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Evolution of Exchange Rate Regimes

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Abstract

This paper studies issues relating to the evolution of exchange rate regimes. Empirical regularities concerning the variation over time of real and monetary disturbances and cross-country inflation differentials are first discussed. The paper then develops a model that incorporates these regularities and thereby enables exchange rate regime changes to be viewed as optimal and predictable responses by policymakers to a changing economic environment.

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Summary

This paper studies issues relating to the evolution of exchange rate regimes. A simple model is developed that attempts to capture some aspects of recent changes in the economic environment. The analysis may be helpful in understanding why countries alter their exchange rate policy in a predictable manner, although sometimes with great reluctance and often with seeming delay.

Historically observed shifts in exchange rate regimes are discussed and attention is drawn to the major shift that took place in the 1970s toward flexible exchange rates. The paper presents an empirical investigation of some aspects of the changing economic environment underlying these regime shifts. In particular, the variation over time of real and monetary shocks and the divergence of inflation rates and government expenditures of the main industrial countries are studied. The decade of the 1970s is shown to exhibit relatively greater turbulence compared to the 1960s and 1980s. Furthermore, a sharp divergence in cross-country inflation rates occurred in the early 1970s. Both empirical regularities are captured in the theoretical analysis.

A theoretical model is constructed that helps explain two types of exchange rate regime changes. The first type is an initial switch that occurs in response to an unexpected event such as an upheaval in the relative variability of real and monetary shocks or a sudden large change in desired government spending. The second type is the predicted return to the prior regime. One interesting implication of the analysis is that a policymaker may switch temporarily from one regime to another while planning to return to the prior regime at some point in the future. Such a decision may be viewed as an optimal response to movements in the systematic component of real relative to monetary variances or of desired government spending that are expected to return to their steady-state level. In both examples, the switch may be delayed because of fixed costs incurred by policymakers in restructuring the existing exchange rate regime.

I. Introduction

From time to time, countries undertake a major reorientation of their exchange rate arrangements. Such a restructuring occurred following World War II with the advent of the Bretton Woods par value system, while another change took place in the 1970s with the widespread adoption of flexible exchange rate arrangements by the main industrial countries. 1/ Each time a major change takes place, it is well-understood that it requires an expensive restructuring of institutions which may have to be altered yet again in the future, when the economic environment so necessitates.

The purpose of this paper is to study the economic environment relevant to recent exchange rate regime switches and to develop simple models capable of generating an exchange rate regime switch as a forecastable and optimal response to the underlying evolving state of the world. The examples we will develop involve switches between fixed and flexible rate regimes and vice-versa but the methodology is broader. The framework may be utilized to analyze switches between other types of exchange rate arrangements; for example the adoption or disbandment of multiple-tier or composite currency (basket) arrangements or between policies in general (such as interest rate versus monetary targets).

Issues related to the choice between fixed and flexible rate regimes have generated a considerable volume of literature over the last three decades. It is important, therefore, to indicate at the outset the manner in which our analysis differs from previous work that is related to the choice of an optimal exchange rate regime. In particular, the focus of the recent literature on the optimal exchange rate regime is to derive the optimal degree of exchange market intervention as a function of the underlying parameters of the economy and of the variances of the existing monetary or real disturbances (see for example, the papers collected in Bhandari (1985)). The principal result that emerges from these studies is that for a small country fixed rates are generally superior to flexible rates when monetary disturbances are dominant, while flexible rates are preferable when real shocks are dominant. 2/

1/ At least two other major realignments can also be discerned: the adoption of the gold standard from approximately 1870 until World War I and the switch to floating rates over 1929-33. It is to be understood that these realignments, along with the two mentioned above, were major in the sense of involving a substantial number of countries. There are of course, numerous cases of single countries experimenting with alternative exchange rate arrangements in isolation.

2/ These results have been shown by various authors to be robust to a wide variety of alternative model specifications, involving for example, staggered wage setting (Bhandari 1982), complex intervention rules (Turnovsky (1985)), finite or perfect asset substitutability (Driskill and

The typical study of exchange rate regime choice however, makes two assumptions which we believe represent an unduly restrictive view of economic reality. First, it is usually assumed that the underlying economic structure (such as parameters and relevant variances) is time-invariant, so that the optimal intervention stance (or exchange rate regime) is obtained as a once-and-for-all solution to a static optimization problem. 1/ Yet, one of the prominent regularities in the financial and real sectors of real world economies is that they undergo periodic turbulence and tranquility with the relative volatility of real and financial shocks often exhibiting dramatic shifts. As the underlying economic structure evolves over time therefore, the nature of the optimal exchange rate regime can be expected to vary correspondingly, leading to an "evolution" of exchange rate regimes. Historically, countries have tended to switch back and forth between exchange rate regimes as discussed in section II below.

Second, the usual study of exchange rate regime choice takes for granted that prospective regime partners have agreed upon similar inflation targets for their respective countries. In our view the temporary abandonment of low inflation targets seems to play a major role in the choice of exchange rate regimes and the timing of their adoption. To the extent that inflation propensities of countries are predictable, exchange rate regime choice will also have predictable aspects.

The adoption or disbandment of various exchange rate arrangements over time may then be viewed as a predictable and optimal response to the inherently time-varying nature of the underlying state of the world. Previous analyses of exchange rate regimes have, as noted above, remained primarily concerned with computing the optimal degree of intervention for a fixed economic environment and as such, cannot provide an explanation of predictably evolving exchange rate regimes. In this study, we will begin to address our concerns with these aspects of the regime choice problem by developing two models which we believe are more in line with the empirical regularities referred to above. In the first model, the underlying stochastic structure of the economy evolves predictably over time, although it is subject to unpredictable shifts at any moment in time. The second model extends the first to incorporate government expenditure as a policy goal. By allowing for time-variation in desired government spending across exchange rate regimes the inflation propensity of the country in question

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McCafferty (1985)). We note however, that this proposition may not survive incorporation of differentiated or heterogeneous information sets (Bhandari 1985).

1/ See however, Flood and Hodrick (1986).

evolves predictably over time. 1/ The decision problem we focus on is at the level of the policymaker. It involves the choice by the policymaker of the exchange rate regime for the next period, together with the formulation of a plan concerning the path of the exchange rate regime over the indefinite future.

While the following text contains a discussion of our substantive results, the most interesting implication of our analysis may be noted at this point. In the model and its extension, a policymaker can switch from one regime to another while planning to switch back at some point in the future. To our knowledge, this possibility has neither been discussed nor analyzed in any previous literature. This implication is suggestive insofar as changes in the exchange rate policy by some countries may be interpreted as a predictable and optimal response to a changing economic environment.

Section II presents a discussion regarding the historically observed shifts between exchange rate regimes and our empirical observations of the time-varying movements of relative monetary and real variances in the main industrial countries over the past three decades. This section also presents some empirical evidence relating to the dispersion of inflation rates in the same group of countries over the same period. Section III sets out the basic analytical framework which involves a time-varying stochastic structure. Policy choices in the context of this model are studied in Section IV. In Section V, we extend the basic model to highlight the links between government expenditure, inflation rates and the choice of the exchange rate regime.

II. Stylized Facts

This section examines some empirical regularities emphasized in our analysis of the choice of exchange rate regime. First, historical shifts in exchange rate regimes are discussed. Next, we attempt to capture three aspects of the changing economic environment underlying these shifts; the relative variability of real and monetary shocks and the divergence of inflation rates and government expenditures of the main industrial countries.

1. Shifts between exchange rate regimes

Four main exchange rate regime switches have occurred over the last century; the adoption of the international gold standard from around 1870;

1/ Our work builds, in part, upon Abel (1986) in incorporating a time-dependent stochastic structure into decision problems of economic agents. See also Hodrick (1987) and Flood (1988).

to World War I 1/; the switch to fluctuating exchange rates from 1929-33 2/; the adoption of the Bretton Woods par value system from 1944-1971/72 3/; and the switch to the present international monetary system that is characterized by independent or joint floating by the main industrial countries and a wide diversity of exchange rate arrangements among other IMF member countries.

From an historical perspective, it is clear that no exchange rate regime has proven to be permanent. Some observers also suggest that policymakers did not expect ex-ante that these switches among regimes would be long-lasting. For example, Yeager (1986, p. 374) argues that many countries still considered the gold standard to be temporarily suspended as late as 1933. The debates throughout the early 1970s and negotiations over the Second Amendment of the Fund Articles of Agreement from 1974 to 1976 also reflect conflicting views about the permanence of floating rates (see De Vries (1986, pp. 113-115).

Within the present international monetary system, there has been a considerable switching both between and within exchange rate arrangements. In Chart 1, shifts in exchange rate arrangements of a constant group of IMF member countries are tracked from 1969 to 1987. 4/ The most striking feature of the chart is the shift away from fixed exchange rate arrangements to limited and more flexible arrangements during the period. 5/ At

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1/ An international gold standard exists when most major countries maintain convertibility between gold and their national monetary units at fixed ratios. Prior to the gold standard, a form of loose bimetallism existed (see Yeager (1976, pp. 295-297)).

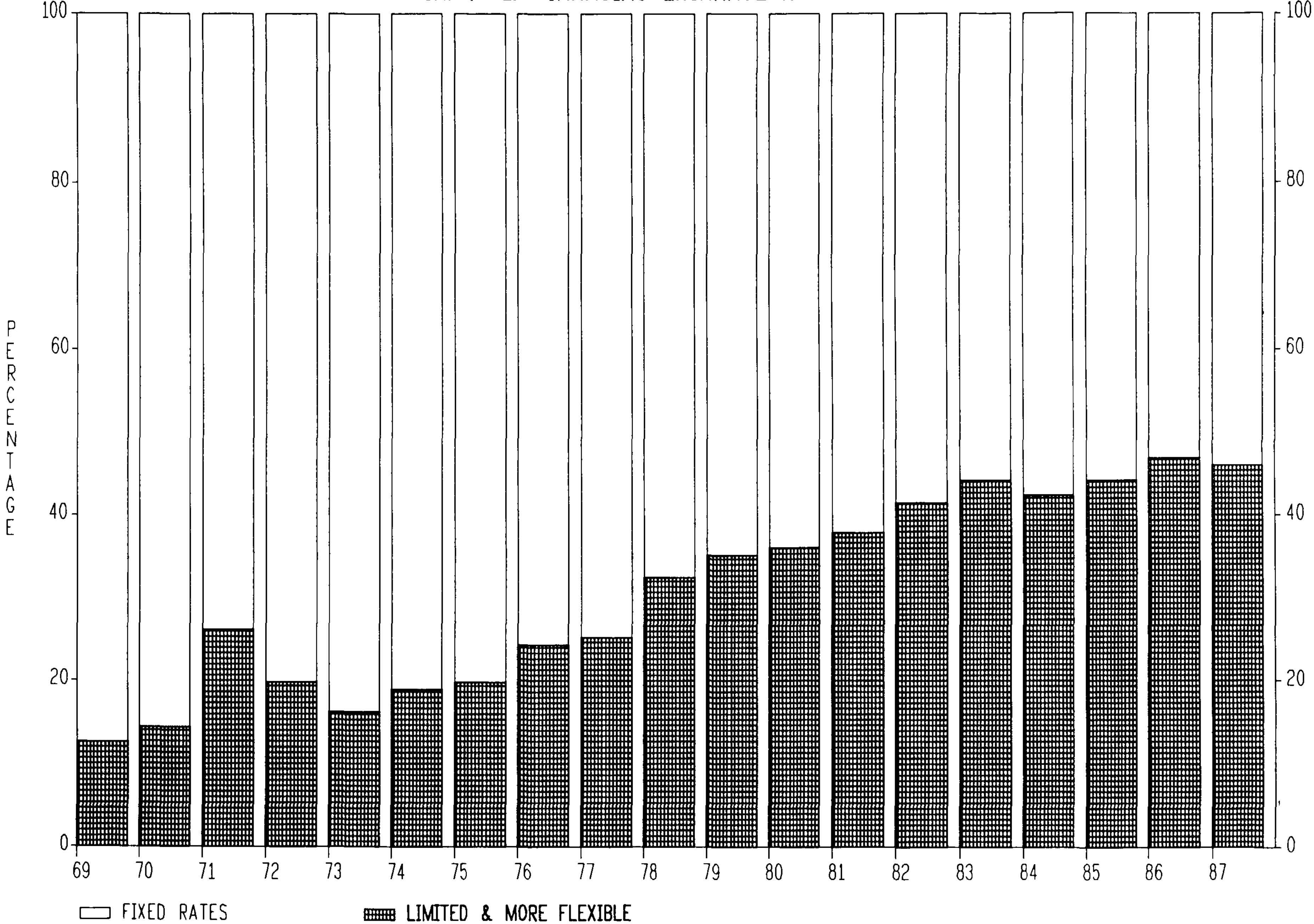
2/ During the period 1929-33, 35 countries abandoned the gold standard.

3/ The breakdown of the Bretton Woods system can be dated from 1971 when its two main features - par values and dollar convertibility were no longer operative (see De Vries (1980, chaps. 2,3)).

4/ The classification of exchange rate regime is based upon the Fund exchange rate arrangements classification (see IMF 1987). Important changes in this classification system occurred over the sample period, especially in 1973 and in 1982. In particular, a new category "exchange rate not maintained within relatively narrow margins" was first introduced in 1973; in 1982, this category was replaced by two new classes; limited flexibility and more flexible arrangements.

5/ The original Articles of Agreement of the IMF reflected the requirement of an agreed par value. However, under temporary and specified circumstances, the Fund supported deviations from exchange rate arrangements, including fluctuating rates (for example, Canada (September 1950-May 1962), see De Vries (1986, pp. 49-56). The classification of countries in the non-fixed category in the pre-1973 period is based upon the criterion that either the country did not maintain a par value or adopted a freely fluctuating unitary effective rate.

CHART 1: CHANGING EXCHANGE RATE REGIMES



the start of the period, 87 percent of the group are classified as having adopted a fixed exchange rate regime; at the end of the period, this percentage had fallen to 54 percent. This shift was most marked for the industrial country group; for the developing country group, the percentage in the fixed rate category fell from 84 percent to 53 percent.

Within the period, shifts between and within exchange rate regimes occurred; in particular, reversible changes were most marked for the developing country group. For example, among 15 developing countries that were classified under more flexible arrangements in 1973, about 60 percent had switched to a fixed arrangement from 1974 to 1976; by 1982 all except for two countries had returned to and remained on a more flexible regime. 1/ Within exchange rate arrangements, shifts are even more marked, especially within the fixed rate group as shown in Chart 2. For example, in 1973, about 55 percent of the group were pegged to the U.S. dollar but by the end of 1987, this percentage had fallen to 38 percent. The main offset was a shift to a currency composite basket (from 18 to 30 percent of the group).

2. Variability of real and monetary shocks

An important aspect of the time-varying environment is time variation in the stochastic environment. We have attempted to capture the historical evolution of the stochastic environment over the Bretton Woods and post-Bretton Woods eras by examining the time-series behavior of some aspects of the distributions of estimated real and monetary shocks of the G-5 countries.

Real and monetary shocks for each country were estimated by first estimating a set of aggregate money demand and output supply equations for each country, deriving the residuals associated with the shocks and then taking the shock to be the innovation in the residual. 2/ Table 1 summarizes the average variability (as measured by the standard deviation) of the percentage shocks for each G-5 country for three periods; 1960s, 1970s and 1980s. 3/ In the upper panel of the table, the standard

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1/ Adjustable indicators were classified under a fixed rate category prior to 1982. This change in classification affects four countries within the group.

2/ A detailed description of the methodology used to estimate these shocks is given in Appendix I. For the United States, both money demand and money supply equations were estimated. Our emphasis is on the time-series behavior of the relative shocks in contrast to Obstfeld (1985) who uses cross-section data to show the relative dominance of real shocks in the early post-Bretton Woods period.

3/ Sample period ends in 1987(4) for all countries except the Federal Republic of Germany which ends in 1988(1).

Table 1. Standard Deviations of Real and Monetary Shocks

Ratio of normalized standard deviation of real to monetary shocks 1/

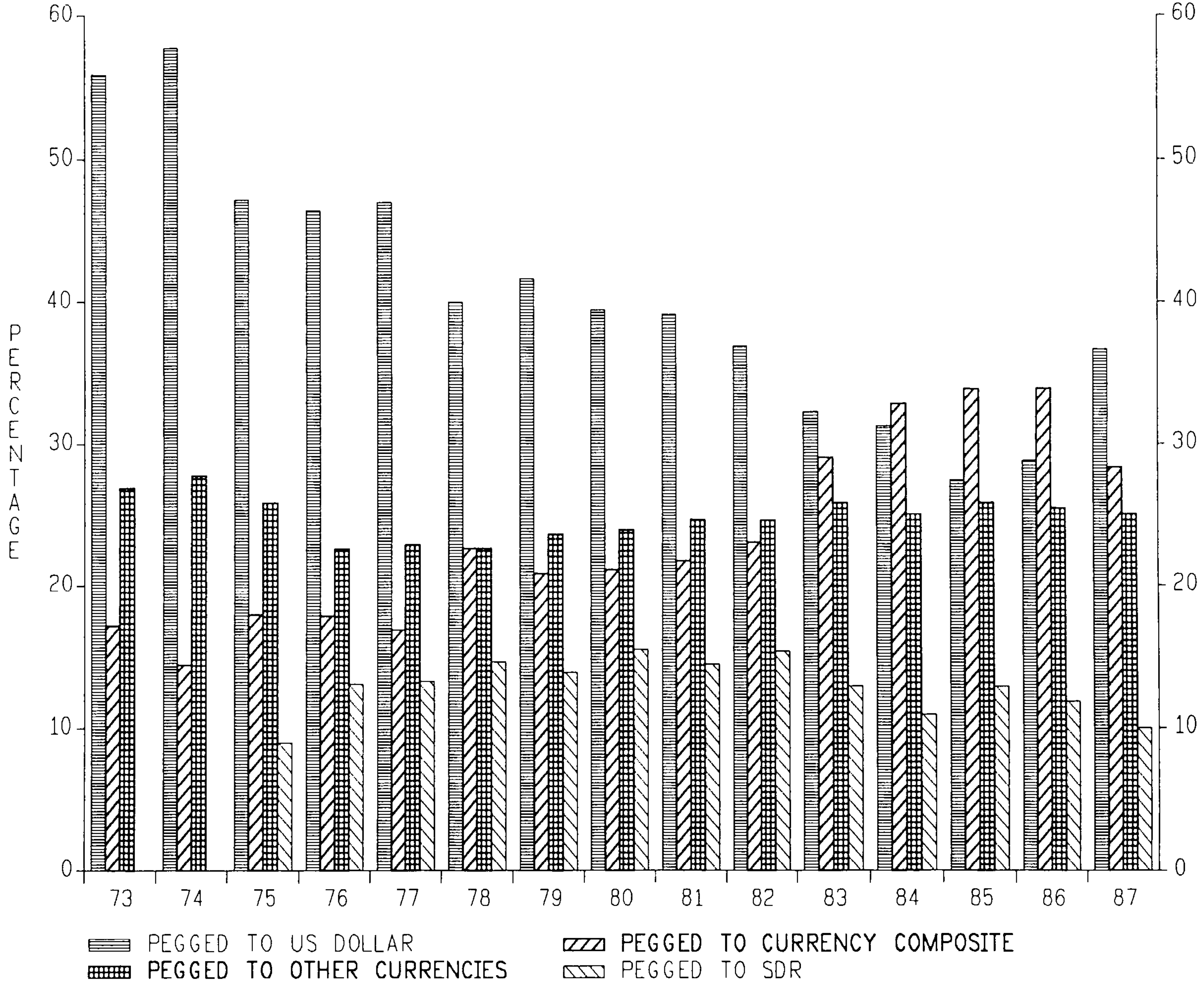
Period		United States	Japan	Fed. Republic of Germany	United Kingdom	France 2/
Decade average	1960-69	1.73	1.24	1.04	0.97	1.93
Sub-period	1960-64	2.15	1.02	1.19	0.78	--
Decade average	1970-79	1.85	0.84	1.06	1.06	0.69
Sub-period	1970-74	1.82	0.94	1.45	1.24	0.87
Decade average	1980-87 3/	0.61	0.81	0.89	0.92	0.55
Sub-period	1980-84	0.57	0.69	1.05	0.98	0.74
		Standard deviations of real shocks (in percent)				
Decade average	1960-69	0.66	1.61	1.52	1.33	2.57
Sub-period	1960-64	0.71	1.58	1.74	1.29	--
Decade average	1970-79	1.03	1.33	1.19	1.81	0.89
Sub-period	1970-74	1.05	1.71	1.38	2.08	0.98
Decade average	1980-87 3/	0.87	0.71	1.11	1.24	0.77
Sub-period	1980-84	1.02	0.62	1.31	1.33	0.89
Whole period	1960-87 3/	0.86	1.30	1.29	1.49	1.33
		Standard deviations of monetary shocks (in percent)				
Decade average	1960-69	0.31	1.09	0.84	1.57	1.74
Sub-period	1960-64	0.26	1.30	0.84	1.88	--
Decade average	1970-79	0.44	1.32	0.65	1.94	1.68
Sub-period	1970-74	0.46	1.53	0.55	1.90	1.47
Decade average	1980-87 3/	1.13	0.74	0.73	1.53	1.82
Sub-period	1980-84	1.42	0.76	0.72	1.54	1.57
Whole period	1960-87 3/	0.69	1.09	0.75	1.70	1.74

1/ Real and monetary residuals divided by their respective standard deviations for the period 1960(1) - 1987(4).

2/ Sample period for France begins 1965(4).

3/ Sample period ends 1987(4) for U.S., Japan, U.K., France; in 1988(1) for Fed. Republic of Germany.

CHART 2: FIXED EXCHANGE RATE REGIMES



deviations of real and monetary shocks are normalized by dividing the shock for each period by the associated standard deviation of the entire sample period; the ratio of the normalized standard deviation of the real to monetary shock is then derived. The lower panel shows the standard deviations of the two types of shocks (measured in percent).

Interpreting the standard deviations, we see for example that the average variability of real shocks for the United States in the 1970s was almost twice that of the 1960s. In the 1980s, U.S. real shock variability had returned to a level close to the average for the entire sample period, 1959(4) - 1987(4). A similar pattern of a relatively smaller turbulence of real shocks in the 1980s compared to previous decades is apparent for all G-5 countries. In contrast to real shocks, monetary shocks in the United States show the greatest turbulence in the 1980s; 1/ their average variability being about three times that of the 1960s and 1970s. Other countries show a mixed pattern; for example, in Japan and the United Kingdom, monetary shocks show a relatively greater turbulence in the 1970s.

Our interest is in both the overall levels of the variances of real and monetary shocks and whether one type of shock tends to dominate the other during or prior to periods of exchange rate regime switching as discussed above. The ratio of the normalized standard deviation of real to monetary shocks reflects the net outcome of two effects; the variability of each shock in a particular period relative to the trend for the entire period and the variability of real relative to monetary shocks. A ratio equal to unity in a particular period signifies that both real and monetary shocks were close to their average level for the whole sample period. A distinct pattern emerges for the 1980s; in all countries the ratio falls below unity and also lies below that of earlier periods. Thus, it may be concluded that the 1980s is a period of relative quiescence compared to two previous decades, especially for the United States. 2/ For three countries (the United States, the Federal Republic of Germany and the United Kingdom), the late 1960s and early 1970s show relatively greater turbulence while for the remaining two countries, the average variability of the ratio of real to monetary shocks is greatest in the 1960s. 3/

1/ When the 1980s is broken into the sub-period, 1980-84, the standard deviation of monetary shocks rises to 1.42, reflecting the well-documented instability in U.S. money demand.

2/ Interpreted in the above sense, a period such as the 1980s may be described as relatively tranquil yet still be characterized by large shocks in absolute terms.

3/ The sharp rise in the variability of the ratio of real to monetary shocks in France in the 1960s reflects primarily a large real shock in 1968. For the United States, this statement is true for the decade

Because the United States was the reserve center country during the Bretton Woods period, the United States may be seen as an exporter of stability or turbulence during the period. By exporting large monetary disturbances to smaller countries through its balance-of-payments deficit, the behavior of variability in the United States influenced the incentive to switch monetary regimes in other countries. Indeed, the time-varying pattern of real and monetary shocks for the United States and other G-5 countries will prove to be consistent with our analysis with the observed shift toward more flexible exchange rate arrangements during the late 1960s and 1970s.

3. Divergence of inflation rates

Central to the second model is the idea that extraordinary events such as wars may necessitate a sharp increase in government spending that in turn generates inflationary pressures incompatible with the continued maintenance of fixed exchange rates. The divergence of inflation rates of G-5 countries as measured by their dispersion around the period cross-section mean inflation rate is given in Chart 3 for the period 1960(1) - 1988(1). From about mid-1971 to the third quarter of 1975, there was a sharp rise in the divergence of inflation rates. Since that period, the standard deviation of inflation rates has fallen from about 4.8 percent per year to about 0.8 percent per year, roughly equal to the variability at the start of the 1960s. The dispersion of government consumption to GNP ratios around their mean value rose to about 5.4 percent in this period, before falling back by the end of 1986 to roughly the level attained in the early 1960s.

In summary, we have identified certain tendencies in the pattern of real and monetary shocks over the past three decades facing the main industrial countries. The late 1960s and early 1970s tended to be periods of relatively greater turbulence (as measured by the variability of the ratio of real to monetary shocks) as compared with the early 1960s and 1980s. Further, the same group of countries experienced a sharp divergence in inflation rates and government spending in the early 1970s. Both "stylized facts" are consistent with our theoretical analysis of exchange rate regime evolution that follows.

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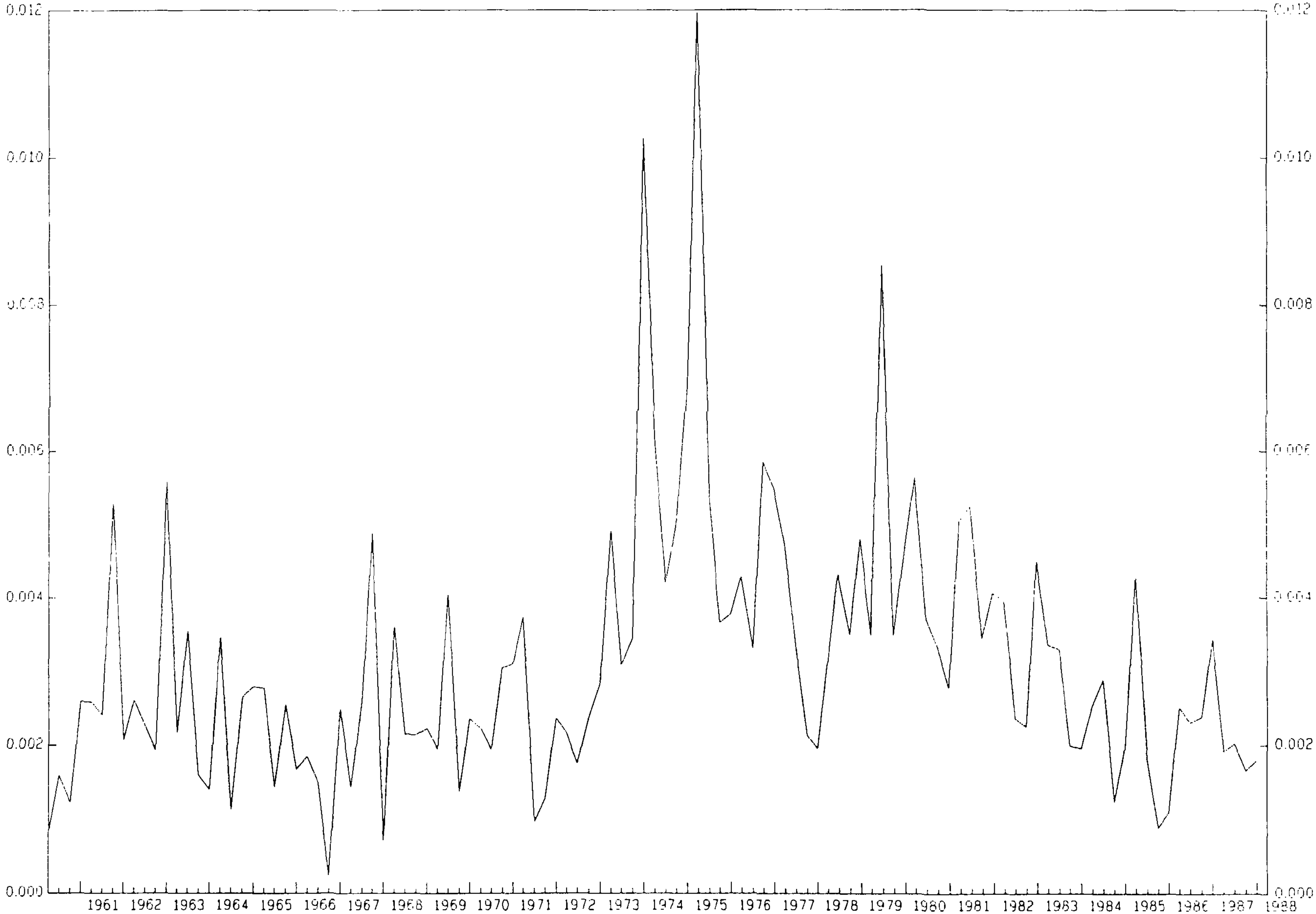
average notwithstanding a large jump in the ratio of real to monetary shocks in the early 1960s.

Chart 3

G5 Countries: Standard Deviation of Inflation Rates

First Quarter 1960 to First Quarter 1988



III. The Model

1. The basic framework

This section describes the analytical framework to be used for our subsequent analysis. We have elected to utilize a very minimal structure involving only three equations, i.e., a statement of money market equilibrium, a Lucas-style output supply function and the purchasing power parity relationship. It is possible of course, to incorporate additional structural detail in the model; however, most of these details (such as for example, price "stickiness" or the inclusion of an opportunity cost in money demand) turn out to leave our substantive results unaffected.

The framework of analysis involves a small country, described by:

$$m_t - p_t = y_t + w_t \tag{1}$$

and

$$y_t = \beta(p_t - E_{t-1}p_t) + u_t, \quad \beta > 0 \tag{2}$$

where m_t is the logarithm of the money supply, p_t is the logarithm of the price level, y_t is the logarithm of output, w_t is a white noise velocity shock and u_t is a white noise productivity shock. The shocks w_t and u_t are uncorrelated but their distributions may have time-varying elements to be specified below. We assume purchasing power parity, i.e., $p_t = p_t^* + s_t$, where p_t^* is the logarithm of the foreign price level and s_t is the logarithm of the exchange rate, quoted as the domestic-currency price of foreign exchange. In what follows we assume p_t^* is constant and set $p_t^* = 0$. It is also assumed that β, the slope of the domestic-goods supply function is a policy-invariant constant. 1/

The process determining the supply of domestic money depends on the exchange rate regime. If the country adopts flexible exchange rates, m_t is exogenously determined and is assumed to be set equal to zero. Under fixed rates however, m_t becomes endogenous and is determined as $m_t = y_t + w_t - \bar{s}$, where $\bar{s} = 0$ is the logarithm of the fixed exchange rate.

1/ In Flood and Marion (1982) β is treated as policy-varying, while in Flood and Hodrick (1986) β is time-varying and moves in accord with agents' perceptions of an endogenously time-dependent stochastic structure.

2. Time varying stochastic structure and fixed costs

The model incorporates two disturbances, w_t and u_t. We assume that the velocity shock w_t, has a time-invariant variance, V(w). In our first model, the variance of u, V(u), is expected to vary through time according to:

$$V_{t-1}(u_t) = (1 - \rho)z + \rho u^2_{t-1}, \qquad 0 < \rho < 1 \tag{3}$$

which implies:

$$V_{t-1}(u_t) = (1 - \rho)z + \rho V_{t-1}(u_{t+i-1}), \; i=2,3,\ldots \tag{4}$$

In our notation, $V_{t-1}(u_{t+i})$ is the variance of u_{t+i} conditional on time t information. More precisely, $V_{t-1}(u_{t+i}) = E_{t-1}[(u_{t+i})^2]$, where E_{t-1} is the mathematical expectation operator conditional on time t-1 information. Equation (3) is an ARCH specification of the real disturbance term and equation (4) is the difference equation derived from the ARCH specification. 1/

The solution of (4) may be written as:

$$V_{t-1}(u_{t+j}) = z + d_{t-1}\rho^j, \quad j = 1,2,\ldots \tag{5}$$

where $d_{t-1} = (u_{t-1})^2 - z$.

IV. Policy Choices

1. The social criterion

It is assumed that policy choices are made by a social planner whose objective is to:

1/ See Engle (1982) for details regarding the autoregressive conditional heteroskedastic (ARCH) error term.

$$\max_{\{X\}} E_{t-1} \sum_{i=0}^{\infty} \{U_{t+i} - C_{t+i}\}\lambda^{i}$$

where $U_{t+i} = y_{t+i} - \gamma(y_{t+i})^2$, $C_{t+i} \geq 0$ is the fixed cost of switching the exchange rate regime during period t+i, $\lambda = 1/(1+r)$ is the social discount rate and r is the social interest rate, and X = FIX, FLEX is the policymaker's choice variable. The policymaker chooses at t-1, the regime to be in place at t and forms a plan concerning the regimes that will be implemented in periods after period t. The plan, however, need not bind the policymaker. Deviations from the planned sequence of exchange rate regimes can always occur as new information becomes available. The cost $C_{t+i} = C \geq 0$ if any regime switch is made during period t+i and zero otherwise. It will be seen below that the presence of this fixed cost can result in postponement of the decision to switch exchange rate regimes. 1/

Four important properties of our chosen policy problem are: (1) the intertemporal separability of the planner's utility function; (2) the quadratic form of the period utility function; (3) the timing of information relevant to the loss; and (4) the timing of the effects of the policymaker's actions. Intertemporal separability is defended only on grounds of analytical tractability. The quadratic utility function is defended on the same grounds, although it is acknowledged that this is an economically substantive assumption. The quadratic utility function causes the criterion function to be linear in conditional variance so that the policymaker is risk neutral with respect to variance risk. Literally, the policymaker makes its decisions based only upon perceptions of the variance of u and is not concerned with variability (however defined) of that variance. The timing of the acquisition of information is also important. In this model, the variance of the u-shock at time t cannot "surprise" agents at time t. Instead, the variance surprise for t occurs during the previous period. At time t, of course, the agents will probably be "surprised" about the actual outcome of the real shock. They will not however, attribute any of this surprise to misperceptions about variance in that period. They will simply update their perceptions of next period's variance in response to the shock.

1/ Even if C = 0 our model predicts regime switches. C > 0 allows the possibility that switches will be delayed. We also assume symmetry in costs for the two regimes. It is possible that costs may differ from one regime to another or at different times for an individual country with respect to one regime. However, in the absence of any compelling rationale, it seems reasonable to retain the assumption of symmetry.

For reasons of tractability we assume that the policymaker's current decision about the exchange rate regime is not implemented until next period. 1/

2. Selection of the appropriate regime

The state variable for this problem is the existing exchange rate regime. The existing regime enters the policymaker's decision problem because the fixed cost C is incurred if the exchange rate regime is changed. Our time series model for the variance of u is such that this variance is expected to approach its steady state monotonically.

It will be convenient in what follows to note that:

$$E_{t-1}(y_{t+i} - \gamma y_{t+i}^2) = \gamma V_{t-1}(y_{t+i}), \quad i = 0,1,2\ldots, \tag{6}$$

V_{t-1} is defined as the variance operator conditional on period t-1 information. Furthermore, because foreign price is constant, it follows that under fixed exchange rates:

$$V_{t-1}(y_{t+i}, FIX) = V_{t-1}(u_{t+i}) \tag{7}$$

Under a flexible exchange rate regime, equations (1) and (2) can be used to yield,

$$V_{t-1}(y_{t+i}, FLEX) = [\beta/(1+\beta)]^2 V(w) + [1/(1+\beta)]^2 V_{t-1}(u_{t+i}) \tag{8}$$

$$i = 0,1,2\ldots m$$

where $V_{t-1}(y_{t+i}, FIX)$ is the time t-1 expectation of the variance of y at time t+i, given that the FIX regime will be operating at t+i and

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1/ It is possible of course, to allow for the immediate implementation of a current decision relating to the exchange rate regime: this leads however, to algebraic complications without affecting any of our principal conclusions.

$V_{t-1}(y_{t+i},FLEX)$ is the time t-1 expectation of the variance of y at time t+i, given that the FLEX regime will be operating at t+i.

When we allow one or the other of the exchange rate regimes to have a steady state advantage, our analysis begins to distinguish itself from the previous literature. Most models of the choice between fixed and flexible exchange rates find that flexible rates have an advantage when real shocks, like u in the above model, are dominant and fixed rates have an advantage when monetary shocks, like w, are dominant. If the stochastic steady states of the two regimes are assumed to be equivalent, our analysis is in conformity with the results emerging from the previous literature. Since allowing steady state asymmetries presents the possibility for considering a sizable taxonomy of cases, we will limit the taxonomy by studying only the case which we consider most interesting, which is $d_{t-1} >> 0$ with a steady state advantage to the fixed rate regime. We will therefore, study a case where there has been a large positive deviation of the variance of u from its steady state value and where there is a natural steady state advantage to a fixed rate regime.

Figure 1 shows the paths of $V_{t-1}(y_{t+i},FLEX)$ and $V_{t-1}(y_{t+i},FIX)$ which we will examine. Note that by assumption $V_{t-1}(y_{t+i},FLEX)$ starts lower than does $V_{t-1}(y_{t+i},FIX)$, but that $V_{t-1}(y_{t+i},FLEX)$ approaches a higher steady state than does $V_{t-1}(y_{t+i},FLEX)$. It follows that the paths of $V_{t-1}(y_{t+1},FLEX)$ and $V_{t-1}(y_{t+i},FIX)$ must cross at some date in the future. Our assumed time series process for the variance of u ensures that they cross exactly once. Since time is counted in integers in our model, there is no reason there should be a date T when $V_{t-1}(y_{t+T},FLEX)=V_{t-1}(y_{t+T},FIX)$. Nonetheless, we will assume for the purposes of our analysis that there is indeed such an integer valued date.

If the economy had adopted a fixed exchange rate regime from t until t+T, there would certainly be no reason at t+T to switch to the flexible rate regime. From t+T onwards the period loss is greater with FLEX than with FIX, so that the policymaker would not wish to incur a fixed cost by switching to FLEX. If however, the economy had been operating FLEX before t+T, however, the situation is more interesting. First, note that there is no incentive to switch from FLEX to FIX before t+T, since such a switch would both increase the period loss and incur the fixed cost.

At t+T-1, the switch becomes more tempting. According to our assumption that $V_{t-1}(y_{t+T},FLEX) = V_{t-1}(y_{t+T},FIX)$ the switch would certainly not be made at t+T-1 to be effective in t+T, because there is no net gain during period t+T in terms of the period loss function by making the switch, and the fixed cost, C, would have to be incurred in t+T-1. Consequently, the decision in t+T-1 is straightforward, i.e. the policymaker will not switch regimes. According to our assumptions, the policymaker expects that during period t+T+1, $V_{t-1}(y_{t+T+1},FLEX) > V_{t-1}(y_{t+T+1},FIX)$. Therefore, there would be a net gain in terms of the period loss function from switching at t+T. But, the policymaker must weigh the present value of this gain against the gain from waiting until next period to incur the fixed switching cost. This gain is rC (where r is the social interest rate as defined above). By delaying switching until the next decision point, the economy must forego $\gamma\rho[V_{t-1}(y_{t+T+1},FLEX) - V_{t-1}(y_{t+T+1},FLEX)]$ but it obtains a gain of rC by deferring the fixed switching cost which must be incurred.

The policymaker will make the switch at T+k-1 where k is the smallest integer such that:

$$\gamma\rho[V_{t-1}(y_{t+T+k},FLEX) - V_{t-1}(y_{t+T+k},FIX)] - rC \geq 0 \tag{9}$$

In the present example, k is the smallest integer such that:

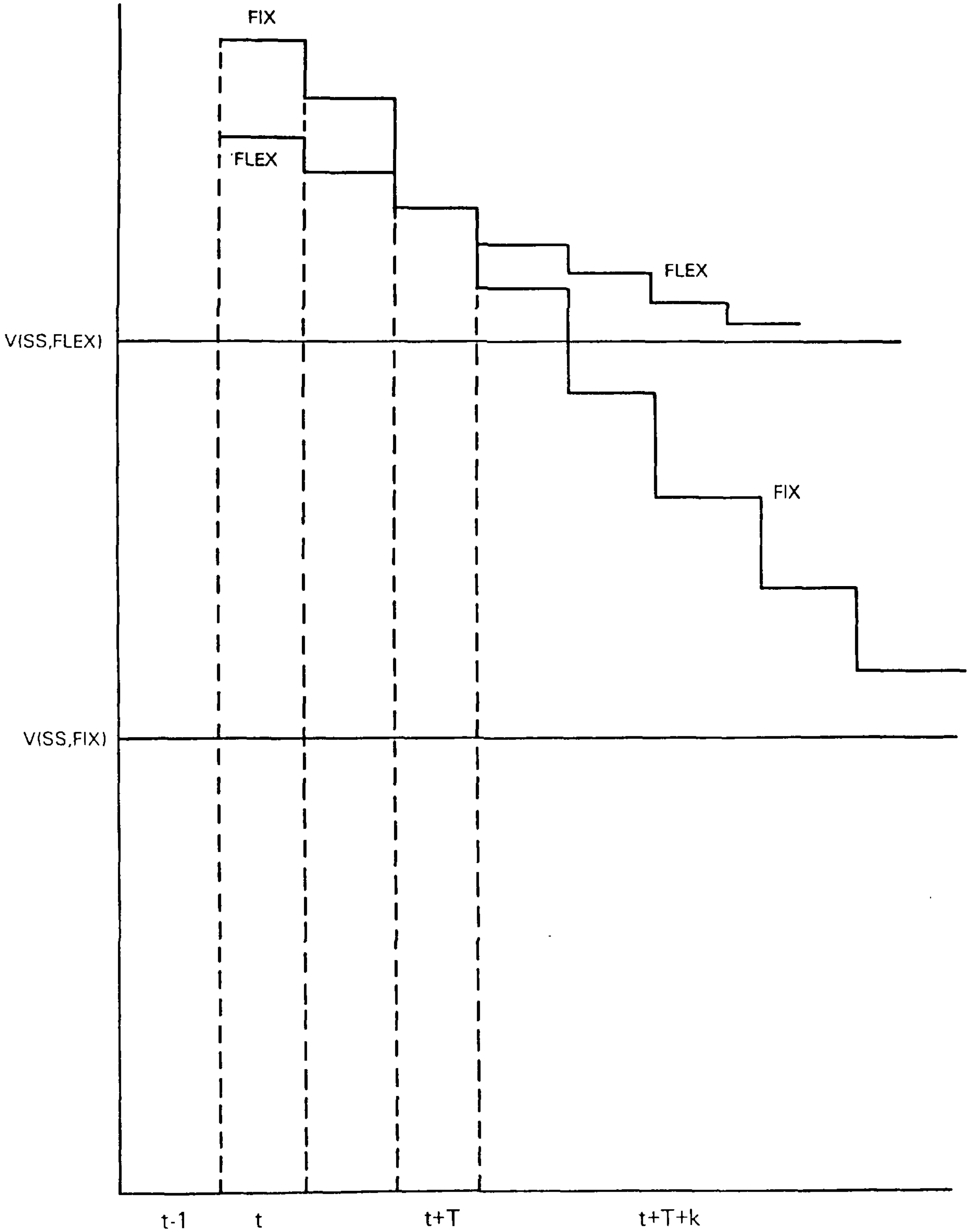
$$\rho^k < 1 - rC/\rho z(\delta-1)\gamma, \quad \delta > 1 \tag{10}$$

where $\delta > 1$ is the ratio $V_{t-1}(SS,FLEX)/V_{t-1}(SS,FIX)$. Clearly, if $C = 0$, $k = 1$. It is possible that no positive integer k fulfills condition (10). This would be true, for example, if C were very large so that it would never be worthwhile to switch regimes. In what follows, however, we assume that there exists an integer $k \geq 1$ which fulfills (10).

Now consider the plans and actions of the policymaker at time t-1. There are two possibilities to consider: (1) at t-1 the economy is operating FLEX; and (2) at t-1 the economy is operating FIX. Consider these possibilities in order. If the economy is operating FLEX during t-1, then the realization of the state in t-1, with a high value of d_{t-1} would not indicate a move to FIX. Indeed, we have just established that if an economy is operating on FLEX with state d_{t-1}, then the planned switch date is t+T+k, which must be greater than t.

Now suppose that the economy is on FIX during period t-1 and experiences a relatively large value of d_{t-1}, as would happen if a period of substantial real turbulence were encountered. The policymaker must decide at t-1 whether to switch from FIX to FLEX effective at t, knowing that if it makes the switch, it plans to switch back effective at t+T+k. The alternative to switching is obviously not to switch. In our model, the gain from delaying a switch for one period is always rC. The gain from switching from FIX to FLEX is at its greatest in period t and thereafter declines toward zero in period t+T. Therefore, if the policymaker plans to switch from FIX to FLEX, it is optimal to make the switch

Figure 1



immediately, i.e., in period t. The policymaker's decision is therefore, between planning to follow FIX indefinitely or switching now to FLEX, while planning to follow FLEX from t until t+T+k-1 with a subsequent switch again at t+T+k. The latter path involves two switches. It is optimal to make the switch at t effective for t+1 if and only if

$$\sum_{i=1}^{T+k} \gamma\left[V_{t-1}(y_{t+i},FIX) - V_{t-1}(y_{t+i},FLEX)\right]\lambda^{i} - (1+\lambda^{T+k})C > 0 \qquad (11)$$

is satisfied. It is possible to evaluate this expression further in terms of its underlying determinants but this is left to the interested reader.

This section has discussed regime selection in the context of a framework which incorporates stochastic evolution of the underlying variances in the economy as well as a cost associated with regime switches. An important result obtained in this section relates to the possible re-switching to the prior regime. This property will be seen to survive the modification in the extension of the model.

V. Model Extension: Inflation, Government Expenditure and Regime Choice

In our analysis so far we have implicitly assumed that domestic inflation is equal on average to rest-of-the-world inflation regardless of the exchange rate regime. Yet, an important consideration in choosing exchange rate regimes is the respective inflation propensities of prospective exchange rate regime partners. In particular, we know of no case where a high inflation industrial country has managed to maintain a fixed exchange rate vis-a-vis a low inflation industrial country. 1/

This section extends the previous model to highlight the links between government expenditure policy, inflation rates and the choice of the exchange rate regime. This is done by incorporating government expenditure as a policy goal and allowing for time-variation in desired government spending across exchange rate regimes. The first model is incomplete as it ignores the role of government revenue and thereby the role of differing propensities to generate government revenue across exchange rate regimes. Extraordinary events such as wars may necessitate

1/ The examples of a high inflation country fixing its exchange rate to a low inflation country seem to involve at least one country where foreign exchange is rationed.

sharply increased government expenditures which in turn, generate inflationary pressures incompatible with the continued maintenance of fixed exchange rates. Thus, during major episodes such as wars, governments attach high priority to attaining specific expenditure targets (in order to finance the war effort) and may be willing to accept the resulting inflation (and consequent abandonment of fixed rates) temporarily. In order to focus on the novel elements introduced by these modifications, we abstract at present from the time-varying element of underlying variances and also from the fixed cost of changing regimes. 1/

The first modification involves an extension of the policymaker's loss function to include a government expenditure goal. The modified period loss function is:

$$W_t = U_t + \psi(g_t - \hat{g}_t)^2 , \quad \psi > 0 \qquad (12)$$

where U_t is defined above, g_t is the logarithm of government spending and $\hat{g}_t$ is the logarithm of desired government spending and ψ is the priority attached by the policymaker to achieving its desired spending level. With the fixed cost of regime switching set at zero, the policy problem now becomes one of period-by-period optimization. It is assumed that the exchange rate regime for period t is set in period t-1 to minimize $E_{t-1}W_t$.

Desired government spending is exogenous to the economy and follows:

$$\hat{g}_t = \bar{g}(1-\psi) + \psi\hat{g}_{t-1} + x_t , \quad 0 < \psi < 1 \qquad (13)$$

where x_t is a white noise, constant variance shock, which is uncorrelated with other shocks in the model. 2/

The next step is to link actual government expenditure with the choice of the exchange rate regime. In our model the only method of government finance is by money creation. The rate of money creation however, is sensitive to the choice of the exchange rate regime. For example, under fixed exchange rates, domestic inflation and money creation

1/ This does not make our subsequent analysis static. As will be seen below, time-dependency in the present model is introduced via the government expenditure process.

2/ A stabilization role for $\hat{g}$ could be built around a covariation of x_t with w_t or u_t. However, we assume away such covariation.

are restrained by "the discipline of world inflation". Because money creation is the only source of revenue in the model, it follows that actual government expenditure is accordingly endogenously constrained under fixed exchange rates. Specifically, the government budget constraint is:

$$\frac{D_t - D_{t-1}}{P_t} = G_t \tag{14}$$

where D_t is the level of the domestic credit portion of the money supply, P_t is the price level and G_t is the level of real government spending. The domestic money supply is $M_t = R_t + D_t$, which may be log-linearized as $m_t = (1-\theta)r_t + \theta d_t$, where r_t is the logarithm of the beginning of period stock of foreign exchange reserves held by the central bank and θ is the share of domestic credit in the monetary base.

Because the rest of the model is log-linear it is necessary to also log-linearize (14) as:

$$\theta(d_t - d_{t-1}) = c + \eta(p_t - m_t + g_t) \quad , 0 < \theta, \eta < 1 \tag{15}$$

where d_t is the logarithm of D_t, θ is the share of domestic credit in the domestic monetary base, c is a linearization constant and η is the ratio of government spending to real balances, which, in our model, is on average equal to the ratio of government spending to output.

Under fixed exchange rates the permissible rate of money creation is set equal to the domestic inflation rate which in turn must equal the foreign inflation rate. 1/ Thus, it follows that:

$$\theta(d_t - d_{t-1}) = \pi^* \tag{16}$$

1/ Other settings for the rate of domestic money printing are possible. An attractive alternative would have $\theta(d_t-d_{t-1}) = \pi^*+u_t-u_{t-1}+w_t-w_{t-1}$ which would accommodate shifts in domestic money demand. We have chosen our policy setting for simplicity.

where π^* is the foreign inflation rate (which is treated as a constant).

Substituting from equation (16) into (15) and using equation (1) obtain:

$$g_t = u_t + w_t + (\pi^* - c)/\eta , \tag{17}$$

which describes government spending under a fixed exchange rate regime. Next combining equations (13) and (17) yields:

$$\hat{g}_t - g_t = \psi(\hat{g}_{t-1} - \bar{g}) + x_t - u_t - w_t \tag{18}$$

where we have set $\bar{g} = (\pi^* - c)/\eta$.

The next step is to compute $E_{t-1}W_t(FIX)$, which is the expected value of the loss if fixed rates are adopted. Combining equation (18) with the fact that $y_t = u_t$ under fixed rates (see equation (2) above) and using the period loss function obtain:

$$E_{t-1}W_t(FIX) = \Omega + \chi\psi^2(\hat{g}_{t-1} - \bar{g})^2 \tag{19}$$

where $\Omega = (1+\chi)V(u) + \chi(V(w) + V(x))$. While we will interpret this expression below, it may be noted at this point that the expression in equation (19) is time-dependent and will vary through time due to the stochastic evolution of desired government spending.

Next consider a regime of flexible exchange rates. It is useful first to point out that the usual analysis of fixed versus flexible exchange rates requires that when flexible rates are adopted, the systematic part of the rate of money growth be determined <u>prior</u> to the realization of the state of the system. On the other hand, the analysis often requires that under fixed rates, the money supply respond to the <u>current</u> state since the state influences the demand for money. There is therefore an asymmetry in the typical treatment of monetary policy under the two regimes. 1/ In this section, we deviate from typical practice, in that under flexible rates we set the rate of domestic money creation at exactly the level required to finance the desired level of domestic government spending. In our view, this is a more symmetric treatment of the two regimes than is typical in the literature in that in both regimes, monetary policy is primarily directed toward a goal other than output stabilization.

The first setting for domestic credit growth was $d_t - d_{t-1} = \theta^{-1}\pi$, which we referred to as fixed exchange rates. The alternative setting for domestic credit growth ensures

$$g_t(\text{FLEX}) = \hat{g}_t \tag{20}$$

Under flexible rates, domestic inflation and money creation are no longer constrained by the world inflation rate, so that government expenditure is exogenous. 2/ Using (15) along with (1) to calculate the price surprise term $(E_{t-1}p_t - p_t)$ and then substituting this into the output supply function, equation (2), yields the expected value of the loss function.

$$E_{t-1}[(y_t - E_{t-1}y_t)^2](\text{FLEX}) = K^2[V(u) + \beta^2(1+\eta)^2V(w) + \beta^2\eta^2V(x)] \tag{21}$$

where $K = [1 + \beta(1+\eta)]^{-1}$. Note that since $g_t = \hat{g}_t$ under FLEX and the fixed cost is set equal to zero, the expression reported in (21) is in fact, equivalent to the expected value of the loss function, i.e., $E_{t-1}W_t$(FLEX). It may also be noted that unlike the expression for FIX (i.e., (19)), the expression in (21) contains <u>no</u> time-varying elements since desired and actual expenditures are equal.

The following additional observations relating to (14) and (21) may also be made. First, flexible rates still have an advantage in coping with supply shocks. This point follows from equations (19) and (21) since

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1/ This asymmetry occurs because a flexible rate is not a policy in the same sense as a fixed rate. Flexible rates simply set out what monetary policy is not--it is not a policy of fixing the exchange rate. See however, Aizenman and Frenkel (1985).

2/ This of course, is the point of a flexible exchange rate policy, i.e., to "free up" government spending as a tool for say, war management.

the coefficient of V(u) in (21), K^2, is less than unity while the coefficient of V(u) in (19) is $(1+\chi) > 1$. Results of comparing the loss functions are ambiguous with respect the how the two regimes cope with monetary and "fiscal" shocks, V(w) and V(x) respectively. 1/

The above comparisons, however, are static and are not the principal novel result of this section. The most interesting aspect of the comparison between equations (19) and (21) is that (19) contains a time-varying element while (21) is purely static. Specifically, the time-varying element in (19) is:

$$\chi\phi^2(\hat{g}_{t-1} - \bar{g})^2$$

which responds through time to variations in desired government spending. Disturbances to desired government spending, i.e., the x shocks, will affect this time-varying element via (18). Furthermore, high values of x shocks may lead to the formulation of a plan involving the current abandonment of fixed exchange rates until the shocks have run their course, coupled with a current plan to reimplement fixed rates in the future. This scenario would apply, for example, to a country operating on fixed rates where the fixed rate regime had a steady-state advantage in terms of the loss function, but which received a large shock to desired government spending (due perhaps, to a major event such as war).

VI. Conclusions

This paper has constructed and analyzed two separate examples that are capable of explaining two types of regime switches by policymakers. The first type is a response to a unexpected event such as upheaval in relative real to monetary variances or a sudden large change in desired government spending. The second type is the possible expected return to the prior regime. The first example uses a time-varying variance structure to generate optimal regime collapse and regeneration. In the second example, we used shocks to desired government spending, such as wars, to produce the same type of behavior. Our brief study of the empirical regularities surrounding post-World War II exchange rate regime shifts, indicates that our theory is in broad conformity with the data and that elements from both of our examples appear to be present in the actual decisions involving major shifts in exchange rate regimes.

1/ For example, a switch to fixed rates would require small coefficients on the ambiguous effects.

Estimation of Real and Monetary Shocks

Estimation of real and monetary shocks requires estimation of the behavioral functions associated with the shocks. While in the text, for purposes of exposition, we assumed stripped-down versions of standard aggregate supply and money demand behavior functions we used somewhat more elaborate specifications in the empirical work. In this appendix we will first explain our estimation of monetary shocks and the normalized-shock monetary variance and then we will explain our estimation of the real shocks and the normalized-shock real variance.

1. Estimation of monetary shocks and the monetary variance

For the United States, monetary shocks are defined as:

$$w_t = w1_t - w2_t \tag{22}$$

where w1 = innovation in money demand shock

w2 = innovation in money supply shock

For all other countries, only money demand shocks were estimated and we defined $w_t = w1_t$.

For all countries, a common money demand specification was used (with correction for first order autocorrelation). 1/ All variables are in logs.

$$m_t = a_o + a_1 p_t + a_2 y_t - a_3 i_t + a_4 m_{t-1} + v_t \tag{23}$$

$$v_t = \rho v_{t-1} + w_{1t}$$

The money supply equation for the United States was specified as:

$$\mu_t = b_o + b_1 \mu_{t-1} + b_2 \mu_{t-2} + v2_t \tag{24}$$

where $\mu_t = m_t - m_{t-1}$.

1/ Linear homogeneity was imposed on the money demand function by setting $a_1 = 1$.

It was found that $v2_t$ did not exhibit first order serial correlation so we took $v2_t = w2_t$. Coefficients and residuals in (23) were estimated using a two stage technique (with i_{t-1} and m_{t-1} as instruments for i_t and y_{t-1} and $[m-p]_{t-1}$ as instruments for y_t). Coefficients and residuals in (24) were estimated by ordinary least squares.

We treated the U.S. differently, with respect to monetary shocks, than the other countries in the G-5 since the U.S. was the center country in the Bretton Woods system during much of our sample period. The variance of money supply residuals is quite small relative to the variance of money demand residuals so that our results reported in Table 1 will, we think, be robust to a variety of money supply treatments.

The normalized monetary standard deviation is the standard deviation of the monetary shock for period t divided by the standard deviation of monetary shocks for the entire sample period.

2. Estimation of real shocks

For all countries the output function was specified as given by equation (25) and estimated using a two-step procedure:

$$x_t = c_o + c_1(p_t - E_{t-1}p_t) + c_2x_{t-1} + c_3x_{t-2} + u_t \tag{25}$$

where $x_t = (1-L)y_t$.

First, unexpected price, $p_t - E_{t-1}p_t$, was modeled as the residual in a price autoregression given by (26).

$$p_t = d_o + d_1p_{t-1} + d_2p_{t-2} + \varepsilon_t \tag{26}$$

The estimated value of these residuals, ε_t, from equation (26), were then substituted into (25) with an imposed parameter value of $c_1 = 0.3$. 1/

Ordinary least squares was applied to (25) with the constraint imposed. We included lags of y_t until there was no evidence of first order serial correlation as judged by the Durbin-Watson statistic.

1/ The value of .3 is approximately the value found by Sargent (1976) for the U.S.. His value was actually slightly higher once correction is made for labor force participation rates. We tried values of c_1 = .15 and .6 which made little difference for our results.

The normalized real standard deviation for period t was derived as the standard deviation of real shocks in period t divided by the standard deviation of real shocks over the entire sample period, J.

Database and Estimation

1. Data sources

All data originates from the IFS data base as at September 1988. Money is taken from lines 34 and 35 (money plus quasi money), interest rates from line 60c for the USA and UK, line 60b for the remaining countries (short term rates). Prices are the consumer price index, line 64. Gross national product is at fixed prices, and comes from line 99a.r for the USA, Japan, and Germany, from line 99b.p for the UK, and from 99b.r for France. Government consumption is from line 91. Logs were taken for all variables except the interest rates and government consumption. For estimation purposes, data were deseasonalized and filtered.

2. Breaks in the data

To accommodate breaks in the data due to different coverage and redefinitions, dummies were constructed and used in the regressions. In all cases these dummies assumed a value of zero before the break point and unity after the break point. A full description of the dummies and estimation results are available from the authors upon request.

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