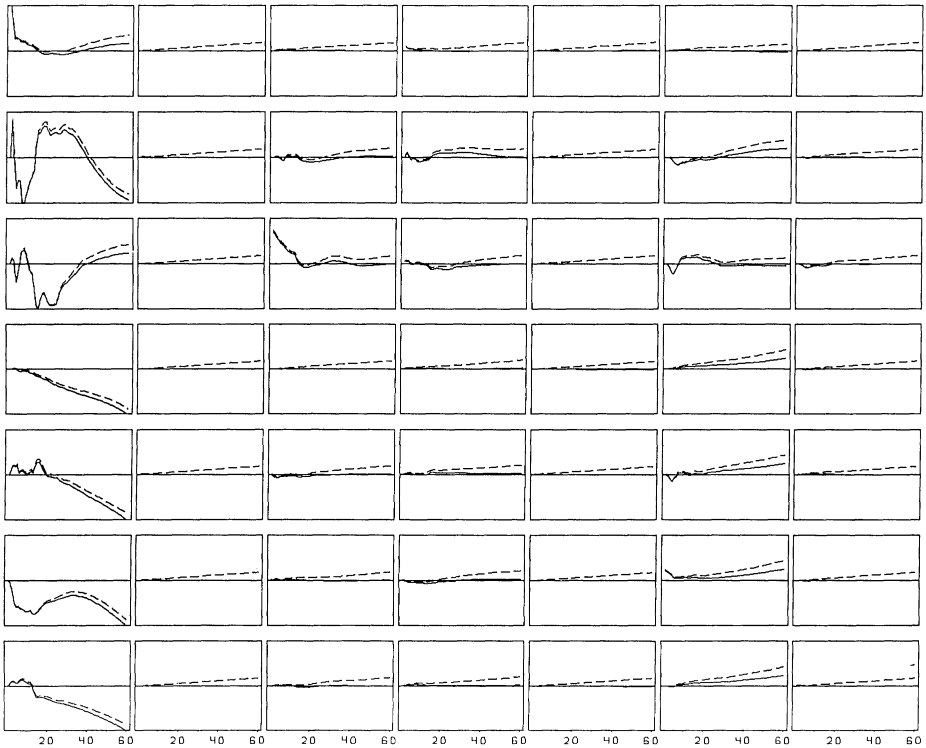

FIGURE 1

IMPULSE RESPONSES, SAMPLE 1891,7–1913,12. ON THE TOP (FROM LEFT TO RIGHT) FOREIGN SHOCK 1, FOREIGN SHOCK 2, PRICE SHOCK, STOCK PRICES SHOCKS, MONETARY POLICY SHOCK, HPM DEMAND SHOCK, PRODUCTION SHOCK. ON THE LEFT (FROM TOP TO BOTTOM) EXCHANGE RATE RESPONSES, U.K. INTEREST RATE RESPONSES, WPI RESPONSES, STOCK PRICES RESPONSES, U.S. INTEREST RATE RESPONSES, HPM RESPONSES, PIG IRON RESPONSES.

crises were induced by (seasonal) currency demand shocks occurring in conjunction with an inelastic supply of HPM;[13]

(b) the Fed introduced some form of elasticity in the supply of HPM after 1914; and therefore
(c) produced changes in the process for interest rates and prices; and
(d) reduced the occurrence of financial crises by eliminating the precondition (the inelastic behavior in the supply of HPM) that made crises more likely to occur.[14]

These claims can be translated in the context of the structural model (2) as follows. Innovations in currency demand should be followed by an insignificant

[13] We identifty crises with "a rapid rise in the rate of discount, a sudden flood of bankruptcy and a fall in consol [as well as stock prices] followed by a rise" (Jevons 1884, p. 8).

[14] In particular, this literature suggests that after 1914 the supply of HPM became seasonal, that interest rate seasonality disappeared and that this was sufficient to make crises less likely to occur.

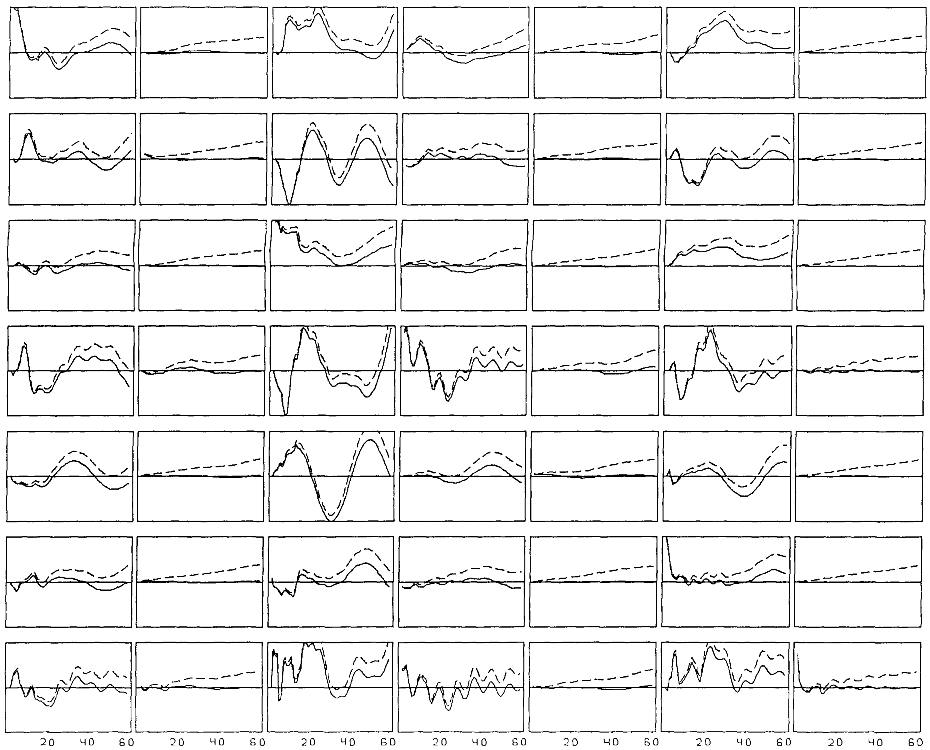

FIGURE 2

IMPULSE RESPONSES, SAMPLE 1924,1–1937,1. ON THE TOP (FROM LEFT TO RIGHT) FOREIGN SHOCK 1, FOREIGN SHOCK 2, PRICE SHOCK, STOCK PRICES SHOCKS, MONETARY POLICY SHOCK, HPM DEMAND SHOCK, PRODUCTION SHOCK. ON THE LEFT (FROM TOP TO BOTTOM) EXCHANGE RATE RESPONSES, U.K. INTEREST RATE RESPONSES, WPI RESPONSES, STOCK PRICES RESPONSES, U.S. INTEREST RATE RESPONSES, HPM RESPONSES, PIG IRON RESPONSES.

response of HPM supply in the first sample. However, when the Fed allowed the supply of HPM to become elastic we should expect to see large and persistent HPM responses following currency demand innovations. In this scenario, call rate and stock price responses should show short-run and irregular fluctuations in the first sample following currency demand innovations. In the second sample their response to these innovations should be marginal and insignificant.[15] This pattern should be evident, in particular, at seasonal frequencies. Innovations in HPM demand should have little (large) explanatory power for the decomposition HPM supply before (after) 1914. The opposite should occur for interest rate and stock price decompositions.

[15] If the adjustment took place within a month, we should expect the coefficient of the HPM innovations in the HPM supply equation (6) to be large in the first sample and insignificant and positive after the Fed was created. This is because the equation is normalized on the call rate and the coefficients on the call rate in the HPM supply equation should be small in the first sample and positive and significant in the second.

TABLE 3

VARIANCE DECOMPOSITION IN SEASONAL BANDS: 90 PERCENT CONFIDENCE BAND

Sample 1891, 7–1913, 12					
Band Around	$\pi/6$	$\pi/3$	$\pi/2$	$2/3\pi$	$5/6\pi$
Decomposition of EXR					
Foreign Shock 1	[92–99]	[92–99]	[97–99]	[97–99]	[98–99]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[.1–1]	[.1–.9]	[.2–.9]	[.1–1]	[.1–.8]
Stock Price	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Monetary Policy	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[.1–.5]	[.1–.4]	[.1–.4]	[.08–.3]	[.1–.5]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of UKD					
Foreign Shock 1	[94–96]	[91–94]	[97–99]	[98–99]	[94–97]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[.5–1]	[.8–1]	[.1–.3]	[0–0]	[.1–.2]
Stock Price	[.3–.8]	[.3–.8]	[.1–.2]	[.1–.1]	[.3–.5]
Monetary Policy	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[1–4]	[3–7]	[.6–2]	[.9–2]	[.8–3]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of WPI					
Foreign Shock 1	[50–68]	[41–62]	[12–30]	[21–40]	[36–51]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[12–30]	[31–50]	[63–81]	[53–78]	[49–62]
Stock Price	[.4–6]	[.3–.5]	[0–0]	[.3–.5]	[.3–.4]
Monetary Policy	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[3–8]	[4–7]	[0–1]	[.3–.8]	[.1–.3]
Production	[.1–.3]	[.1–.3]	[0–0]	[0–0]	[0–0]
Decomposition of SP					
Foreign Shock 1	[90–96]	[91–96]	[91–95]	[90–95]	[90–95]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Stock Price	[1–2]	[1–2]	[1–2]	[1–2]	[1–2]
Monetary Price	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[3–5]	[4–6]	[4–6]	[5–6]	[4–5]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of Call					
Foreign Shock 1	[86–94]	[85–95]	[87–95]	[87–94]	[87–95]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[.7–1]	[.7–1]	[.5–.7]	[0–0]	[.1–.2]
Stock Price	[1–2]	[1–2]	[1–2]	[1–2]	[1–2]
Monetary Policy	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[5–9]	[5–9]	[3–6]	[4–6]	[5–6]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of HPM					
Foreign Shock 1	[84–89]	[86–91]	[86–91]	[84–89]	[81–90]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[.1–.1]	[0–0]	[0–0]	[0–0]	[0–0]
Stock Price	[1–2]	[1–2]	[1–2]	[1–2]	[1–2]
Monetary Policy	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[6–14]	[5–12]	[5–11]	[7–14]	[7–16]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]

TABLE 3
(continued)

Band Around	π/6	π/3	π/2	2/3π	5/6π
Sample 1891, 7–1913, 12					
Decomposition of PP					
Foreign Shock 1	[89–95]	[88–95]	[91–98]	[91–98]	[91–98]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Stock Price	[1–2]	[1–2]	[1–2]	[1–2]	[1–2]
Monetary Price	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[4–9]	[4–9]	[2–8]	[2–9]	[2–8]
Production	[.1–.2]	[.1–.2]	[0–.2]	[0–0]	[0–0]
Sample 1924, 1–1937, 1					
Decomposition of EXR					
Foreign Shock 1	[69–79]	[61–72]	[55–70]	[60–73]	[61–72]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[11–20]	[21–29]	[28–36]	[23–30]	[21–28]
Stock Price	[0–1]	[0–1]	[0–1]	[0–.2]	[0–1]
Monetary Policy	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[1–4]	[1–3]	[1–2]	[0–1]	[1–3]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of UKD					
Foreign Shock 1	[23–36]	[10–21]	[5–11]	[9–17]	[10–16]
Foreign Shock 2	[0–.7]	[0–2]	[1–3]	[1–2]	[1–3]
Price	[30–43]	[45–56]	[54–68]	[51–66]	[42–53]
Stock Price	[0–0]	[10–20]	[2–6]	[2–7]	[2–6]
Monetary Policy	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[18–26]	[8–17]	[15–26]	[12–21]	[18–29]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of WPI					
Foreign Shock 1	[18–25]	[1–3]	[1–2]	[1–2]	[1–2]
Foreign Shock 2	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[60–71]	[88–93]	[89–95]	[86–92]	[83–92]
Stock Price	[.1–.5]	[.1–.5]	[.1–.2]	[0–.2]	[0–.2]
Monetary Price	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[5–12]	[4–8]	[4–9]	[5–11]	[7–12]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of SP					
Foreign Shock 1	[23–34]	[5–12]	[4–11]	[8–13]	[10–15]
Foreign Shock 2	[0–.1]	[0–.1]	[0–0]	[0–0]	[0–0]
Price	[40–49]	[21–31]	[41–46]	[46–55]	[50–59]
Stock Price	[7–11]	[32–43]	[40–46]	[27–34]	[21–30]
Monetary Policy	[.1–.3]	[.1–.2]	[.1–.4]	[.1–.3]	[.1–.6]
HPM Demand	[11–20]	[21–30]	[1–3]	[1–2]	[1–2]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of Call					
Foreign Shock 1	[15–22]	[10–16]	[2–8]	[3–10]	[7–16]
Foreign Shock 2	[.1–.3]	[.1–.3]	[.1–.4]	[.1–.2]	[0–.2]
Price	[15–22]	[7–14]	[21–31]	[14–23]	[4–11]
Stock Price	[3–6]	[2–9]	[3–6]	[3–6]	[4–7]
Monetary Policy	[.1–.3]	[.1–.3]	[.1–1]	[1–1]	[1–2]
HPM Demand	[48–56]	[61–73]	[58–66]	[60–72]	[66–75]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]

TABLE 3
(continued)

Sample 1924, 1–1937, 1					
Band Around	π/6	π/3	π/2	2/3π	5/6π
Decomposition of HPM					
Foreign Shock 1	[28–36]	[3–8]	[.4–.5]	[.5–1]	[1–2]
Foreign Shock 2	[.1–.2]	[0–0]	[0–0]	[0–0]	[0–0]
Price	[5–10]	[2–5]	[5–10]	[1–3]	[1–5]
Stock Price	[1–3]	[1–3]	[.5–1]	[.5–1]	[1–2]
Monetary Policy	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
HPM Demand	[50–62]	[84–92]	[86–93]	[90–97]	[89–95]
Production	[0–0]	[0–0]	[0–0]	[0–0]	[0–0]
Decomposition of PP					
Foreign Shock 1	[26–36]	[3–7]	[0–1]	[0–2]	[3–6]
Foreign Shock 2	[1–2]	[0–.1]	[0–0]	[0–.4]	[0–.1]
Price	[23–29]	[60–71]	[69–80]	[30–41]	[58–65]
Stock Price	[4–12]	[5–9]	[1–2]	[0–1]	[0–.2]
Monetary Policy	[0–.2]	[0–0]	[0–0]	[0–1]	[0–.1]
HPM Demand	[13–22]	[7–17]	[7–13]	[15–23]	[1–5]
Production	[7–12]	[3–8]	[8–14]	[40–47]	[22–29]

Figure 1 indicates that innovations in the demand for HPM produce a positive response in the U.S. interest rate only after 8 months because of the immediate jump in HPM supply and a persistent upward movement in stock prices. The response of HPM supply to surprise movements in HPM demand is significant, instantaneous and persistent. Since the domestic source component of HPM (composed of National Banknotes, U.S. notes and silver certificates) was somewhat rigid in this period, this behavior is primarily due to gold inflows. The upward trend in the U.K. interest rate is consistent with the idea of a persistent drain of gold from Europe.

The dynamics of the system following a HPM demand innovation are altered in the second sample in the sense that the call rate responds to HPM demand with oscillations of wider period and the magnitude of the long-run responses of HPM supply is reduced. However, the qualitative properties of the propagation mechanism are unchanged. HPM demand innovations still cause a dollar appreciation in the short run (because of gold inflows) and a 12-period oscillatory response in U.S. and U.K. financial variables.

The variance decomposition reinforces these results. HPM demand innovations account for less than 1/5 of the forecast error variance of interest rates and of stock prices in the first sample at long horizons. In the second sample currency demand and price innovations account for most of the variance of these series at long horizons. In this sample a significant portion of the variability of the call rate is explained by price innovations, a result which agrees with Shiller's (1980) findings for the post World War II period. Also, HPM demand innovations account for a significant portion of the forecast error variance of the U.K. interest rate, a result which is again consistent with the existence of substantial gold inflows.

A final piece of evidence from Table 3. In the first sample, HPM demand innovations explain a small fraction of the forecast error variance of the call rate and a slightly larger fraction of HPM supply and stock price forecast errors at seasonal frequencies. In the second sample, the explanatory power of HPM demand innovations increases and about 55 percent of the call rate variance in the band corresponding to 12 month cycles is explained by these innovations.

The results presented so far seem to contradict the standard interpretation of the experience. We have shown that the supply of HPM was not as inelastic before 1914 as has been suggested and did not become much more elastic after 1914. Further, HPM demand innovations generate seasonal (and nonseasonal) responses in financial variables in the U.S. and the U.K. in both samples. Finally, HPM demand innovations seem to have a stronger impact on financial variables in the second sample. In particular, more than half (about 15 percent) of the forecast error variance of the call rate (stock price index) at seasonal frequencies in the second sample is due to HPM demand innovations. In conclusion, it seems unlikely that financial crises in the U.S. were caused primarily by the inelastic response of HPM to currency demand innovations and that the prevention of crises after 1914 occurred through the channels described by the traditional hypothesis.

3.2. *An Alternative View.* Based on these results we advance the following alternative interpretation of the pre-WWI experience in the U.S.

Integration in international financial markets and gold flows between the U.S. and the continent insured diversification of country-specific risk in normal circumstances. In this scenario seasonal and nonseasonal movements in U.S. interest rates, generated by recurrent HPM demand surges, were transmitted to European markets and, because the stock of gold existing in the world was approximately fixed, interest rates across the world moved together (see Canova 1988 for this point). Therefore, liquidity crunches in the U.S. market were accommodated by a drain of gold from European Countries.[16] However, when an exceptionally large and unexpected event occurred in the world arena, informational and physical barriers prevented a proper adjustment of the share of risk that a country bore. In this situation international financial markets stopped providing the liquidity that the U.S. system needed to operate appropriately. Although these shocks were not concentrated in a specific season of the year, they exerted their strongest impact whenever the demand for gold and credit in the U.S. was large. We also expect the effect of this improper operation of international financial markets to be more evident in the U.S. than in other European nations since the U.S. was more dependent on international markets to satisfy its needs for seasonally elastic currency.

Our interpretation therefore suggests the existence of a strict relationship between international shocks, the emergence of tight conditions in U.S. financial markets and crises. The argument made restricts the structural responses of the system as follows. First, innovations in HPM demand should produce short-run inflows of gold, a positive response of U.K. and U.S. rates at longer horizons, but no dramatic adjustments in the system. Second, external HPM supply innovations should be the major source of dynamics in the system. By affecting the availability of HPM in the U.S., they should account for most the forecast error variance of

[16] Officer (1986) shows that gold points violations hardly occurred in pre-1914 period.

financial variables, cause substantial gold outflows, sharp increases in interest rates and persistent drops in stock prices.

Figure 1 and Tables 2 and 3 indicate that one of the foreign innovations is in fact responsible for most of the dynamics of the system. Since the other foreign innovation creates only small adjustments in the system, I will henceforth term the first shock an external HPM supply innovation.

In the first sample (see Table 2), more than 50 percent of the forecast error variance of interest rates, stock prices and HPM is due to external HPM supply shocks. Similarly, in Table 3, in the band corresponding to cycles of 12 months, approximately 90 percent of the forecast error variance of six out of the seven variables of the system is due to these innovations. From Figure 1 an external HPM supply shock generates an upward jump in the exchange rate (i.e. a dollar depreciation), a persistent downward movement in HPM supply (i.e. a gold outflow) and oscillatory behavior of U.K. and U.S. interest rates, a sharp drop in stock prices in the long run and a similarly persistent downturn in industrial production. Since all these responses are typically associated with the emergence of difficulties in the money market and of stringencies in financial markets, we find some support to the idea that international shocks may have been responsible for crises in the pre-WWI U.S. experience.

An examination of the major historical events preceding the occurrence of crises and panics suggests that external HPM supply shocks were indeed significant in those years. In 1890 a crisis was set off by a shift of British investments to Argentina, which caused a loss of gold in New York, a few months before the crop-moving season (Friedman and Schwartz 1963, p. 104). In 1893 the passage of the Sherman Act generated distrust among foreign agents in the maintenance of the gold standard in the U.S. This distrust was sufficient to reduce regular gold inflows and to create a liquidity crisis (Friedman and Schwartz 1963, p. 108; Sprague 1910, p. 153). In 1899, the Boer war in South Africa resulted in a slowdown in gold production and in an outflow of gold from the U.S. (Friedman and Schwartz 1963, p. 145). In 1907 restrictions to gold outflows imposed by the Bank of England contributed to create the environment where a panic developed (Friedman and Schwartz 1963, p. 158). In 1914 with the commencement of World War I the regular functioning of international capital markets collapsed and left the U.S. with substantial gold outflows (Friedman and Schwartz 1963, p. 145 and p. 172). Only in 1901 did the collapse of the stock market seem to be generated entirely by internal conditions in the U.S. (Friedman and Schwartz 1963, p. 149). Figure 3 shows that in these episodes gold outflows exceeded the lower bound of two standard errors around the mean of the series. The magnitude of these outflows as a percentage of total HPM in the hands of the public was 2.8 percent in 1890, 2.7 percent in 1893, 3.0 percent in 1899, 1.1 percent in 1901, 2.2 percent in 1907 and 4.7 percent in 1914.

This view that financial crises were generated by the addition of exogenous factors to the regular domestic seasonal pattern in HPM demand is consistent with Jevons' (1884, p. 164) view that:

> ... we see that the most striking (seasonal) fluctuations are due to the gathering of the harvest. ... Some perhaps would attribute the sudden changes in the rate of discount, bankruptcies and consols to the occurrence of panics during the months of October and November. It would be more correct to say that there is a periodical tendency to

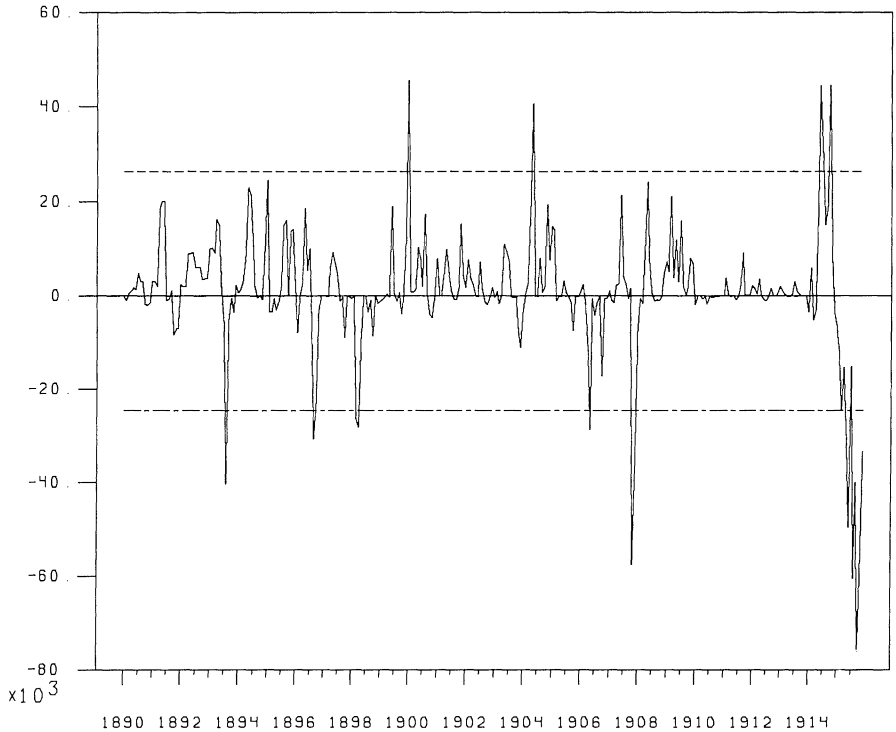

FIGURE 3

NET GOLD INFLOWS.

commercial distress and difficulties during these months of which all concerned should be aware. It is when *great irregular fluctuations* aggravate this distress, as in the years 1836, 1839, 1847 and 1857 that disastrous breaches in commercial credit occur.

3.3. *The Effects of the Creation of the Fed.* Figure 2 and Tables 2 and 3 indicate that the effect of foreign shocks on U.S. financial markets declined in the second sample and that the qualitative features of the transmission mechanism of these shocks changed. The percentage of the variance of all decompositions at long horizons due to external HPM supply shocks substantially decreases. Note that this decline occurred despite a 100-fold increase in variance of these innovations. Also, after 1914 the response of the call rate to external HPM supply shocks reverses its sign up to 24 months, HPM supply responses are positive even if their magnitude is small (i.e. a gold outflow leaves HPM supply substantially stable because the domestic source component of HPM instantaneously makes up for the differences) and the responses of stock prices are oscillatory with cycles of decreasing amplitude.

These results suggest that the establishment of a Central Bank might have limited the effects of external monetary shocks on the U.S. financial system by providing an elastic supply of currency at times when international markets were unable to meet regular liquidity demands. As a lender of last resort, the Fed insulated the

U.S. financial market from unexpected shortages in the availability of gold and credit, reduced the dependence of financial intermediaries on foreign markets and prevented liquidity crunches from degenerating into crises (see also Friedman and Schwartz, p. 297, for a somewhat similar view).

The change in the Granger priority across samples documented in Tables 2 and 3 is consistent with this interpretation. In the first sample external HPM supply shocks were statistically prior for domestic and foreign interest rates and for HPM supply. This Granger priority emerged because these shocks were the predominant source of disturbances in the economy and caused large adjustments in U.S. variables. In the second sample domestic HPM demand and price innovations jointly become Granger causally prior in the system. Sims (1983) indicates this is what one ought to expect if the supply of HPM passively adjusts to domestic nominal shocks in the economy, if external shocks play a minor role in the availability of HPM and if the price level adjusts to real innovations. In other words, when external shocks are less important for the system, price and HPM demand innovations act as Granger causally prior as a result of the price level anticipating future levels of real returns on capital and HPM demand transmitting monetary shocks. Since innovations in the real return to capital and to the transaction demand for HPM were small relative to HPM supply innovations throughout the sample, one could expect the adjustment of the system to these innovations to be much less burdensome than adjustments to HPM supply innovations. Consistent with this argument Figure 2 shows a decrease in the variability of interest rates, a more erratic response of HPM supply to HPM demand innovations but a less volatile response to foreign monetary shocks.

One implication of this interpretation of the experience is that the domestic source component of HPM is independent of the foreign source component of HPM in the first sample and inversely related to the foreign source component in the second sample. Since in Figures 1 and 2 HPM supply responses are a mixture of these two components, they are not fully indicative of the plausibility of the interpretation. If we compute the impulse response function for the system where HPM includes only its domestic source component, we see that our predictions are confirmed (Figure 4 reports the responses of the domestic component of HPM to external shocks in the two samples). Note that the contemporaneous correlation between net gold inflows and the domestic component of HPM is .01 in the first sample and $-.30$ in the second.

One may wonder if the results obtained are the consequence of the creation of the Federal Reserve System or of other events. For example, Sprague (1915), Dewald (1972) and Timberlake (1985) have suggested that the restructuring of the National Banking System induced by the Aldrich-Vreeland Act (1908) was as effective as the Fed in preventing the occurrence of crises. Even though no direct test for this proposition is available, it is instructive to break the sample at 1908 and compare the dynamics in the 1890–1908 and 1890–1914 periods. Point estimates of the impulse responses for the 1890–1908 period appear in Figure 5. Except for the inversion of WPI and call rate responses, the dynamic patterns of Figures 1 and 5 are qualitatively identical. However, quantitatively, the height of the peaks of the responses of financial variables to external HPM supply innovations are softened in

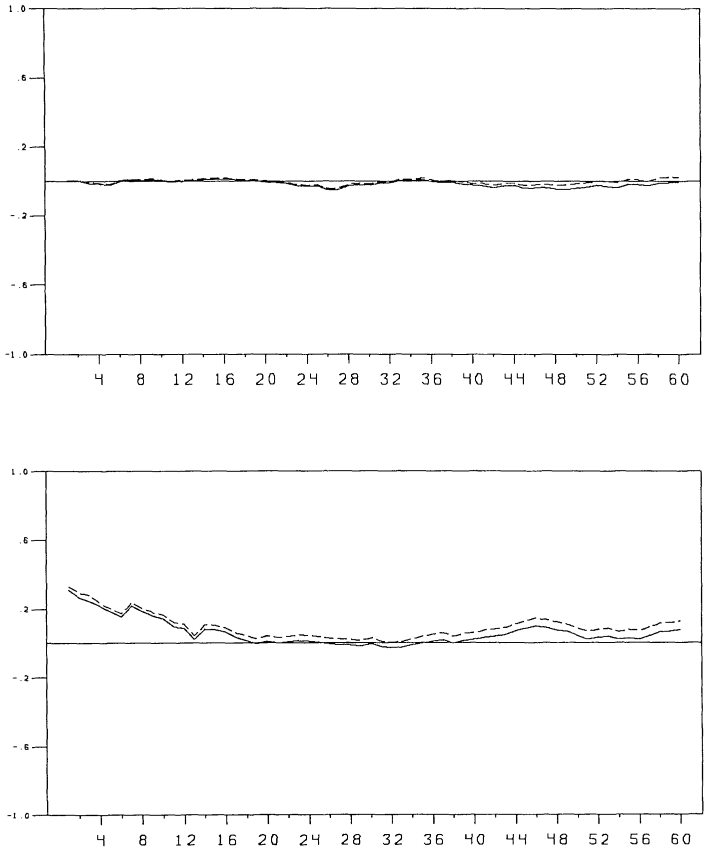

FIGURE 4

RESPONSES OF THE DOMESTIC SOURCE COMPONENT OF HPM TO EXTERNAL HPM SHOCKS. UPPER PANEL: SAMPLE 1891,7–1913,12. LOWER PANEL: SAMPLE 1924,1–1937,1.

the 1890–1914 period by 5 percent on average. Therefore, the neutralization of external shocks may have started before 1914.

Following Clark (1986), one may be led to think that the abandonment of the classical gold standard that accompanied the beginning of World War I was responsible for the reduced impact of external shocks on the U.S. economy. The statistics presented are unable to distinguish directly the impact of this event from the creation of the Fed. However, there are two reasons to doubt that the repudiation of the gold standard per se was responsible for the observed changes. First, for about half of the second sample, both the U.S. and the U.K. were under some form of gold standard. The system was not as automatic as before 1914, but still provided a solid and credible discipline. Second, the variance of external HPM supply shocks had a 100-fold increase in the second sample.

Finally, there is a great deal of controversy surrounding the lender of last resort function of the Fed in the first few years of its activities (see e.g. Friedman and Schwartz 1963, p. 193, Miron 1988). Figure 2 and Tables 2 and 3 indicate that

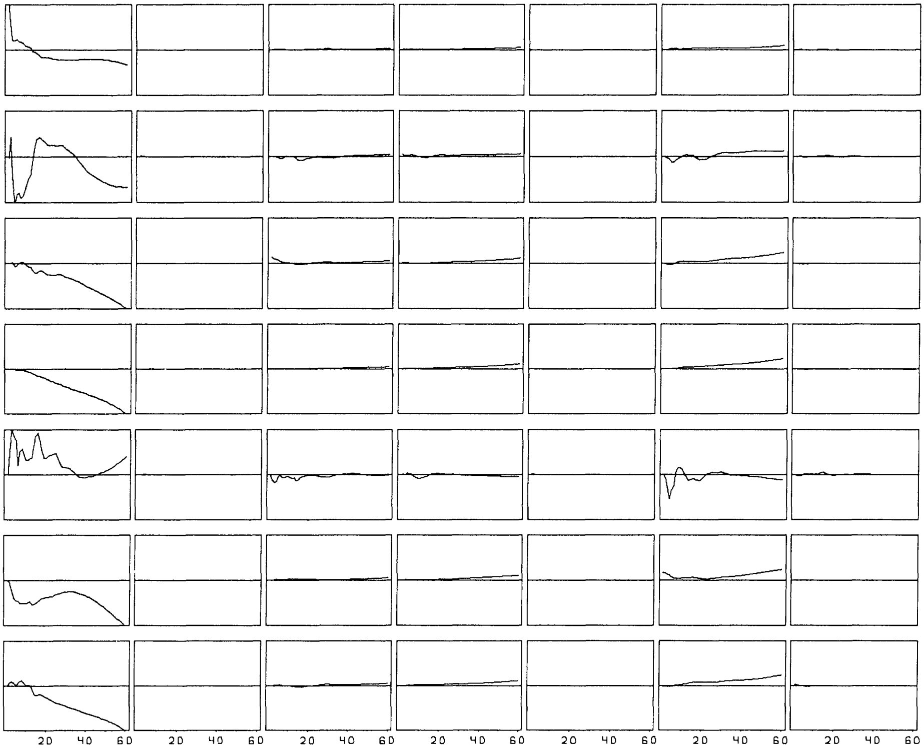

FIGURE 5

IMPULSE RESPONSES, SAMPLE 1891,7–1908,12. ON THE TOP (FROM LEFT TO RIGHT) FOREIGN SHOCK 1, FOREIGN SHOCK 2, PRICE SHOCK, STOCK PRICES SHOCKS, MONETARY POLICY SHOCK, HPM DEMAND SHOCK, PRODUCTION SHOCK. ON THE LEFT (FROM TOP TO BOTTOM) EXCHANGE RATE RESPONSES, U.K. INTEREST RATE RESPONSES, WPI RESPONSES, STOCK PRICES RESPONSES, U.S. INTEREST RATE RESPONSES, HPM RESPONSES, PIG IRON RESPONSES.

domestic HPM supply shocks had negligible effects in the system.[17] This suggests that the Fed did not actively try to change or offset any tendency in U.S. money and financial markets during this period but simply reacted to the developments in private markets. However, active sterilization activities were not necessary for the Fed to have insulated the U.S. economy from foreign shocks. A discount window policy of the type described in Sargent and Wallace (1982), where the Fed stands ready to discount any amount of real bills at a given fixed rate, would be sufficient to eliminate undesired repercussions due to shocks to the availability of gold and credit.

4. CONCLUDING REMARKS

The purpose of this paper was to examine the propagation mechanism of HPM demand and supply innovations before and after World War I, the sources of

[17] Since no monetary authority existed before 1914 and the banking system was extremely fragmented, it is not surprising to see that these innovations generate little dynamics in the system.

variability in interest rates, stock prices and HPM and the contribution of the creation of the Fed to the dynamics of the U.S. economy in the post-1914 experience. It is shown that external shocks to gold flows were of fundamental importance in explaining the dynamics of the U.S. economy before World War I and that their influence was reduced once the existence of a lender of last resort cushioned the U.S. financial system from these shocks. The evidence presented suggests that Jevons' (1884) idea that financial crises were generated by a combination of internal seasonal movements and unexpected external shocks to the availability of gold, is appropriate for the U.S. experience.

We also show that despite the fact that HPM supply responds to HPM demand innovations, U.S. interest rate and stock price responses are still seasonal after 1914. Therefore, the idea that the introduction of seasonality in HPM is the key to understanding the decreased frequency of crises after 1914 is not supported in this study. Moreover, the neutralization of the crises of July 1914, which occurred before the Fed started its operations, indicates that the presence of a Central Bank per se was not crucial in decreasing the occurrence of crises. A nonseasonal domestic source component of HPM supply combined with emergency measures to provide liquidity when external shocks threatened the U.S. financial system could have been successful in reducing the occurrence of crises. In addition there are no strong reasons to believe that following a seasonal monetary policy is appropriate on welfare grounds. The fact that in the post-World War II experience the Fed chose to inject seasonality in HPM in an environment where external shocks were of minor importance and the FDIC had eliminated the incentives for bank runs constitutes an interesting area of research (see Canova 1991).

There are two reasons why our results differ from those reported in the existing literature. First, the HPM series we employ is substantially different from the one used in previous work (e.g. Clark 1986). Since previous work spliced two different data sets (one obtained from NBER tapes containing averages over the month before 1914 and one obtained from BMS reporting end of the month values after 1914), it is possible that the differences found across samples were due to measurement error, not to structural changes. In this paper, on the other hand, we construct a consistent series using averages over the month for the entire sample period. Second, previous studies have used primarily univariate analyses to examine the effects of the creation of the Fed and simple tools to assess the changes in the stochastic processes for interest rates and prices. Since univariate analysis produces meaningful results only if all variables can be treated in isolation, these studies failed to take into account the crucial interdependences existing among variables and to capture the correct sources of shocks.

Finally, although a decline in the seasonal pattern of interest rates is present in the second sample, the significance of this change has been overemphasized. The lack of an appropriate distinction among various sources of shocks obscured the sense of the major changes which occurred and impeded a coherent and unified interpretation of the interwar experience.[18] When appropriate statistical adjustments are made, the important role that external shocks to gold flows played in determining the dynamics of the U.S. economy and the contribution of the creation of the Federal Reserve System clearly emerges.

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[18] For example the emergence of seasonality in real variables in the interwar period documented Figure 2 is at odds with the standard interpretation of the experience (see Miron 1988 for an attempt to explain this fact in the context of a simple ISLM framework).

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