THE INCIDENCE AND EFFECTS OF MACROECONOMIC DISTURBANCES UNDER ALTERNATIVE EXCHANGE RATE SYSTEMS: EVIDENCE SINCE THE CLASSICAL GOLD STANDARD

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ABSTRACT

The objective of the paper is to examine the relationship between exchange rate systems and incidence and effects of macroeconomic disturbances within the context of a simple aggregate supply/aggregate demand model. Using data from the Gold Standard, Bretton Woods, and the Modern Float and structural VARs, the paper tries to isolate supply shocks, real demand shocks, and monetary shocks. Comparing the performance of exchange rate systems, the paper finds a lower incidence of demand shocks under fixed rate systems which can be attributed to the limited discretion afforded by fixed rates. Moreover, there seems to be an increase over time in the effectiveness of real demand policies.

I. INTRODUCTION

The traditional debate on exchange rate systems focused on insulating properties of flexible exchange rates as in Friedman (1953) and Meade (1955). The subsequent literature

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showed that insulating properties depend on some structural characteristics[1] (e.g., openness, capital mobility), as well as the types and the sources of shocks impinging on the domestic economy. The monetary theory of the balance of payments emphasized the differences in macroeconomic adjustment under fixed versus flexible exchange rates. One consequence of fixed exchange rates is that nations may not be able to pursue independent monetary policies. Specifically, an external imbalance has to be offset by a change in the net reserve position which can affect the domestic money supply. Commitment to a fixed rate also entails buying or selling domestic currency in exchange for foreign currencies at declared parities to satisfy autonomous changes in currency demands, which unless successfully sterilized, makes the money supply endogenous.

Another aspect of the exchange rate system is the different operating procedures of macroeconomic policies under alternative exchange rate systems. The Mundell-Fleming framework compares the effectiveness of monetary and fiscal policy under fixed and flexible exchange rate systems. The textbook version of the model (e.g., Mankiw, 1997, pp. 308–323; Blanchard, 1997, pp. 250–267) predicts that under high capital mobility, fixed exchange rates render fiscal policy powerful in altering aggregate demand while monetary policy is impotent. Under flexible rates the contrary holds.

More recent work on exchange rate systems emphasizes the disciplining effects of fixed rates and the discretion afforded to policymakers by flexible rates. The "rules versus discretion" debate has been partially revitalized by the literature on the European monetary integration. Simply stated, this approach views fixed rates as a pledge not to follow inflationary policies, which has been interpreted as a commitment mechanism that "ties one's hands" (Giavazzi & Pagano, 1988), and solves the time consistency problem initially analyzed by Kydland and Prescott (1977). However, a pledge not to inflate may not be desirable when the policymaker faces an emergency. This raises the possibility that the choice of the exchange rate system may not be independent of the macroeconomic environment. Indeed some interpret historical alternating periods of fixed and floating exchange rates as a rule with an escape clause (De Kock & Grilli, 1989; Giovannini, 1993).

Analysis of historical macroeconomic data has provided little conclusive evidence on the role of the exchange rate system.[2] There have been some attempts to analyze the incidence of aggregate demand and aggregate supply shocks under alternative exchange rate systems (Bordo, 1993; Eichengreen, 1993). The objective of this paper is to reexamine empirical evidence on the exchange rate system by focusing on the distinction between nominal demand (monetary) shocks, which the exchange rate system can be expected to influence, and real shocks, which may be irrelevant because they are not caused by the exchange rate system. We also analyze the effects of macroeconomic disturbances and try to evaluate money supply behavior under alternative exchange rate arrangements. Using historical annual data and more recent quarterly data, we impose a combination of long-run and short-run restrictions to distinguish between real demand (IS) shocks, monetary shocks, and supply shocks within a structural VAR framework. We then analyze the incidence and effects of these shocks to evaluate any possible effect that can be traced to the exchange rate system. To preview our results, the data seem to support the notion that fixed rate systems set limits to monetary discretion and constrain expansionary demand policies. Moreover, there seems to be an increase over time in the effectiveness of real aggregate demand policies. Section II contains a brief discussion of the International Monetary System and related propositions to be evaluated empirically. Section III presents a simple model and the identification methodology. Section IV presents empirical results, limitations, and suggestions for future research, while Section V concludes.

II. THE INTERNATIONAL MONETARY SYSTEM

Although the history of the Gold Standard can be traced back many centuries, the period 1870–1913 is regarded as the most prosperous period of the Gold Standard, and is referred to as the "Classical Gold Standard." Many countries operated under gold convertibility at a pre-declared parity. The period is also known for virtually no capital controls and extensive capital movements. The United States restored gold convertibility de facto in 1873 which was suspended at the outbreak of the Civil War; the greenbacks officially were convertible in 1879. The system lasted until many countries suspended gold convertibility with the First World War.

The period thereafter, the interwar period, had many exchange rate arrangements: floating exchange rates until the middle 1920s, followed by a resumption of the Gold Standard. However, runs on the banking systems in Austria and Germany in 1931 brought a collapse of the Gold Standard in Austria, Germany, and later in England. The United States suspended gold convertibility in 1933, and many European countries followed suit in the mid-1930s. The floating period that followed the collapse of the Gold Standard in 1930s was characterized by massive interventions to limit exchange rate flexibility and beggar-thy-neighbor policies. The Bretton Woods system that followed the Second World War was designed to limit intervention in the foreign exchange market and avoid the destabilizing effects of arbitrary exchange rate changes.

The Bretton Woods System was inaugurated in 1944 with the signing of Articles of Agreement of the International Monetary Fund (IMF). The system called for fixed exchange rates against the US dollar which itself was pegged to gold. Member countries held their international reserves largely in dollar assets making the dollar the main reserve asset. Most countries maintained the official par values of their currencies by intervening in the foreign exchange market. The Bretton Woods system was characterized by massive capital controls; current account transactions were inconvertible until 1958, while controls remained in place for capital account transactions for the entire period. Since the dollar was the principal reserve asset, other countries could accumulate dollars through US balance of payments deficits. A commonly held view is that the expansionary domestic programs in the US along with Vietnam era defense spending brought inflation, and eroded competitiveness of US exports. The ensuing balance of payments deficits made it difficult to sustain gold convertibility at the official parity value. Finally in August 1971, the US suspended redeeming dollar assets into gold, ending the last official link between the dollar and gold. With the Smithsonian Agreement, the dollar was devalued but that did not ease the pressure on the US dollar. Finally in March 1973, the currencies of all major industrial countries started to float against the dollar. The floating period that followed is characterized as "dirty floating" due to occasional intervention in the foreign exchange market by the authorities and was officially sanctioned by an amendment to the IMF Articles of Agreement in 1976.

After the breakdown of the Bretton Woods system, some European countries continued their efforts to coordinate their monetary policies and prevent intra-European exchange rate fluctuations. In March 1979, Germany, France, Italy, Belgium, Netherlands, Luxembourg, Denmark, and Ireland agreed to fix their mutual exchange rates within certain bands, and let their currencies fluctuate jointly against the US dollar within the "European Monetary System" (EMS). The Exchange Rate Mechanism (ERM) of the EMS grew to include Spain in 1989, the UK in 1990, and Portugal in 1992. Finally in September 1992 a major speculative attack forced the UK and Italy out of the ERM, and in August 1993, the remaining members agreed to widen their exchange rate margins.

It is known that theoretical considerations may not be sufficient to ascertain the optimality of a given exchange rate arrangement and empirical work may provide some insights on the issue. An interesting question is to examine the incidence of macroeconomic shocks under alternative exchange rate systems and investigate whether i) the incidence of monetary shocks under fixed rate systems is lower as fixed rates set limits to monetary discretion, ii) the behavior of the money stock is different under fixed versus flexible exchange rates, iii) fixed exchange rates prevail in stable macroeconomic environments, and iv) the switch to flexible rates was prompted by an unusual incidence of real demand or supply shocks that make maintaining fixed rates costly. It is also possible to evaluate whether policy effectiveness varies with the exchange rate system as predicted by the Mundell-Fleming model.

In our empirical analysis, we use historical annual data from the Classical Gold Standard (1870–1913) pertaining to Canada, Italy, Japan, UK, and the US, and quarterly data from the Bretton Woods (1957.I–1971.IV) and the Modern float (1973.II–1996.I) pertaining to the G-7 countries. We also try to evaluate the experience of Germany, France, and Italy under the European Monetary System (1979.II–1996.I). Degrees of freedom considerations and data availability makes it difficult to adhere strictly to this designation of exchange rate arrangements in that some countries may not have fully participated in a particular exchange rate arrangement. For example, the Canadian dollar floated in the 1950s and the US dollar was not convertible to gold at the beginning of our Gold Standard sample period in 1870s. When this is the case, the results should be interpreted accordingly.

III. THEORETICAL FRAMEWORK AND METHODOLOGY

In order to provide an identifying framework for a set of orthogonal impulses, consider the IS/LM model augmented by a Lucas-type supply function, which is referred to as the aggregate supply (AS)/ aggregate demand (AD) model:

$$y_t = \beta_0 y_t - \beta_1[i_t - (E_{t-1} p_{t+1} - E_{t-1}p_t)] + \varepsilon_{dt} \quad (1)$$

$$y_t = \alpha (p_t - E_{t-1} p_t) + \delta_t \quad (2)$$

$$\delta_t = \delta_{t-1} + \varepsilon_{st} \quad (3)$$

$$m_t = p_t + \psi y_t - \lambda i_t + \varepsilon_{mdt} \quad (4)$$

where y is real output, δ_t is trend output, p is the price level, i is the nominal interest rate, m is the money stock, ε_i are mutually uncorrelated stochastic disturbances, E_t is the conditional expectations operator, and all variables except the nominal interest rate are in logarithms.

Equations (1) is the goods market equilibrium relationship where aggregate spending depends on the ex-ante real interest rate, real output, and a stochastic real demand shock, ε_d. Equation (2) is a Lucas-type aggregate supply equation where actual output deviates from the trend level due to price prediction errors. For simplicity, trend output is assumed to follow a random walk, where ε_{st} is a "pure" supply shock (equation 3). Equation (4) represents a conventional money market equilibrium relationship with a stochastic disturbance term. Taking conditional expectations at time $t-1$ and subtracting from equations (1), (2) and (4), the system can be expressed as:

$$(y_t - \delta_t) = \beta_0 (y_t - \delta_t) - \beta_1 (i_t - E_{t-1}\, i_t) + \varepsilon_{dt} \tag{5}$$

$$(m_t - E_{t-1} m_t) = (p_t - E_{t-1}\, p_t) + \psi (y_t - \delta_t) - \lambda (i_t - E_{t-1}\, i_t) + \varepsilon_{mdt} \tag{6}$$

$$(y_t - \delta_t) = \beta (p_t - E_{t-1}\, p_t) \tag{7}$$

Solving for $(y_t - \delta_t)$.

$$(y_t - \delta_t) = (1/J)[\alpha\beta_1 (m_t - E_{t-1} m_t) + \alpha\lambda\, \varepsilon_{dt} - \alpha\beta_1\, \varepsilon_{mdt}] \tag{8}$$

where $J \equiv \alpha\, [(1-\beta_0)\lambda + \beta_1\, \psi] + \beta_1$. Suppose the monetary authority sets the money supply according to the following rule:

$$m_t = \theta_0 + \theta_1\, m_{t-1} - \theta_2\, (y_{t-1} - y_{t-2}) + \theta_3\, r_{t-1} + \varepsilon_{mst} \tag{9}$$

where r_t is the real interest rate and ε_{mst} is the surprise component of the money supply. Under rational expectations, the unexpected component of money supply, $(m_t - E_{t-1} m_t)$, is simply ε_{mst}. Combining this with equations (3) and (8), output *growth* can be expressed as:

$$\Delta y_t = \varepsilon_{st} + (1/J)\, [\alpha\beta_1\, (\varepsilon_{mt} - \varepsilon_{mt-1}) + \alpha\lambda(\varepsilon_{dt} - \varepsilon_{dt-1})] \tag{10}$$

where $\varepsilon_{mt} = \varepsilon_{mst} - \varepsilon_{mdt}$ is a composite monetary shock reflecting the effect of a surprise monetary expansion net of a stochastic money demand shift. Notice that according to equation (10), aggregate demand shocks (ε_{mt} and ε_{dt}) have temporary effects on output, while output in the long run is driven by supply shocks. It is common to use the long run output neutrality of demand shocks to distinguish between supply shocks and demand shocks (Shapiro & Watson, 1988; Blanchard & Quah, 1989; and Gali, 1992). However, the distinction between real demand shocks (IS shocks), and monetary shocks (LM shocks) is less straightforward. We consider some possibilities based on conventional treatments of the transmission mechanism of monetary policy.

A. Stationarity of the Data

In order to properly specify the VAR, we test for stationarity using the KPSS test due to Kwiatowski et al. (1992). The KPSS test takes stationarity as the null hypothesis

Table 1. KPSS Statistics

	Gold Standard	Bretton Woods	Modern Float	Gold Standard	Bretton Woods	Modern Float
		Output: Δy			Nominal Interest Rate: Δi	
Canada	0.609	0.733	1.110	0.445	0.512	0.253
France	—	0.732	1.103	—	0.380	0.279
Germany	—	0.716	1.095	—	0.415	0.055
Italy	0.563	0.732	1.103	0.583	0.391	0.242
Japan	0.579	0.734	1.114	0.140	0.435	0.654
UK	0.608	0.727	1.088	0.425	0.590	0.261
US	0.607	0.737	1.111	0.149	0.516	0.387
		Inflation: Δp			Real Interest Rate: $i - \Delta p$	
Canada	0.355	0.541	0.897	0.436	0.452	0.179
France	—	0.182	0.906	—	0.406	0.135
Germany	—	0.287	0.502	—	0.386	0.061
Italy	0.177	0.111	0.961	0.388	0.249	0.354
Japan	0.090	0.327	0.792	0.275	0.573	0.382
UK	0.541	0.527	0.804	0.555	0.585	0.451
US	0.346	0.537	0.690	0.363	0.342	0.261
		Monetary Growth: Δm				
Canada	0.439	0.127	0.106			
France	—	0.181	0.671			
Germany	—	0.111	0.116			
Italy	0.138	0.160	0.711			
Japan	0.127	0.219	0.181			
UK	0.152	0.249	0.106			
US	0.093	0.308	0.109			

Note: Critical values for the KPSS statistics are, 0.347 (10 %), 0.463 (5 %), 0.574 (2.5 %), 0.739 (1 %). Lag truncation used in the test is 8.

against the alternative of a unit root. Under the maintained hypothesis that the exchange rate system plays a role in the conduct of macroeconomic policy and its operational procedures, we present separate test statistics for different exchange rate arrangements. Table 1 presents KPSS test statistics for output, nominal interest rates, inflation, real interest rates, and monetary growth. Specific measures of these variables, and data sources are given in an Appendix.

Table 1 indicates that the null hypothesis of stationarity for output can be rejected for all periods at conventional significance levels while nominal interest rates are on the borderline in several cases, particularly in the Bretton Woods period. Similarly, inflation seems stationary under the Classical Gold Standard except for the UK, while there is increasing evidence that it tends towards non-stationarity over time. Notice that the null hypothesis of a stationary inflation process can be rejected for all countries except Germany under the Modern Float at the 5% significance level. The ex-post real interest rate, $r_t \equiv i_t - (p_{t+1} - p_t)$, is stationary at the 5% except for the UK under the Gold Standard, and Japan and the UK under Bretton Woods. However, there is a strong theoretical prior for a stationary real interest rate since a unit root in the real interest rate is inconsistent with standard equilibrium growth models (Shapiro & Watson, 1988). Notice that the unit root evident in inflation disappears in most cases when one considers the real interest rate. This suggests the possibility of cointegration of nominal interest rates and inflation. The test statistics for the growth of the money stock indicate stationarity except for France and Italy under the Modern Float. In the empirical model, we start with $\mathbf{X} = [\Delta y\ r\ \Delta m]'$ as a stationary process, and then consider a unit root in the real interest rate.

B. *Identification Strategy*

Consider three types of orthogonal shocks that are the sources of the observed movements in output, real interest rates, and money stock: supply shocks (ε_s), real demand shocks (ε_d), and monetary shocks (ε_m). If the vector $\mathbf{X} = [\Delta y\ r\ \Delta m]'$ is covariance stationary, it can be written as an infinite moving average process in the structural shocks:

$$\begin{bmatrix} \Delta y_t \\ r_t \\ \Delta m_t \end{bmatrix} = \begin{bmatrix} a_{11}(L) & a_{12}(L) & a_{13}(L) \\ a_{21}(L) & a_{22}(L) & a_{23}(L) \\ a_{31}(L) & a_{32}(L) & a_{33}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{st} \\ \varepsilon_{dt} \\ \varepsilon_{mt} \end{bmatrix} = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i} = A(L)\varepsilon_t \tag{11}$$

where $\mathbf{a_{ij}(L)}$ are polynomials and $\mathbf{A_i}$ are matrices in the lag operator, L. The time paths of the effects of the three shocks on the growth rate of output, the real interest rate and growth of the money stock are given by the coefficients of the polynomials $\mathbf{a_{ij}(L)}$. Moreover, coefficient $a_{ij}^{(k)}$ in the $\mathbf{a_{ij}(L)}$ polynomial is the response of variable i to a unit shock in ε_{jt} after k periods. We also adopt the notation such that $a_{ij}(1)$ is the sum of all the moving average coefficients and gives the cumulative effect of ε_{jt} on variable i over time. Note from equation (11) that the *contemporaneous* interactions among the variables can be written as:

$$HX_t = \varepsilon_t \tag{12}$$

where $\mathbf{H} = \mathbf{A_0}^{-1}$ and $\mathbf{A_0}$ is a non-singular matrix. The objective of identification in a VAR is to discern the elements of the $\mathbf{A_0}$ matrix which maps the structural innovations to the reduced form (composite) innovations. Identification through Choleski decomposition restricts $\mathbf{A_0}$ to be a lower triangular matrix while Bernanke (1986), and Sims (1986) introduce direct restrictions on the contemporaneous, short-run interactions (the $\mathbf{H}$ matrix in equation 12). Blanchard & Quah (1989), and Shapiro & Watson (1988) restrict the dynamic long-run effects of the structural innovations ε_{ijt} on the variables in $\mathbf{X}$, which implies restrictions on the elements of the $\mathbf{A(1)}$ matrix. Gali (1992) uses a combination of short-run and long-run restrictions on the $\mathbf{H}$, $\mathbf{A_0}$, and $\mathbf{A(1)}$ matrices.

In our empirical implementation, just identification of the orthogonal innovations (ε_s, ε_d, ε_m) requires three additional restrictions beyond the restrictions embedded in the variance-covariance matrix of the reduced form innovations. In order to identify the shocks, we assume that aggregate demand shocks (ε_d, ε_m) have no long run effect on output as implied by the $AS-AD$ model presented above. This is equivalent to $a_{12}(1) = a_{13}(1) = 0$ in the $\mathbf{A(1)}$ matrix and provides two restrictions. An additional restriction is needed to distinguish between real demand shocks (ε_d), and nominal demand/monetary shocks (ε_m). Under the assumption that the real interest rate is stationary, we assume that the *contemporaneous* nominal money stock does not appear in the IS equation (equation 1 above). This corresponds to $h_{23} = 0$ in the **H** matrix[3] and is sufficient to recover the orthogonal shocks.

As an alternative model, we consider a unit root in the real interest rate and let $\mathbf{X}^* = [\Delta y\ \Delta r\ \Delta m]'$. In this case we assume that demand shocks have no long run effect on output $[a_{12}(1) = a_{13}(1) = 0]$, and monetary shocks have no long run effect on the real interest rate $[a_{23}(1) = 0]$. Although there is a strong theoretical reason for assuming a stationary real interest rate, empirical evidence is far from being clear. Except for some variance decomposition results, the empirical results of both models are very similar. In what follows, we present the results for the $\mathbf{X} = [\Delta y\ r\ \Delta m]'$ model. Notice that the money supply process is not restricted to follow a particular process in either empirical model. The money stock is allowed to adjust to all present and possible past values of other endogenous variables. Allowing a general money supply process for each exchange rate system can accommodate different degrees of monetary discretion and different operational practices of monetary policy under alternative exchange rate arrangements.

Each identifying assumption presented above is open to debate. Specifically, long run aggregate demand neutrality may be controversial in that real aggregate demand policies may influence real interest rates and affect output through labor supply and terms-of-trade. Second, there may be other variables that are important in influencing output in the long run. The specific transmission mechanism of monetary policy (the absence of money from the contemporaneous IS equation) can be controversial as well. Having recognized the limitations, the advantage of structural identification as opposed to the early VAR literature is that it makes the identification restrictions more explicit. One can also interpret the results such that the assumed effects dominate in the long run.

After recovering the shocks, we examine their standard deviations across exchange rate systems. Recall that discretionary monetary policy under fixed rate systems is relatively limited and floating rate systems do not exert external constraints on domestic money creation. As such, nominal demand shock variability should be higher under floating rates. Similarly, one may expect the variance of the money stock to be primarily due to its own shocks under floating rates, since flexible rates allow the monetary authority to conduct relatively more "independent" monetary policies. We present variance decomposition results to evaluate the extent of output and money stock variability due to each shock and assess the empirical validity of these propositions.

IV. EMPIRICAL RESULTS

We fit a two-lag VAR for the Gold Standard, and a four-lag VAR for the Bretton Woods and the Modern Float. Residual test statistics indicate that these lag lengths are sufficient to remove serial correlation from the reduced form residuals in all cases.

After orthogonalizing the residuals to conform to the identification scheme presented above, we present standard deviations of the shocks for the $\mathbf{X} = [\Delta y\ r\ \Delta m]'$ model in Table 2. Note that since the data are in logarithms, a value of 0.02 represents a variation of approximately 2 percent. Moreover, since we use annual data for the Gold Standard and quarterly data for the more recent exchange rate arrangements, we divide standard deviations pertaining to the Gold Standard by four to make variation figures comparable.

Table 2. Standard Deviations of Shocks

	Supply: ε_s	*Real Demand:* ε_d	*Monetary:* ε_m
		Classical Gold Standard*	
Canada	0.0173	0.0097	0.0111
Italy	0.0076	0.0110	0.0062
Japan	0.0186	0.0173	0.0294
UK	0.0048	0.0067	0.0033
US	0.0099	0.0066	0.0082
		Bretton Woods	
Canada	0.0121	0.0105	0.0480
France	0.0209	0.0099	0.0253
Germany	0.0221	0.0090	0.0151
Italy	0.0148	0.0067	0.0558
Japan	0.0135	0.0121	0.0200
UK	0.0159	0.0217	0.0276
US	0.0214	0.0094	0.0203
		Modern Float	
Canada	0.0221	0.0375	0.0321
France	0.0129	0.0227	0.0327
Germany	0.0244	0.0194	0.0253
Italy	0.0209	0.0237	0.0276
Japan	0.0076	0.0122	0.0253
UK	0.0143	0.0177	0.0337
US	0.0109	0.0267	0.0213
		European Monetary System	
France	0.0077	0.0151	0.0167
Germany	0.0201	0.0118	0.0222
Italy	0.0069	0.0093	0.0242

Note: * For comparison purposes, standard deviation figures for the Classical Gold Standard are divided by four.

Standard deviations of supply shocks indicate that the Gold Standard period was relatively stable except for Canada and Japan.[4] The evidence on the supply shocks under the Bretton Woods and the Modern Float is mixed. The incidence of supply shocks seems to be lower in Canada, Germany, and Italy under the Bretton Woods than the Modern Float, while the reverse holds for France, Japan, UK, and the US. Hence within the context of the empirical model, there seems to be no conclusive evidence that the stability of the macroeconomic environment was significantly different under the two recent exchange rate systems. As for the European Monetary System, all three countries seem to have lower incidence of supply shocks as compared to the Bretton Woods and the entire Modern Float.

The most interesting aspect of our empirical results concerns the incidence of aggregate demand shocks. First, consider the *real* demand shocks. There is evidence that the variability of real demand shocks is lower under fixed rate than flexible rate systems. Notice that the standard deviation of real demand shocks are similar under the Gold Standard and Bretton Woods except for Japan. Second, the standard deviations of real demand shocks are higher under the Modern Float than any other exchange rate arrangement for all sample countries, except for the UK under the Bretton Woods. As compared to the Modern Float, the Bretton Woods period also shows less dispersion in the size of the real demand shocks. Particularly, the evidence from our empirical model does not lend support to the notion that the differences in the incidence of real shocks contributed to the break down of the Bretton woods system. There does not seem to be pronounced differences in the incidence of real shocks in general, and the US experience as the system leader is not overly divergent in particular.

The incidence of monetary shocks exhibits a similar but less uniform pattern. The variability of monetary shocks seems to be the smallest under the Gold Standard except for Japan, which is partially due to an outlier in the money supply in 1906 (see fn. 4). Compared to the Modern Float, the variation of monetary shocks under the Bretton Woods is smaller except for Canada and Italy. Canadian results may be explained in terms of the float of the Canadian dollar between 1950.IV–1962.II. Indeed Eichengreen (1993) reports that the variability of money growth rates for the G-7 countries under the convertible Bretton Woods (1959–70) was smaller than any subperiod in the 1881–1989 period. The table further indicates that the variability of monetary impulses is the lowest in Germany, Japan, and the US under the Bretton Woods. The US maintained a relatively greater monetary autonomy under the Bretton woods since its currency was the key reserve currency. Notice also that France, Germany, and Italy all have a lower incidence of monetary shocks under the European Monetary System than the entire Modern Float. The relatively low variability of demand shocks under Bretton Woods and the EMS is consistent with the approach that views the exchange rate system as a disciplining device to policymakers. By committing to a fixed rate, the policymaker refrains from following expansionary policies, hence "the advantage of tying one's hands." While there may be limited discretion afforded to policymakers by fixed rates, the increase in the incidence of demand impulses may partly be due to the shift toward greater policy activism. It is known that the use of monetary policy toward achieving stability and growth was virtually unknown before the Modern Float (Eichenbaum & Evans, 1993).

A. Variance Decompositions

Recall that the exchange rate system may influence the effectiveness of monetary and fiscal policy. The conventional Mundell-Fleming model under highly elastic international capital flows predicts that fiscal policy is effective in altering aggregate demand under fixed rates while monetary policy is effective under flexible rates. Assuming a positively sloped short run and a vertical long run AS curve, the implication is that real demand impulses that alter the IS curve can be expected to explain a higher proportion of output under fixed rates. Similarly, monetary shocks should explain a higher proportion of output under flexible rates. For this implication to hold, one must also assume that the underlying supply relationships are stable across exchange rate systems. Using US data, Gordon (1982) shows that price setting behavior exhibits a high degree of stability over the last century. If this is interpreted as the stability of the underlying short term supply relationships, the proposition regarding the effectiveness of demand policies will be valid.

In order to assess the relative importance of each shock in explaining output, Table 3 presents variance decompositions at 1, 4, 8, 16, and 24 step[5] forecasting horizons. The table indicates that under the Gold Standard demand shocks explain a relatively small proportion of the forecast error variance of output except for Japan where real demand shocks have a noticeable role in the short run. Real demand shocks play a relatively higher role in explaining output for Canada, and to some extent the UK under the Gold Standard as compared to monetary shocks. Variance decomposition of output under the Bretton Woods reveals that real demand shocks explain a higher proportion of output *within* the period as

Table 3. Variance Decomposition of Output

	Proportion of the forecast error in output attributable to											
	ε_s	ε_d	ε_m	ε_s	ε_d	ε_m	ε_s	ε_d	ε_m	ε_s	ε_d	ε_m
step	*Gold Standard*			*Bretton Woods*			*Modern Float*			*EMS*		
							Canada					
1	86.5	13.5	0.0	58.6	35.4	6.0	8.4	89.3	2.3			
4	93.1	6.6	0.3	75.9	21.1	3.0	36.1	63.4	0.5			
8	96.1	3.7	0.2	85.3	12.3	2.4	69.5	29.9	0.5			
16	97.9	2.0	0.1	91.4	7.2	1.4	88.2	11.6	0.3			
24	98.5	1.4	0.1	93.9	5.1	1.0	93.1	6.7	0.2			
							France					
1				58.0	9.1	32.9	19.8	78.0	2.3	46.2	53.7	0.1
4				77.8	5.8	16.4	43.2	56.4	0.4	66.8	31.1	2.1
8				85.5	4.0	10.5	75.1	24.6	0.2	82.4	13.9	3.7
16				92.0	2.3	5.8	90.0	9.9	0.1	91.2	6.0	2.8
24				94.5	1.5	3.9	94.1	5.8	0.1	94.5	3.6	1.9
							Germany					
1				50.5	22.0	27.5	20.1	78.0	2.0	24.7	68.7	6.6
4				65.2	19.3	15.5	35.0	63.4	1.6	46.1	51.3	2.6
8				62.1	30.7	7.2	69.4	29.6	1.0	74.3	24.6	1.1
16				73.8	22.2	3.9	87.4	12.2	0.4	89.0	10.5	0.5
24				82.9	14.6	2.5	91.3	8.4	0.3	92.4	7.2	0.3
							Italy					
1	93.2	1.6	5.3	94.4	2.4	3.2	14.8	73.1	12.1	55.5	0.3	44.2
4	97.2	1.1	1.7	88.6	10.4	0.9	41.4	46.3	12.3	61.2	10.9	27.9
8	98.7	0.5	0.8	91.5	7.9	0.6	63.5	28.1	8.4	57.0	20.9	22.1
16	99.4	0.3	0.4	95.3	4.4	0.3	82.0	13.6	4.4	59.2	21.4	19.5
24	99.6	0.2	0.2	96.7	3.0	0.2	88.9	8.3	2.8	66.3	17.4	16.3
							Japan					
1	61.5	24.6	13.8	86.0	13.8	0.1	93.9	5.5	0.5			
4	84.8	9.8	5.4	91.9	7.2	0.8	97.8	1.7	0.6			
8	91.5	5.5	3.0	94.5	4.2	1.3	99.0	0.7	0.3			
16	95.5	2.9	1.6	96.5	2.5	1.1	99.6	0.3	0.1			
24	96.9	2.0	1.1	97.5	1.7	0.8	99.7	0.2	0.1			
							UK					
1	87.0	7.9	5.1	49.9	45.7	4.3	60.0	1.7	38.3			
4	95.4	2.4	2.2	66.2	32.2	1.6	82.5	1.6	16.0			
8	97.2	1.5	1.4	81.7	17.2	1.1	92.2	1.1	6.6			
16	98.4	0.9	0.8	91.3	8.1	0.6	96.5	0.7	2.8			
24	98.8	0.6	0.5	94.6	5.0	0.4	97.8	0.5	1.7			
							US					
1	97.3	2.7	0.0	20.2	66.8	13.1	15.5	83.4	1.0			
4	95.8	3.2	1.0	14.9	55.7	29.4	55.2	39.3	5.5			
8	97.5	1.9	0.6	39.0	35.5	25.5	77.1	17.9	4.9			
16	98.7	1.0	0.3	66.7	18.9	14.4	87.8	9.5	2.7			
24	99.1	0.7	0.2	79.6	11.4	9.0	91.7	6.5	1.8			

compared to monetary shocks, except for France. However a close look at the Modern Float and the EMS periods indicates that in general, real demand shocks continue to dominate monetary shocks in explaining output. Hence there seems to be an increase over time

Table 4. Variance Decomposition of the Money Stock

	Proportion of the forecast error in the money stock attributable to											
	ε_s	ε_d	ε_m	ε_s	ε_d	ε_m	ε_s	ε_d	ε_m	ε_s	ε_d	ε_m
step	*Gold Standard*			*Bretton Woods*			*Modern Float*			*EMS*		
						Canada						
1	24.0	12.3	63.7	6.6	4.5	88.9	46.9	0.0	53.0			
4	23.3	45.3	31.4	3.9	21.7	74.4	59.7	6.3	34.0			
8	22.8	50.4	26.7	2.5	22.7	74.9	57.5	2.4	40.1			
16	22.4	52.8	24.8	1.4	18.9	79.7	52.2	3.2	44.6			
24	22.3	53.5	24.2	1.1	16.9	82.0	47.1	6.3	46.5			
						France						
1				29.7	12.7	57.7	10.8	0.3	88.8	5.1	0.5	94.5
4				28.9	25.9	45.2	10.1	1.5	88.4	12.4	1.4	86.1
8				24.3	31.8	43.9	10.8	0.9	88.3	13.7	0.7	85.6
16				20.6	37.5	42.0	11.4	0.8	87.8	12.7	0.5	86.8
24				19.1	39.9	41.0	11.9	0.9	87.2	11.9	0.5	87.6
						Germany						
1				26.5	7.5	66.0	37.3	0.0	62.6	56.3	0.0	43.7
4				14.8	30.6	54.6	48.8	1.6	49.6	65.8	0.3	33.9
8				15.0	22.6	62.4	48.2	1.1	50.7	65.3	0.7	34.0
16				34.0	10.2	55.8	36.9	2.6	60.4	59.4	4.3	36.3
24				41.0	9.7	49.3	31.4	4.8	63.9	56.6	7.1	36.4
						Italy						
1	11.4	0.9	87.7	0.0	9.1	90.9	60.6	0.1	39.3	36.2	0.3	63.5
4	43.4	2.3	54.3	0.6	2.7	96.8	83.2	0.5	16.3	35.6	4.7	59.7
8	53.2	2.5	44.3	0.3	7.6	92.0	71.9	5.2	23.0	42.2	1.9	55.9
16	57.3	2.5	40.2	0.2	19.9	79.9	63.5	7.1	29.4	48.5	3.1	48.4
24	58.4	2.5	39.0	0.1	25.6	74.3	59.5	7.1	33.4	49.5	7.1	43.4
						Japan						
1	37.3	22.7	39.9	1.6	4.7	93.7	0.7	0.4	98.9			
4	29.2	27.8	43.0	19.7	22.0	58.3	1.2	16.1	82.7			
8	26.9	27.9	45.2	33.7	17.5	48.8	0.6	18.5	80.8			
16	25.7	28.0	46.3	37.0	11.8	51.3	0.6	15.7	83.7			
24	25.3	28.1	46.6	35.8	8.9	55.2	0.5	13.6	85.9			
						UK						
1	3.4	0.1	96.5	44.0	2.4	53.6	55.4	0.2	44.4			
4	21.9	0.7	77.4	51.1	5.0	43.9	61.8	1.2	37.0			
8	23.4	1.2	75.4	46.2	5.5	48.3	59.3	0.9	39.8			
16	23.9	1.3	74.8	42.6	4.9	52.4	58.1	0.7	41.2			
24	24.1	1.3	74.6	40.6	4.4	55.0	58.2	0.5	41.3			
						US						
1	24.9	2.6	72.5	48.4	0.0	51.6	0.1	0.2	99.8			
4	14.1	23.5	62.4	38.0	2.6	59.4	2.9	6.0	91.2			
8	14.6	28.2	57.2	48.4	2.4	49.2	3.0	5.1	91.9			
16	14.6	30.2	55.2	55.9	1.4	42.7	2.1	2.5	95.4			
24	14.6	30.9	54.5	58.7	1.5	39.8	1.3	2.2	96.5			

in the effectiveness of real demand shocks and it is not clear whether this is related to the international monetary regime itself.[6]

Finally variance decomposition of the money stock is given in Table 4. The results may give an idea on whether money supply behavior exhibits any pattern that may be attributed to the exchange rate system. Recall that countries may enjoy greater autonomy in conducting monetary policy under flexible rates. A flexible rate system may also be expected to free monetary policy from maintaining interest parity unless the country in question relies on extensive capital controls. For example, if the monetary authority is committed to maintain a fixed exchange rate, it must maintain a domestic interest rate compatible with the world interest rate to prevent capital flights. A domestic demand expansion has to be accommodated with a monetary expansion to keep the nominal interest rate at the world level. Similarly under fixed exchange rates, a world interest rate shock will prompt the domestic monetary authority to contract the money supply and raise the domestic interest rate to the world level. In both cases the domestic monetary authority allows the money supply to change so as to maintain interest parity under fixed exchange rates. The traditional argument for flexible exchange rates was that it allows monetary policy to be used for "domestic" policy objectives, since under flexible rates the exchange rate is free to adjust to create a premium/discount on domestic assets and alter the relative price of domestic goods when needed (expenditure switching).

Variance decomposition of the money stock indicates that supply shocks and real demand shocks explain a sizable proportion of the money stock under the Gold Standard and Bretton Woods. Note that the role of real demand shocks in explaining the money stock is diminished under the Modern Float. This may be attributed monetary autonomy under flexible rates which is alluded to above. Recall that monetary policy need not be used to adjust to certain types of shocks under flexible rates since such adjustment can be accomplished by exchange rate policy. The problem with making such claims is that variance decompositions are often sensitive to the assumptions made in orthogonalizing the innovations. It is also possible for domestic money supply targets/rules to change over time[7] which makes money supply behavior attributable to the monetary regime hard to distinguish from a policy change independent of the regime.

B. Sensitivity of Results and Limitations

In order to check for the sensitivity of the results, we try alternative specifications of the VAR. First, we consider the possibility of a unit root in the real interest rate and let $\mathbf{X}^* = [\Delta y\ \Delta r\ \Delta m]'$ with the identifying assumptions stated above. The results on the incidence of shocks are remarkably similar to the main model. However, variance decomposition results seem to indicate a greater role for monetary shocks in explaining output across exchange rate regimes, and a smaller role for real demand shocks. This also seems to be the case when real fiscal spending is substituted for the real interest rate to gauge aggregate demand: qualitatively the incidence of policy induced shocks seem to be lower under fixed rates, although individual country results seem to vary, and variance decomposition results are not robust to alternative specifications. Another question is whether an observed change in the money stock reflects a change in the money supply or a shift in money demand. As our theoretical model indicates, the monetary shock measures an unanticipated money supply change net of a stochastic shift in money demand. However evidence by Gali (1992) shows that money supply innovations dominate money demand innovations in terms of their contribution to the variation in money and output.

In general, our results may be deemed as dependent on an aggregated framework where we distinguish among three types of shocks. Although degrees of freedom considerations precludes one from using a disaggregated framework for evaluating earlier periods, high frequency data can be used for more recent exchange rate arrangements. Incorporating more shocks into the analysis may strengthen the results; we leave these as possible avenues for future research.

V. SUMMARY AND CONCLUSIONS

The debate on exchange rate regimes and exchange rate stability has reemerged as an important policy issue after more than two decades of floating. Events such as the change in the Japanese Yen/US dollar exchange rate by more than 60% in 1995–1997 has called into question how well the foreign exchange market is functioning. Although many recognize the difficulty of a fixed rate system *a la* Bretton Woods, some find the recent swings in real exchange rates to be due to the international monetary regime and suggest some stabilizing mechanism. Misaligned exchange rates aside, economic theory predicts that the exchange rate regime may pose important constraints to policymakers in open economies. This paper tried to provide empirical evidence regarding the incidence and effects of macroeconomic shocks using the structural VAR methodology. Using historical annual data and more recent quarterly data, we imposed a combination of short run and long run restrictions to isolate supply shocks, real demand shocks, and monetary shocks. Incidence of monetary and real demand shocks seem to be lower under fixed rates, as fixed rate regimes tend to set limits to discretionary demand policies. This result seems to be robust to alternative specifications of the VAR and various identification assumptions. Variance decomposition of output indicate that there is an increase over time in the effectiveness of real aggregate demand policies although the results seem to be sensitive to the identification restrictions used to isolate the shocks.

DATA APPENDIX

Classical Gold Standard: Annual data from 1870–1913 for Canada, Italy, UK, and the US, and from 1874–1913 for Japan. The series definitions and sources are as follows:

Canada: Money stock (M1) and nominal interest rate (average yield on domestic government bonds) are from Rich (1988). Output (GDP) is from Maddison (1982). Prices (PPI excluding gold) are from Statistics Canada (1983).

Italy: Output and prices are GDP and CPI from Maddison (1982). Money stock (M1), and nominal interest rate (yield on long term government bond) are from Fratianni & Spinelli (1984).

Japan: Output (industrial production index) for the 1874–1884 period is from Ohkawa, Shinohara, & Meissner (1979). Output (GDP index) for the 1885–1913 period is from Maddison (1982). Prices (cost of living index) for the 1874–1878 period is from Tsuru (1958). Prices (CPI) for the 1879–1913 period is from Maddison (1982). Nominal interest rate (average interest rate on loans between 1,000 and 10,000 Yen) for the 1874–1900 period is from Tsuru (1958). Nominal interest rate (average interest rate on loans with collaterals by the Bank of Japan) for the 1901–1913 period is from Bank of Japan (1954). Money stock (M1) is from Mitchell (1995).

UK: Output and prices are GDP and CPI series from Maddison (1982). Money stock (M1) and nominal interest rate (rates on three month bills) are from Friedman & Schwartz (1982).

US: Output and prices are GDP and CPI from Maddison (1982). Money stock (M1) and nominal interest rate (commercial paper rate) are from Friedman & Schwartz (1982).

Bretton Woods and thereafter: Quarterly data from 1957.I–1996.I for the G-7 countries. Output and prices are GDP and CPI respectively. Money stock is M1, nominal interest rate is the call money rate or equivalent, except for Italy (discount rate), and Canada (interbank rate.) Data are from the International Financial Statistics, except for missing national accounts data which have been obtained from *OECD National Accounts*. The UK call money rate for 1957–72 is from *OECD Historical Statistics: Main Economic Indicators*. Real quarterly GDP data for France, Germany, and Italy for 1957 59 are obtained by simulation using industrial production.

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NOTES

1. Argy and Porter (1972), Mussa (1979), Dornbusch (1983), and Witte (1983) among others provide detailed discussion on the effects of exchange rate regimes.
2. Swoboda (1983), and Baxter & Stockman (1989) see no clear relation between exchange rate flexibility and stability of macroeconomic variables.
3. It can be shown that $h_{23} = 0$ in the **H** matrix is equivalent to $a_{11}^{(0)}a_{23}^{(0)} = a_{13}^{(0)} a_{21}^{(0)}$ in the $\mathbf{A_0}$ matrix.
4. The Japanese data for the Gold Standard has some outliers. For example there is a surge in demand deposits which increases the money supply by 70 percent in 1906. Estimation based on a midpoint money supply for 1906 reduces standard deviations of monetary and supply shocks by about 30 percent.

5. The results for the Gold Standard are not strictly comparable to the rest of the results due to the difference in data frequency.

6. A previous version of this paper used a VAR in output, government spending, prices, and found a greater role for nominal demand shocks under the Modern Float.

7. Recall that a fixed exchange rate system may influence the external reserve component of the money supply.

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