

# ***R E V I E W***

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**Does the Exchange Rate Regime Affect  
the Economy?**

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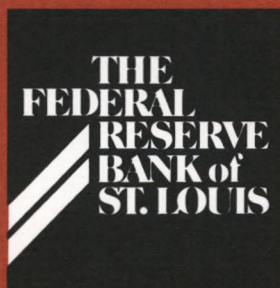
**Central Bank Independence and Economic  
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### **Does the Exchange Rate Regime Affect the Economy?**

***Terence C. Mills and Geoffrey E. Wood***

Terence C. Mills and Geoffrey E. Woods examine what makes pegged exchange rates so attractive, and consider empirically the relationship between the exchange rate regime and a number of key macroeconomic variables, such as output, prices and interest rates, to see whether any systematic relationship exists between the behavior of these variables and the exchange rate regime. They focus their study on the United Kingdom, because the U.K. experienced a wide variety of exchange rate regimes over the period covered by the data, and because Britain has not endured hyperinflation or recessions as severe as those in some other countries. Their findings support the conclusion that the exchange rate regime has not been a source of volatility for the macroeconomic performance of the British economy.

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### **Central Bank Independence and Economic Performance**

***Patricia S. Pollard***

Central bank independence is becoming popular, as evidenced by the number of countries that have recently enacted legislation removing their central banks from government control. Examining the economic rationale for this popularity, Patricia S. Pollard employs empirical studies to reveal that countries with independent central banks tend to experience low inflation with no loss of economic growth. On the other hand, theoretical studies illustrate that an independent bank may increase policy conflicts within a country, resulting in poor economic performance. Weaknesses in both types of studies, however, may limit their ability to prove or disprove the usefulness of central bank independence regarding economic performance. Pollard concludes that the relationship between central bank independence and the economy is not fully understood.

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### **Hypothesis Testing with Near-Unit Roots: The Case of Long-Run Purchasing-Power Parity**

***Michael J. Dueker***

As a principle, it has long been asserted that the quantity of goods one can buy with a given currency, such as the dollar, should be equal across countries, at least in long-run equilibrium. This condition, known as long-run purchasing power parity (PPP), has been subjected to numerous empirical tests. One source of disagreement in statistical tests of PPP has been the choice of null hypothesis: Tests whose null hypothesis is that PPP holds often fail to reject PPP, while tests whose null hypothesis is that PPP fails

often come to the opposite conclusion. Thus, there is a danger in testing only one null hypothesis for a broad set of countries, failing to reject it, and concluding that the evidence is clearly for or against PPP.

In this article, Michael J. Dueker tests post-1973 monthly data from major countries using a long-memory model. The advantage of this approach is that one can test both null hypotheses with the model and demonstrate that it is unclear whether long-run PPP holds, because real exchange rates have near-unit roots, which may preclude strong conclusions as to whether real exchange rates are mean-reverting.

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## **The Effect of Mortgage Refinancing on Money Demand and the Monetary Aggregates**

**Richard G. Anderson**

During the last two years, lower interest rates have stimulated extensive refunding of long-term debt, sharply increasing the relative volume of financial transactions. Mortgage refinancing has been a highly visible part of those transactions. Richard G. Anderson examines the effect of recent waves of mortgage refinancing on the demand for liquid deposits and growth of the monetary aggregates.

Mortgage servicers may hold unscheduled principal payments received following a refinancing in liquid deposits as long as six weeks prior to remittance to the investors who own the underlying mortgage-backed securities. In addition, the growth of other checkable deposits also appears to have been affected by fluctuations in mortgage refinancing, perhaps because of households converting home equity to cash. The persistence of these increased demands for liquid balances illustrates that all transactions are not completed instantaneously, as is implicitly assumed. Anderson finds that the increased mortgage refinancing accounts for a great deal of the volatility of M1's growth during the last two years, although not for its continued strong underlying trend.

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**Terence C. Mills and Geoffrey E. Wood**

*Terence C. Mills is a professor at the University of Hull. Geoffrey E. Wood, a professor at City University Business School in London, was a visiting scholar at the Federal Reserve Bank of St. Louis. Kevin White provided research assistance. The authors would also like to thank Mervyn King and Paul Mizon for their helpful comments.*

## ***Does the Exchange Rate Regime Affect the Economy?***

**I**T SEEMS TO BE a general rule that countries wish to peg their exchange rates but sometimes have floating rates thrust upon them. On three occasions during the twentieth century—the breakup of the international gold standard in the 1930s, the breakup of the Bretton Woods system in the 1970s and most recently the exodus of countries (notably Britain) from the exchange rate mechanism (ERM) of the European Economic Community (EEC)—external pressures led to the demise of fixed rate schemes and their replacement by some degree of exchange rate flexibility. In each case, the passing of the fixed rate scheme was mourned and within relatively short periods a new fixed rate plan was advanced to replace its fallen predecessor. In view of these failures, however, it is reasonable to ask: What makes pegged exchange rates so attractive?

Recently, in the context of the ERM, two arguments have been advanced. Exchange rate fixity is, as David Hume described in 1752, a way of importing another country's monetary policy.<sup>1</sup> In the case of the ERM, the deutsche mark served as the system's anchor currency, and

Germany's low inflation rate was supposed to spread throughout the EEC. Moreover, the ERM's member nations believed that the Bundesbank's reputation would provide some credibility to the anti-inflation commitment of other central banks and therefore reduce the costs of lowering inflation throughout the EEC. A second motive for adopting fixed exchange rates has been the claim that they, and ultimately a single currency, are important to the EEC's Single Market Programme.<sup>2</sup> The logic is that the full benefits that could accrue from the free intra-European movement of goods, labor and capital will be realized only with a fixed exchange rate regime.<sup>3</sup> A third argument, not emphasized recently but important on earlier occasions, is that economic performance—growth, inflation or any other important measure—is better under a fixed exchange rate system.<sup>4</sup> This third argument differs from the second in that it identifies no specific causal chain from exchange rate regime to economic performance.

But does the exchange rate regime matter for economic performance? That is the question

<sup>1</sup>See Hume (1970).

<sup>2</sup>We do not consider whether a single currency really is a natural development of fixed exchange rates.

<sup>3</sup>This argument usually takes as axiomatic that trade creation will outweigh trade diversion.

<sup>4</sup>This was an important motivation for Britain's return to the gold standard in 1925, for example.



addressed in this paper. We examine empirically the relationship between the exchange rate regime and a number of key macroeconomic variables to see whether any systematic relationship exists between the behavior of these variables and the exchange rate regime. We have chosen to investigate this question for the United Kingdom because data over long periods are available for the variables we wish to examine and because the United Kingdom experienced a wide variety of exchange rate regimes over the period covered by these data.

## TRADE AND THE EXCHANGE RATE REGIME

The claim that exchange rate flexibility hampers international trade in goods and in capital and thus depresses welfare and perhaps growth is based on the existence of uncertainty.

It is argued that removing the possibility of exchange rate change will remove an important nontariff barrier, because the possibility of exchange rate changes will deter some traders and investors altogether, whereas others will have to pay a substantial cost to fix the domestic value of their foreign currency receipts. Floating exchange rates, in other words, are believed to impose additional volatility, and hence costs, on international markets. If this is correct, a case for pegged exchange rates exists, and the case is particularly strong for any group of countries (such as the EEC) that wants to encourage mutual international trade and investment.

The proposition seems unexceptional, and for a number of years studies supported the proposition. For example, Cushman (1983) and deGrauwe and deBellefroid (1987), which are representative of the early literature, found that floating rates did impede trade. But as time passed, an increasing number of studies supported it.<sup>5</sup>

By the early 1990s, not only had evidence shifted to support the notion that floating exchange rates do not impede trade, but Feldstein (1992) even went so far as to suggest that float-

ing rates are more favorable to trade than are fixed rates.<sup>6</sup> Attention is thus directed to other reasons for favoring pegged exchange rates.

There are two rather distinct types of effects of exchange rate fixing. The first arises because if a fixed exchange rate is in place, it is unlikely to stay fixed without policy actions. These can take several forms. Most common are foreign exchange intervention and short-term interest rate manipulation. Accurate figures on official intervention or the stock of foreign exchange reserves are not always available. Interest rate figures, however, are available, and several authors have found that unpredictable interest rate variability increased after exchange rates are pegged.<sup>7</sup> These actions in turn make money growth more volatile, and this can have important consequences for the economy. It may create additional uncertainty about the future behavior of the price level and thus about real rates of return, which would affect investment. If future prices were uncertain, wage bargaining would be more complex because it would be harder to judge the future purchasing power of an agreed money wage. This uncertainty would also affect nominal variables. Risk-averse investors would be more reluctant to buy government bonds because they would be uncertain what the coupons would be worth and what the capital would be worth at maturity. This would raise nominal interest rates, the cost of debt service and thus the taxes necessary to service the debt. All these factors could have an adverse effect on long-term growth, depressing its trend.

In summary, the choice of exchange rate regime could affect the long-run behavior of the economy, influencing trends or cycles in important macroeconomic variables.

If the choice of exchange rate regime does not have these long-run consequences, then in terms of macroeconomic effects, all that the choice of exchange rate regime does is shift the distribution of short-run fluctuations from one market to another. This is the second type of effect noted above.

The question we examine is whether any as-

<sup>5</sup>Examples of these studies are Gotur (1985); the IMF's (1984) extension of Cushman (1983) to cover the bilateral trade of the seven largest industrial countries; Bryant (1987), Bailey, Tavlas and Ulan (1986 and 1987), Bailey and Tavlas (1988) and Ascheim, Bailey and Tavlas (1987).

<sup>6</sup>Haberler (1986) suggested the same thing some years earlier.

<sup>7</sup>See Batchelor and Wood (1982), Wood (1983) and Belongia (1988). Wood and Belongia's research was conducted in the context of the ERM. In Wood (1983) there was an exception to this—Eire (South Ireland) after it joined the ERM. Unpredictable interest rate variability fell in that country, although it increased in every other ERM member country.



sociation exists between the exchange rate regime and the trend or cyclical behavior of some key macroeconomic variables—in other words, whether there is any evidence for the first type of effect. If no such association exists, then the only macroeconomic consequence of the choice of exchange rate regime is the change in the distribution of short-term volatility between the foreign exchange market and the short-term money markets. If, in contrast, such an association exists, then the choice of exchange rate regime may be a macroeconomic policy decision of considerable importance for national well-being.<sup>8</sup>

It is now appropriate to present the data we use for exploring this question. We then examine the properties of those data in light of the preceding discussion.

## THE STOCHASTIC PROPERTIES OF U.K. MACROECONOMIC SERIES ACROSS EXCHANGE RATE REGIMES

In this section we consider the stochastic properties of five major U.K. macroeconomic series since the mid-nineteenth century. The exchange rate regimes since then have encompassed every possible type except the crawling peg. Until 1914, the United Kingdom was on the gold standard. That was suspended (that is, the United Kingdom left the standard but with the declared intention of returning) at the outbreak of World War I in 1914. After the war, the United Kingdom implemented a deliberate, discussed and announced policy of a return to the gold standard at the prewar parity. Monetary policy and foreign exchange intervention were used to this end, and the policy succeeded in 1925. The United Kingdom left the gold standard in 1931, however, and the exchange rate floated with varying degrees of intervention until the outbreak of World War II in 1939.<sup>9</sup> The rate was then pegged to the U.S. dollar. After

the war, the United Kingdom joined the Bretton Woods system. Several sterling devaluations occurred under Bretton Woods, but sterling did not finally float until 1972. Again, there were varying degrees of intervention under this regime of dirty floating, but the United Kingdom did not formally peg sterling until it joined the ERM in 1990 after shadowing the deutsche mark in 1988 and 1989. The United Kingdom subsequently left the ERM in 1992 to float once more. The series we examine across these various regimes are output, prices, money, and short- and long-term interest rates.

Our particular interest, and the focus of the empirical work that follows, is the trend and the cycle in output and prices primarily, but also in money and interest rates. We look to see how these variables have behaved over our close to a century-and-a-quarter of data, seeking changes in trend and changes in cyclical pattern. When these are identified, we examine whether any of these changes are associated with exchange rate regime changes and, if so, consider why this might be.

### Output

Annual output in the United Kingdom (measured in logarithms) over the period 1855–1990 is shown in figure 1. Detailed econometric analyses of this series in Mills (1991) and Mills and Wood (1993) show that it can be represented as the sum of a segmented linear trend, with breaks at 1918 and 1921 and a stationary, autoregressive, cyclical component.<sup>10</sup> Thus these results indicate that if output can be decomposed as  $y_t = \mu_t + n_t$ , then the trend function  $\mu_t$  is

$$(1) \mu_t = \alpha + Bt + \lambda_1 D_{1t} + \lambda_2 D_{2t},$$

where  $D_{it} = (t - T_i)$  if  $t > T_i$  and zero otherwise. The identified breakpoints are at  $T_1 = 64$  and  $T_2 = 67$ , which coincide with 1918 and 1921. The cyclical component,  $n_t$ , on the other hand, is found to be adequately modeled as an AR(2)

<sup>8</sup>It is, of course, possible that the exchange rate regime is a product of the behavior of the economy; it need not be an exogenous choice.

<sup>9</sup>For a review and evaluation of explanations that have been advanced to explain the United Kingdom's abandonment of the gold standard, see Capie, Mills and Wood (1986a).

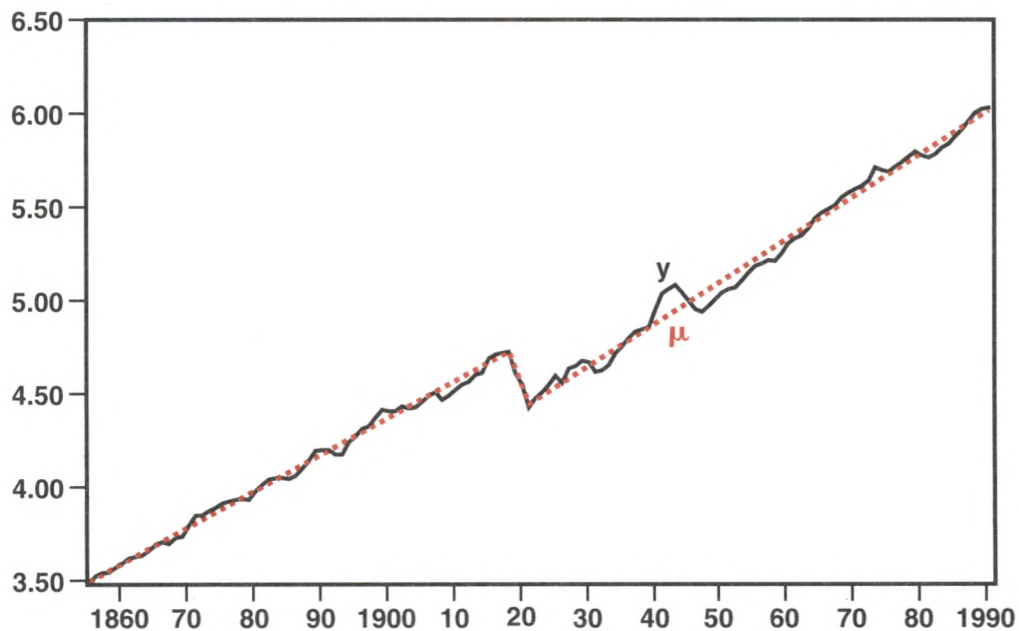
<sup>10</sup>Testing for stationarity has no *direct* economic significance. Rather, it lets us separate the cycle from the trend. The notion is that the trend and the cycle are economically

separate. The cycle comprises fluctuations about a horizontal average; growth is all in the trend. This separation is consistent with most views of the cycle, but it should be noted that some scholars see the cycle as an integral part of the growth process. For an example, see Schumpeter (1950).



Figure 1  
Annual U.K. Output (1855-1990)

Logarithms



process, leading to the fitted model (standard errors shown in parentheses),

$$(2) Y_t = 3.474 + 0.0196t - 0.1137D_{1t} + 0.1170D_{2t} + n_t$$

$$(0.026) \quad (0.0007) \quad (0.0103) \quad (0.0101)$$

$$n_t = 1.099n_{t-1} - 0.346n_{t-2} + a_t$$

$$(0.083) \quad (0.083)$$

This model has some simple properties. Trend growth is 1.96 percent per year until 1919 and 2.29 percent per year from 1922 on, with the level of trend output falling 28.3 percent in the intervening three years. The component  $n_t$  implies that output exhibits stationary cyclical fluctuations around the trend growth path, with cycles averaging 8.1 years. The residual standard error of the equation is 2.33 percent.

The trend component is shown superimposed

on the output series in figure 1, and we thus conclude that, apart from the three years immediately after World War I, during which the series fell dramatically, the stochastic process generating output has remained remarkably stable. Output is a trend stationary process, irrespective of the exchange rate regime in force.

### Prices

Figures 2 and 3 present plots of the (logarithmic) U.K. price level annually from 1870 to 1990 and monthly from January 1922 to May 1992, respectively, excluding the war years from 1940 to 1945. Unit root tests, calculated over various sample periods, provide little or no evidence against the hypothesis that prices are difference stationary, that is,  $I(1)$ .<sup>11</sup> The post-1973 era may differ and is discussed later.

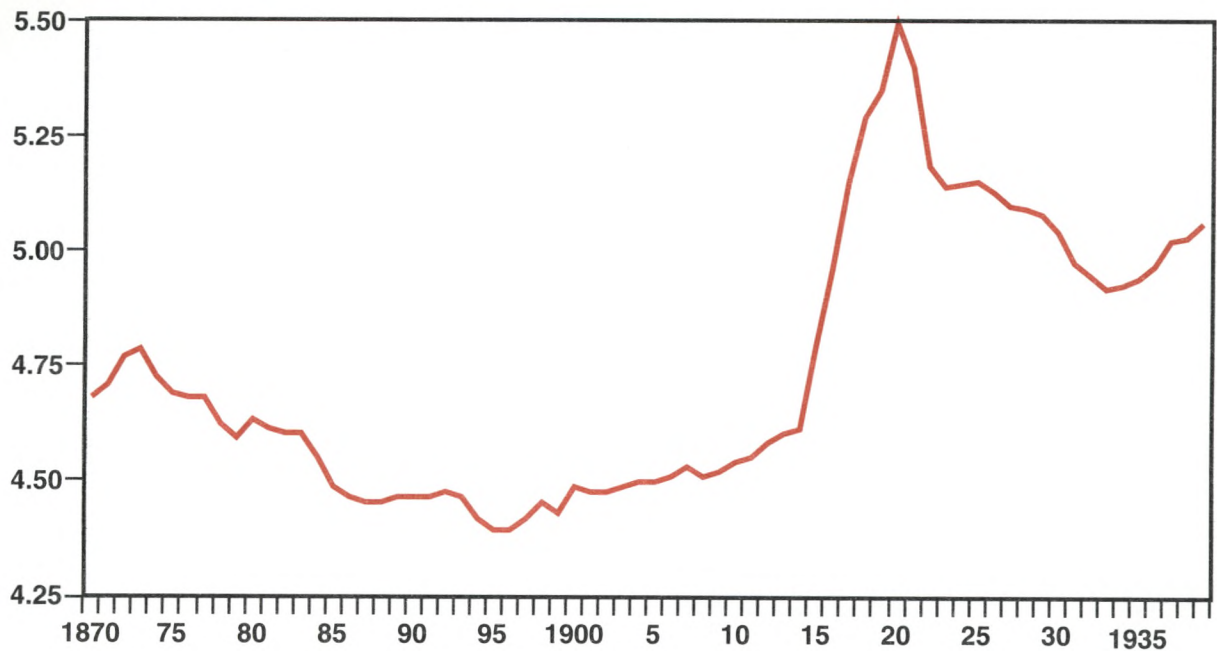
Two aspects of price behavior are worth fur-

<sup>11</sup>Details of these tests and similar tests for the other series investigated are reported in Mills and Wood (1993).



Figure 2  
Annual U.K. Price Level (1870-1939)

Logarithms



Annual U.K. Price Level (1946-1990)

Logarithms

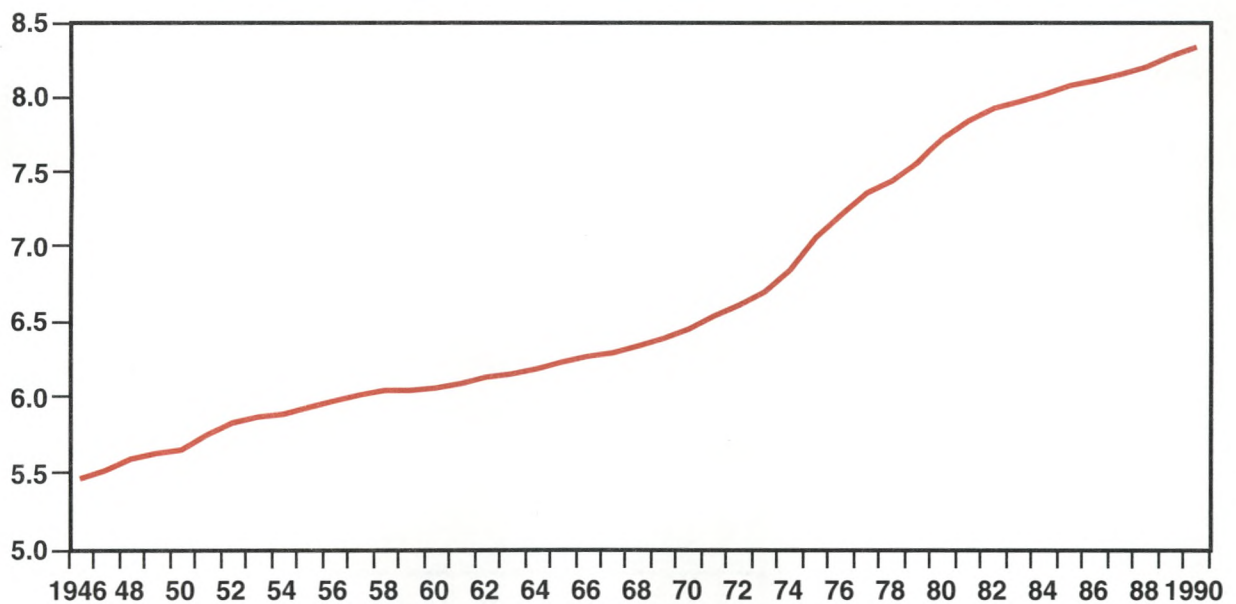
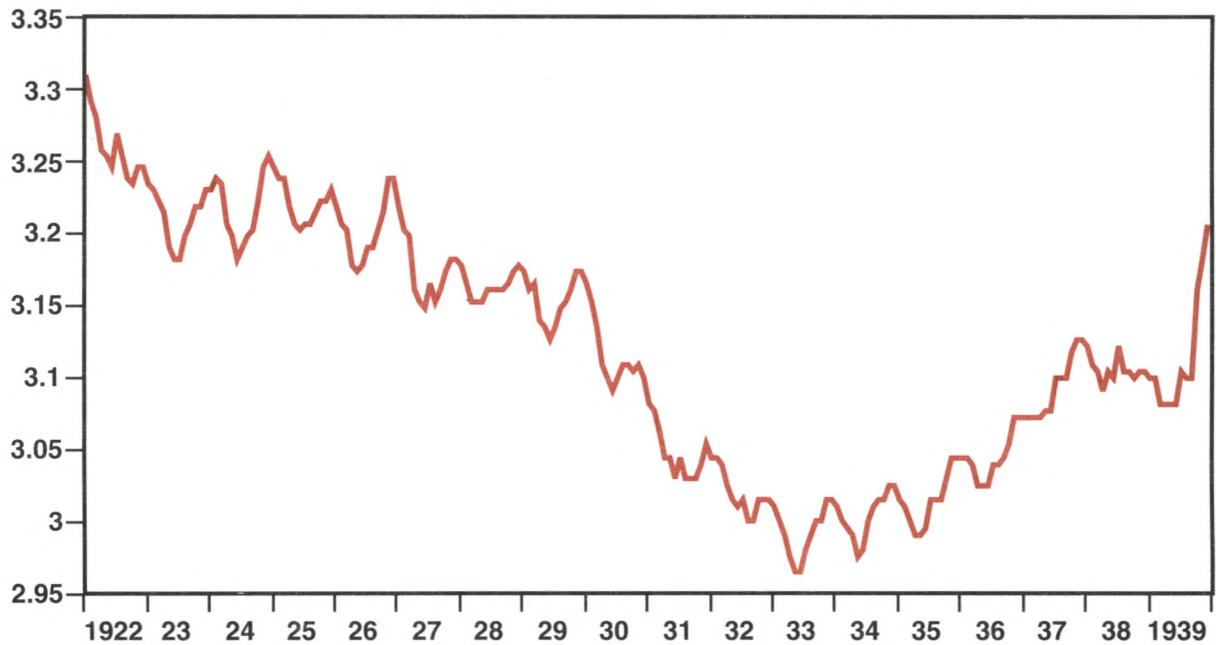




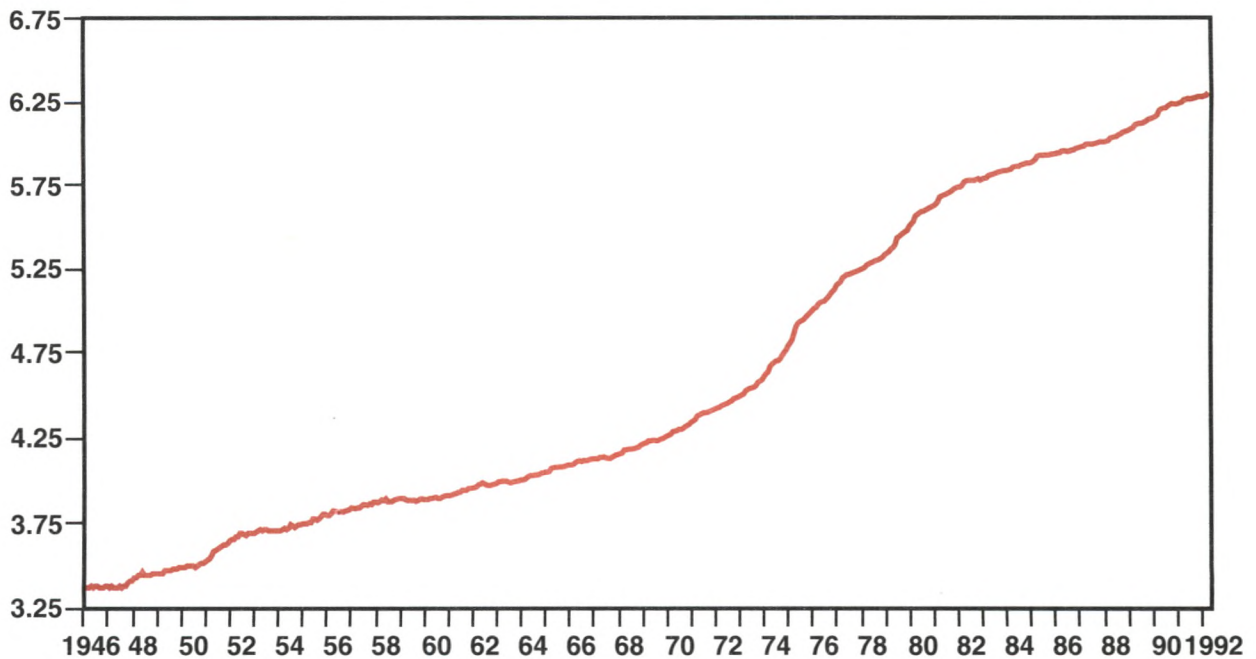
Figure 3  
U.K. Price Level (1922-1939)

Logarithms



U.K. Price Level (1946-1992)

Logarithms





ther investigation. The first is the behavior of the price level before the United Kingdom abandoned the gold standard in 1931. Mills (1990) analyzes the long gold standard period from 1729 to 1931 and obtains an estimate of the largest autoregressive root of 0.93, identical to that obtained for the shorter sample beginning in 1870. The corresponding unit root test, though, rejects the unit root null hypothesis at the 5 percent significance level, and the process found to generate the price level (an autoregression of order two) yields cycles of around 50 years, close to the long swings thought to have characterized prices during this period.<sup>12</sup>

The second aspect concerns the post-1946 behavior of prices. Figures 2 and 3 show the series to have undergone slope changes around 1973 and 1983; possible explanations for these are discussed in the next paragraph and in the Interpretation and Conclusions section. Statistically, this behavior is typical of an  $I(2)$  process, and repeating the unit root tests for the (logarithmic) price changes, that is, for inflation, yields some evidence that postwar prices can be modeled as an  $I(2)$  process (evidence that inflation is nonstationary), particularly for the post-Bretton Woods era beginning in 1973.

The results are therefore suggestive of the U.K. price level undergoing two shifts in its generating process. The first might be associated with the abandonment of the gold standard, shifting the series from  $I(0)$  to an  $I(1)$  process. (From figure 3 it is in fact clear that prices did not start a secular increase until mid-1933, some two years after the move from the gold standard.)<sup>13</sup> A stable price level is certainly in accordance with what would be expected under the gold standard (or, in principle, any commodity standard). There were fluctuations in the supply of gold, but in countries such as the United Kingdom, which had developed and stable banking systems, these fluctuations had only modest price level effects. The system was to some extent self-stabilizing. If prices were falling (the value of money rising) because the supply of gold was falling short of demand, there was an incentive to produce more gold. And if prices were rising (the value of money falling), then as the costs of gold production rose relative to what the monetary authorities would pay for

gold, the incentive to produce gold would diminish.<sup>14</sup> The second shift is around 1973 and could be associated with both the move to floating exchange rates and the first oil price shock.

## Money

Figure 4 plots annual observations of the logarithms of M3 from 1871 to 1912 (the only aggregate apart from the monetary base available for this period), and figure 5 plots monthly observations of M3 from 1922 to 1989, excluding the war years. From a battery of unit root tests, we found that, for all sample periods investigated, the null hypothesis of a unit root cannot be rejected. Moreover, the series is indeed  $I(1)$  because we could not establish that further differencing was required for stationarity.

## Interest Rates

Figures 6 through 8 plot monthly observations of short- and long-term interest rates from 1870 to 1992, excluding war years and related periods of interest rate restrictions.

From the results of unit root tests, we find that since the lifting of restrictions after World War II both short- and long-term interest rates have been  $I(1)$  processes, but their behavior before 1939 is rather different. Both are stationary between 1932 and 1939, but during the 1920s long-term rates are stationary ( $I(0)$ ) and short-term rates are  $I(1)$ , whereas before 1914 the orders of integration are reversed.<sup>15</sup>

## Trend and Cycle Decompositions

Has the variability about trend of the series altered across regimes? This is an important question because of the widespread belief that floating exchange rates increase volatility in prices, interest rates, and economic activity and are in some general sense destabilizing. To answer this question, we need to decompose each series into trend and cycle components. There are many ways to do this, ranging from using a predetermined moving average to calculate trend to designing a signal extraction filter based on the stochastic process generating the data and a set of assumptions relating to the behavior of the unobserved components.

<sup>12</sup>See Cagan (1984) for an extended discussion of this view.

<sup>13</sup>See the discussion in Capie, Mills and Wood (1986a).

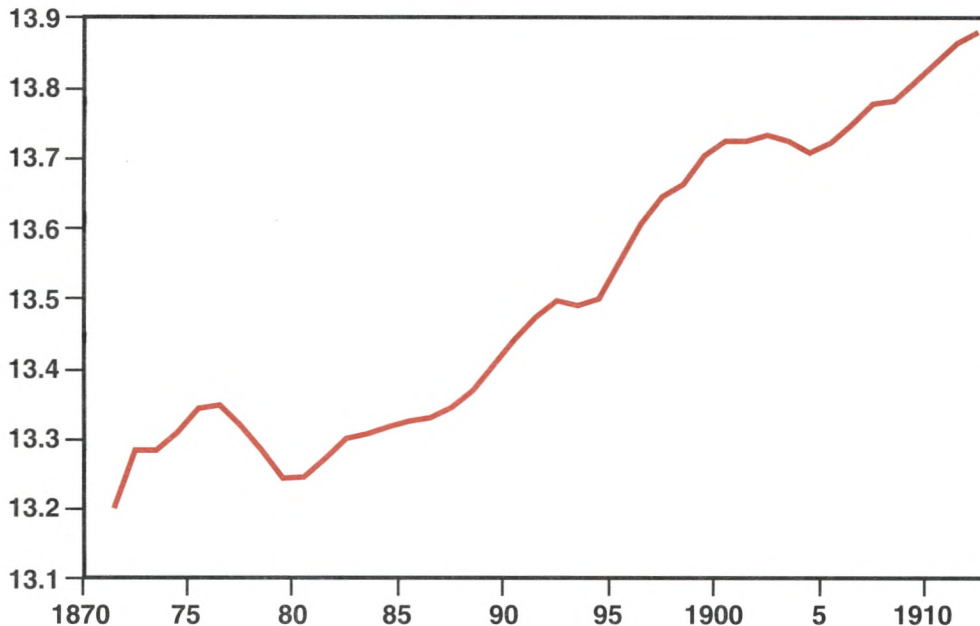
<sup>14</sup>See Barro (1979) and Rockoff (1984) for a discussion of this.

<sup>15</sup>Capie, Mills and Wood (1986b) provides an extended discussion of the behavior of these two interest rate series in relation to the Stock Conversion of 1932.



Figure 4  
Annual U. K. Money Supply: M3 (1871-1912)

Logarithms



For output, equation (1) provides the appropriate decomposition. Table 1 thus reports the standard deviations of the cyclical component  $n_t$  for a variety of sample periods. The sample periods shown were chosen by two quite distinct criteria—output trend change and exchange rate regime alteration. The 1922 break was used because after the 1919–22 discontinuity, output resumed a new trend, 1855–1913 were gold standard years, and 1925–31 were years during which the United Kingdom was either on or committed to returning to the gold standard. The period comprising 1855–1913 and 1922–31 is the same period omitting war and the postwar years of the break in output's trend. The period 1922–31 has a stable output trend combined with commitment to gold; the period 1922–39 has a stable output trend with a change in exchange rate regime. The period 1932–90 is our whole sample period after gold. The years 1932–39 and 1946–90 are, of course, the same period excluding the World War II years. The period 1946–90 is simply postwar; 1946–72 is Bretton Woods; and 1973–90 is the period of various degrees of float. (Further subdivision of the series to examine the association

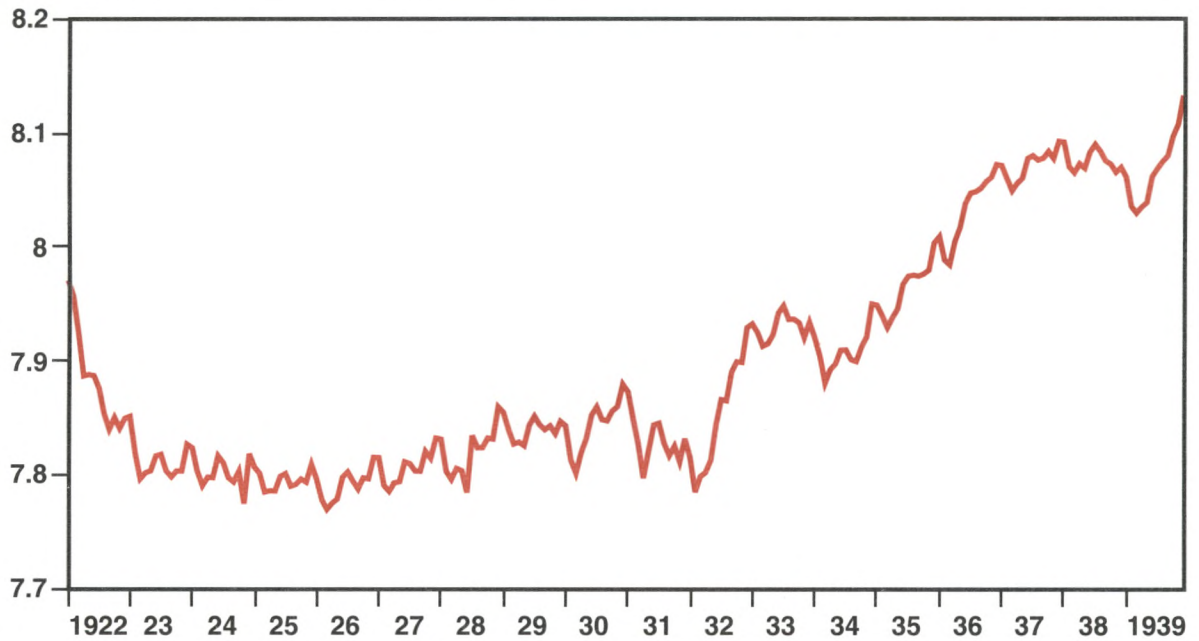
with various exchange rate regimes more minutely, although appealing, is ruled out by many of these regimes having too few output observations for our statistical techniques.) From all these statistics, one gets the impression that variability about trend has increased during the twentieth century. In particular, the abandonment of the gold standard in 1931 seems to have been accompanied by an increased variability of output about trend, even after the war years are excluded. In summary, the standard deviation almost doubled (from 2.87 percent to 5.49 percent) after 1931. But it should be noted that variability fell after the pound floated in 1972. From 1946 to 1972 the standard deviation was 4.45 percent; from 1973 to 1990 it was 3.64 percent.

For the other series, we have presented evidence of shifts in the stochastic processes generating them, so signal extraction techniques would be rather difficult to apply. We have chosen therefore to use a technique that has proved popular in recent years for re-examining the stylized facts of macroeconomic time series, namely the detrending filter proposed for use in economics by Hodrick and Prescott and used,



Figure 5  
U.K. Money Supply: M3 (1922-1939)

Logarithms



U.K. Money Supply: M3 (1946-1989)

Logarithms

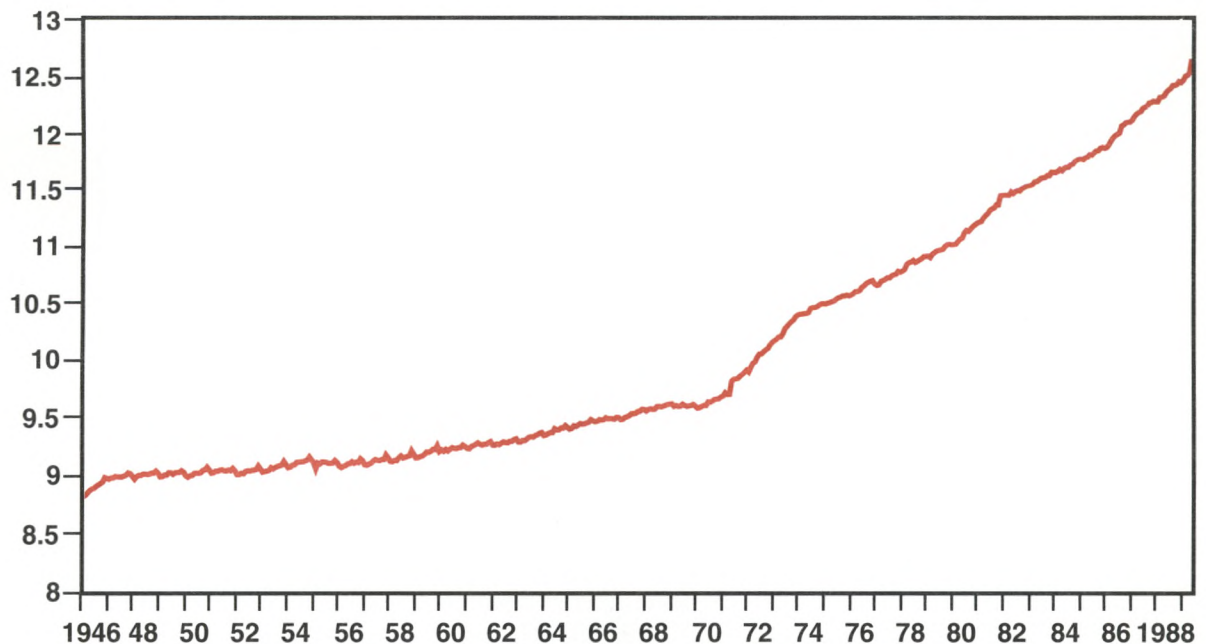




Figure 6  
U.K. Interest Rates (1870-1913)

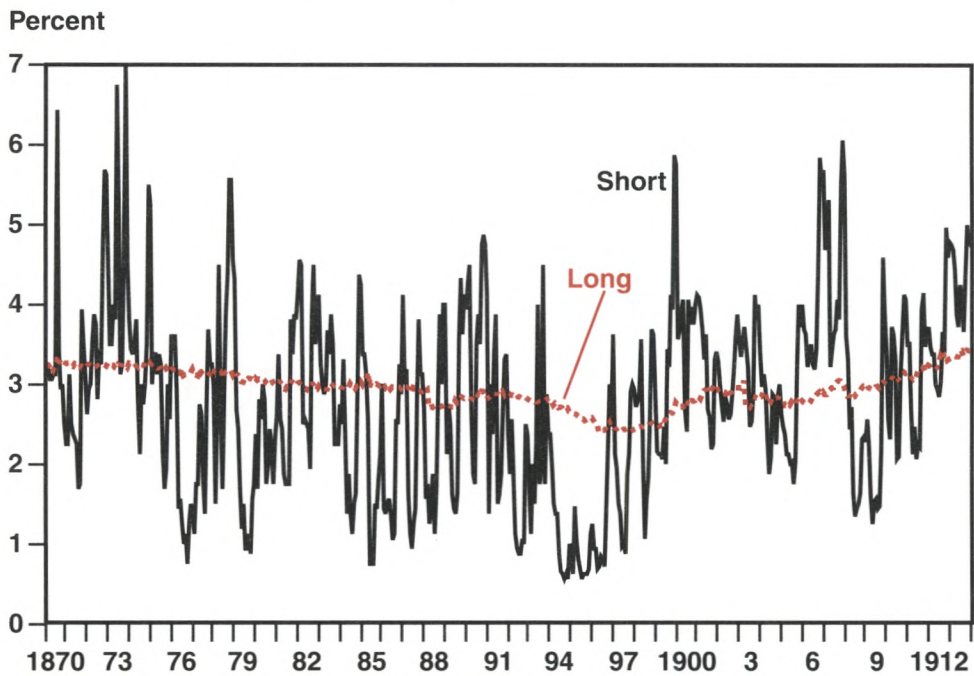


Figure 7  
U.K. Interest Rates (1922-1939)

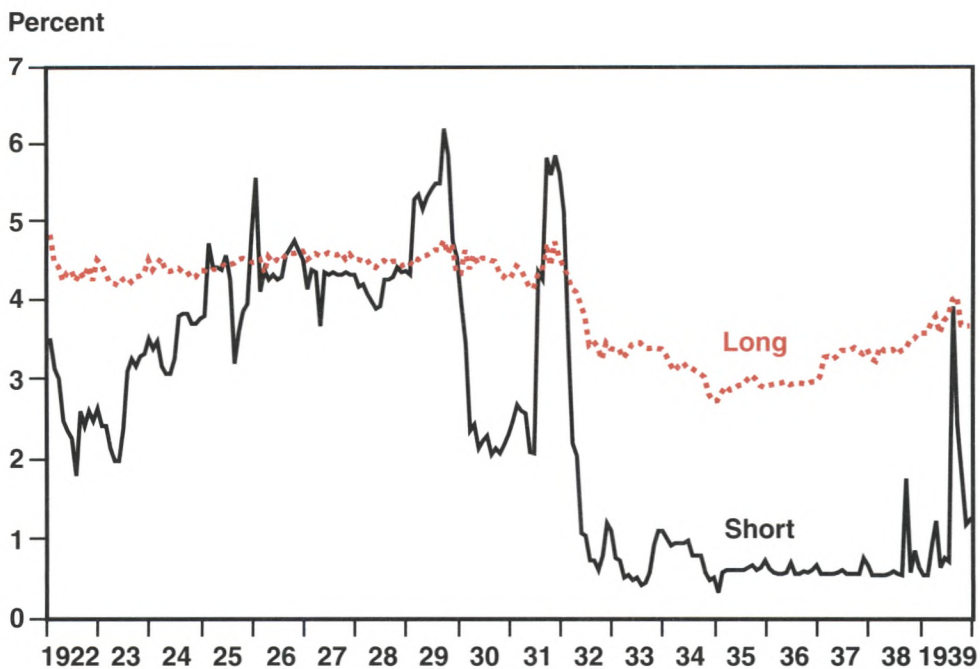
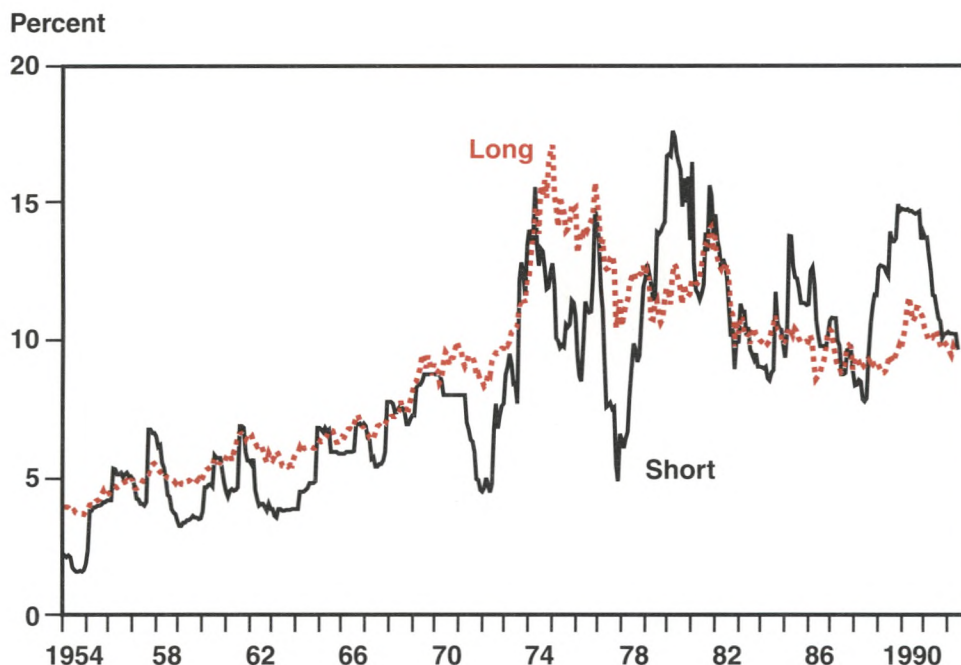


Figure 8  
U.K. Interest Rates (1954-1992)



for example, in Kydland and Prescott.<sup>16</sup> This is an alternative to the method used earlier in the paper for separating a series into trend and cycle. It is described in the appendix, which also contains a summary of when this method is appropriate and when it may be misleading.

Tables 2 through 5 report statistics assessing the variability of the trend and cycle components of the price level, money supply and short- and long-interest rates, and figures 9 through 12 present graphs for these components. Although these tables report results from the examination of monthly data, the breakpoints are at year ends except for 1992, whose data end with June.

This choice of breakpoints reflects two considerations. The first relates to when an exchange rate regime changed. Does *change* for our purposes relate to when the change was formally announced or to when it became expected and affected behavior? The latter is the more significant, but it is not clear *a priori*

when it would be. Nor as it turns out does detailed examination of the data case by case give clear-cut answers.<sup>17</sup> Accordingly, the simple expedient of using calendar years as breakpoints was adopted, on the grounds that using other dates close to these would not change the results.

For the interwar years, the trend of the price level was relatively flat, with a slow decline until 1933 and an upward drift thereafter. The cyclical component, in contrast, is relatively volatile, no doubt, in view of the unchanged behavior of money, reflecting the changes in exchange rate policy in the United Kingdom, as well as the disturbed external environment. Not only did the interwar years include the Great Depression in the United States, with the associated severely depressing effects on the prices of commodities, but in continental Europe there were inflations—hyperinflations in some cases—civil war and revolutions. Meanwhile Britain's exchange rate regime was changing rapidly. Between 1919 and 1925 there was a

<sup>16</sup>See Hodrick and Prescott (1980) and Kydland and Prescott (1990).

<sup>17</sup>See Mills and Wood (1993). For a subset covering the years 1870–1939, see Capie and Wood (forthcoming).



Table 1

**Variability of the Cyclical Component of Output**

Period	Standard Deviation
1855-1913	2.69
1855-1931	2.87
1855-1913 and 1922-1931	2.95
1922-1931	3.45
1922-1939	3.93
1932-1939	3.58
1932-1990	5.49
1932-1939 and 1946-1990	4.27
1946-1990	4.42
1946-1972	4.45
1973-1990	3.64

Table 2

**Component Variability of Prices**

	$\bar{x}$	$s_x$	$s_T$	$s_C$
1922.01-1939.12	3.12	0.09	0.09	0.02
1946.01-1992.05	4.60	0.94	0.94	0.01
1946.01-1972.12	3.88	0.30	0.30	0.01
1973.01-1992.05	5.61	0.51	0.51	0.01

 $\bar{x}$ : sample mean $s_x$ : sample standard deviation $s_T$ : sample standard deviation of trend component $s_C$ : sample standard deviation of cycle component

commitment to return to gold at the prewar parity, and the exchange rate rose steadily toward that. Gold was abandoned in 1931, and the exchange rate thereafter floated with various degrees of intervention until the outbreak of war in 1939.

After 1946, the trend is smooth and monotonic, and the cyclical component is less volatile than before. Trend money is rather similar to trend prices. Its variability is stable throughout the sample period, supporting the suggestion that external factors were important in interwar price volatility.

Pre-1914 trend interest rates fluctuate around

Table 3

**Component Variability of Money**

	$\bar{x}$	$s_x$	$s_T$	$s_C$
1922.01-1939.12	7.90	0.10	0.10	0.02
1946.01-1992.05	10.04	1.08	1.08	0.02
1946.01-1972.12	9.27	0.27	0.27	0.02
1973.01-1989.06	11.29	0.67	0.67	0.02

 $\bar{x}$ : sample mean $s_x$ : sample standard deviation $s_T$ : sample standard deviation of trend component $s_C$ : sample standard deviation of cycle component

Table 4

**Component Variability of Short-Term Interest Rates**

	$\bar{x}$	$s_x$	$s_T$	$s_C$
1870.01-1913.12	2.79	1.21	0.77	0.84
1922.01-1931.12	3.75	1.07	0.68	0.76
1932.01-1939.12	0.86	0.71	0.51	0.53
1954.01-1972.12	5.42	1.76	1.54	0.66
1973.01-1992.04	11.43	2.44	1.84	1.22

 $\bar{x}$ : sample mean $s_x$ : sample standard deviation $s_T$ : sample standard deviation of trend component $s_C$ : sample standard deviation of cycle component

3 percent, although the far greater stability of long-term rates is reflected in the almost constant components of this series relative to short-term rates.<sup>18</sup> Volatility is indeed fairly stable until 1972, after which both trend and cycle components became considerably more variable.

## INTERPRETATION AND CONCLUSIONS

When discussing the preceding findings, it is convenient to consider the trend and cyclical behavior of each series together. We start with output. As noted previously, the trend growth

<sup>18</sup>We have noted this result in a series of previous papers. Mills and Wood (1982) suggested it was due to the stable price expectations provided by the gold standard. Mills

and Wood (1992) was unable to reject this hypothesis after exhaustive testing.



**Table 5**  
**Component Variability of Long-Term Interest Rates**

	$\bar{x}$	$s_x$	$s_T$	$s_C$
1870.01–1913.12	2.94	0.23	0.22	0.04
1922.01–1931.12	4.45	0.13	0.11	0.13
1932.01–1939.12	3.31	0.35	0.31	0.14
1954.01–1972.12	6.35	1.71	1.67	0.24
1973.01–1992.04	11.32	1.91	1.74	0.61

$\bar{x}$ : sample mean

$s_x$ : sample standard deviation

$s_T$ : sample standard deviation of trend component

$s_C$ : sample standard deviation of cycle component

of output changed from 1.96 percent per year to 2.29 percent per year between 1919 and 1922. Speculating on what produced that welcome change is outside the scope of this paper. What we would note is the stability of the post-1922 trend in the face of a wide variety of monetary experiences and exchange rate regimes, a finding clearly consistent with the long-run neutrality of money.

In contrast to that long-run neutrality, the cyclical behavior was affected. The variability of output rose substantially with the abandonment of the gold standard. The significance of this is discussed later.

Turning now to prices, what do we find? The first notable feature is the essentially flat trend, with long swings around it, under the gold standard. More dramatic and equally revealing about the nature of the monetary regime is the post-1946 period. The trend of prices was positive after 1946, accelerated sharply around 1973 and slowed around 1983. The United Kingdom went to a floating exchange rate in 1972, but at around the same time there was also the first oil price shock and the Heath-Barber monetary expansion. That the acceleration of prices was the result of these factors rather than the new exchange rate system is suggested by the slowing of prices around 1983, when the United

Kingdom was still under a floating rate regime but had a government strongly committed to reducing inflation by introducing money supply targets and a commitment to budget balance over the cycle.<sup>19</sup> The cyclical component of prices became much smoother and was unaffected by the exchange rate regime; its variability was unchanged from 1946 to 1992 and identical over subperiods and the period as a whole.

And finally, interest rates. The striking contrast is between the behavior in the pre-World War II period, when long-term rates were stable and short-term rates were volatile, an observation usually interpreted as reflecting expectations of long-run price level stability and behavior in the post-1972 period, when inflation first accelerated and then slowed, and both interest rate series displayed markedly increased variability.<sup>20</sup>

How do these findings as a whole bear on the hypothesis that the exchange rate regime is not a source of volatility? They support it. Of the variety of exchange rate regimes after 1913 (we turn to the gold standard in a moment), none seemed to increase the volatility of any series examined to any significant extent. The policy changes necessary to hold rates pegged may have appeared in foreign exchange reserves, a series that we did not examine because reliable data were not available. The policy changes did appear in movements that had higher frequencies than the trends and cycles we isolate.<sup>21</sup> Interest rate cyclical variability did increase with the move to floating exchange rates in 1972, but there are numerous other factors to explain this. Shocks to the price of oil disturbed financial markets very substantially in this period. Two other shocks were superimposed on the oil price shocks. There was a commitment to reduce inflation—particularly after 1979. What this meant in terms of the operation of monetary policy was unknown, so the commitment increased uncertainty for a time. And further, monetary targets were adopted. These affected how the authorities used short-term interest rates; and as commitment to monetary targets

<sup>19</sup>The role of the exchange rate regime in the 1970s episode is also discussed in Williamson and Wood (1976). The conclusion that the exchange rate regime was not at fault was also, by different means, argued there.

<sup>20</sup>See Mills and Wood (1982). Fisher (1930), Friedman and Schwartz (1982), and Mills and Wood (1992). All have ex-

planations of the Gibson paradox that depend on slow-moving price expectations.

<sup>21</sup>See Batchelor and Wood (1982), Wood (1983) and Belongia (1988).



Figure 9  
Price Level Trend and Cycle (1922-1992)

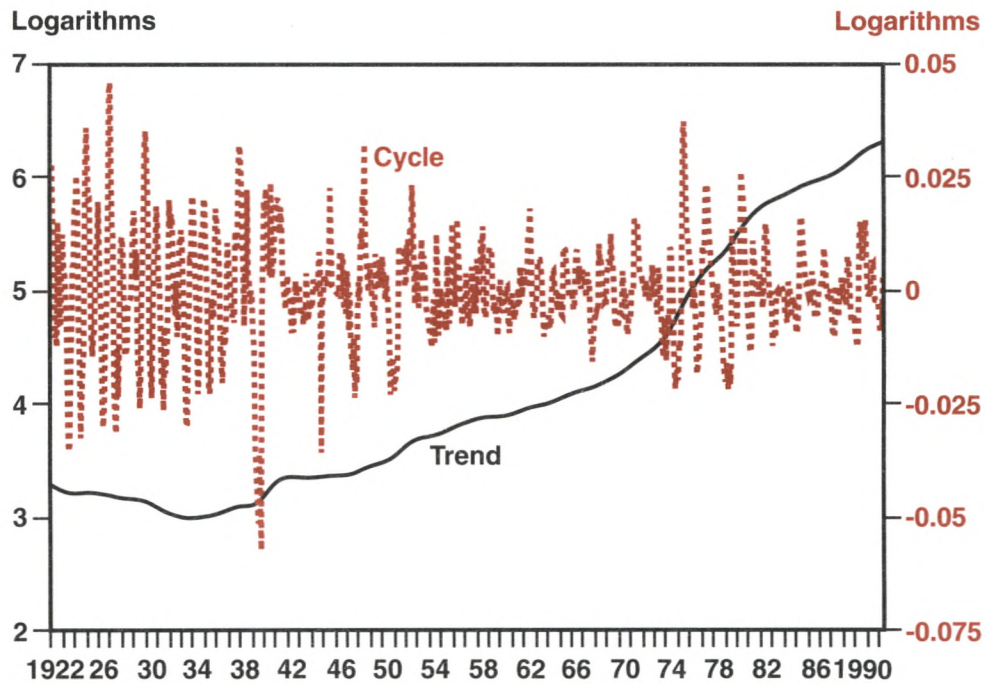


Figure 10  
Money Supply: M3 Trend and Cycle (1922-1989)

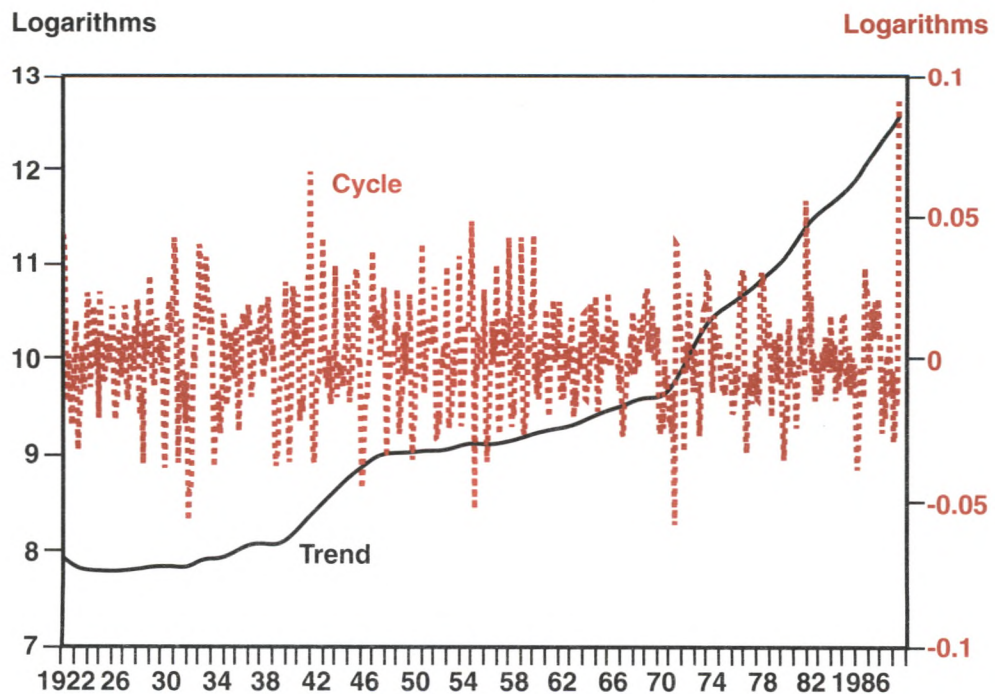


Figure 11  
Short Interest Rate Trend and Cycle (1870-1992)

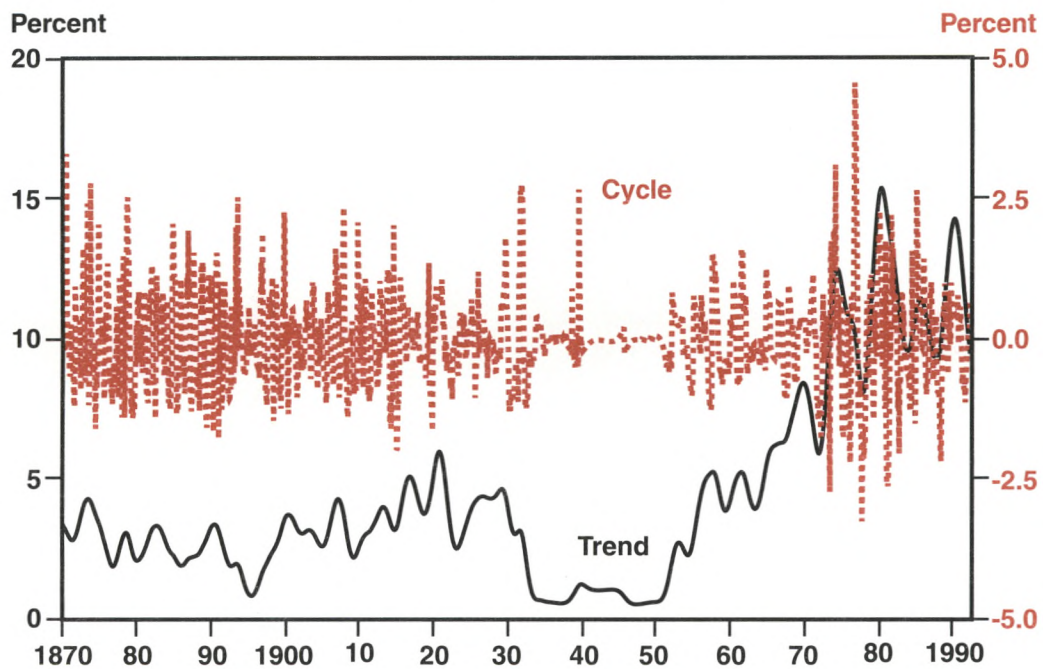
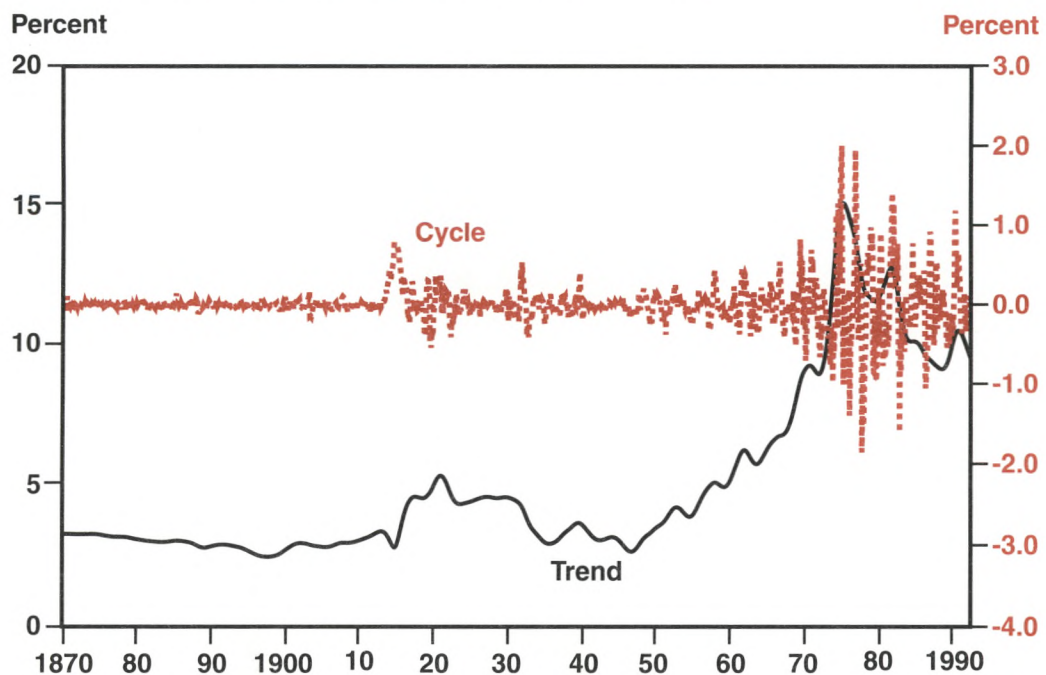


Figure 12  
Long Interest Rate Trend and Cycle (1870-1992)





became increasingly credible, the relationship between movements in short- and long-term rates changed.<sup>22</sup>

It cannot but be observed that there was greater stability of output, interest rates and prices under the gold standard than under any subsequent exchange rate regime. But, of course, the gold standard was more than an exchange rate regime. It was a system, a set of rules, for the conduct of monetary policy. As Bordo (1993) wrote, "The gold standard rule can be viewed as a form of contingent rule or a rule with escape clauses. The monetary authority maintains the standard—that is, keeps the price of the currency in terms of gold fixed—except in the event of a well-understood emergency, such as a major war or a financial crisis. In wartime it may suspend gold convertibility and issue paper money to finance its expenditures, and it can sell debt issues in terms of the nominal value of its currency on the understanding that debt will eventually be paid off in gold. The rule is contingent in the sense that the public understands that the suspension will last only for the duration of the wartime emergency plus some period of adjustment. It assumes that afterward the government will follow the deflationary policies necessary to resume payments at the original parity." It may be consistent with this interpretation of the gold standard that with the floating exchange rate of the 1970s, output variability fell, but not to where it had been under the gold standard. The argument would be that monetary policy was now clearly focused on internal objectives and not subject to the vicissitudes of a multitude of shocks from the outside world.

All in all, then, it appears clear that the exchange rate regime in the United Kingdom has not been a source of volatility for the main macroeconomic variables. For that reason we need not consider why exchange rate regimes might affect real economic performance—in the United Kingdom they did not. The case for a fixed rate regime in the United Kingdom apparently must depend only on its traditional source of support—the desire to import price level performance.

It is, of course, important to consider whether these results generalize to other economies.

There is virtually no feature of the U.K. economy to indicate that they should not.<sup>23</sup> The composition of output is not unusual; the U.K. economy has always been fairly open. It was a dominant economy internationally for only a modest part of our period, and it has not gone through hyperinflation or recessions as severe as those in some other economies, so such problems cannot have biased our results. Though we would not claim that our findings are more than those of a case study, we would suggest that they are findings we would not be surprised to see roughly repeated in studies of other countries.

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<sup>22</sup>Initially, rises in short-term rates produced rises in long-term rates. But as markets became convinced that the authorities were serious, short- and long-term rates started to move much more independently of each other.

<sup>23</sup>This is also suggested by the similar structure of models used to explain and predict the economies of a wide range of countries.



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## Appendix

### The Hodrick-Prescott Filter

The filter proposed by Hodrick and Prescott (1980) has a long tradition as a method of fitting a smooth curve through a set of points, versions of it being used as an actuarial graduation formula. Given the traditional decomposition  $y_t = \mu_t + n_t$ , the trend series  $\mu_t$  is obtained as the solution to the problem of minimizing

$$(1) \sum_{t=1}^T [y_t - \mu_t]^2 + \lambda \sum_{t=1}^T [(\mu_t - \mu_{t-1}) - (\mu_{t+1} - \mu_t)]^2$$

with respect to  $\mu_1, \mu_2, \dots, \mu_T$ . The first order condition for this minimization problem is

$$(2) y_t = \lambda[\mu_{t+2} - 4\mu_{t+1} + (6 + \lambda^{-1})\mu_t - 4\mu_{t-1} + \mu_{t-2}]$$

Using the lag operator  $B$ , defined such that  $B^j \mu_t = \mu_{t-j}$ , this can be written as

$$(3) Y_t = \lambda[B^{-2} - 4B^{-1} + (6 + \lambda^{-1}) - 4B + B^2]\mu_t = \lambda[(1-B)^2(1-B^{-1})^2 + \lambda^{-1}]\mu_t$$

so that if an infinite series of  $y$  values were available,  $\mu_t$  would be given by the two-sided moving average

$$(4) \mu_t = \sum_{j=-\infty}^{\infty} \alpha_j Y_{t-j}, \quad \alpha_j = \alpha_{-j}$$



where the weights can be calculated from

$$(5) \alpha(B) = [\lambda(1-B)^2(1-B^{-1})^2 + 1]^{-1}.$$

King and Rebelo (1989) provide expressions for the  $\alpha_j$ , which do not take a simple form. Fortunately, Hodrick and Prescott (1980) provide an algorithm that removes the need to calculate the moving average weights and so allows the trend to be computed when only a finite number of  $y$  observations are available. This algorithm was employed to compute the decompositions used here, noting that the cyclical component can be obtained by residual as  $n_t = y_t - \mu_t$ . Typically, following Hodrick and Prescott,  $\lambda$  is set at 100 if annual data are used or 1,600 if quarterly or monthly data are used.<sup>1</sup>

Harvey and Jaeger (1991), for example, show that the filter  $\alpha(B)y_t$  can be interpreted as being the optimal estimate of  $\mu_t$  when  $y_t$  is generated

by the structural model

$$(6) \quad \begin{aligned} y_t &= \mu_t + n_t \\ \mu_t &= \mu_{t-1} + \Psi_{t-1} \\ \Psi_t &= \Psi_{t-1} + \xi_t \\ n_t &\sim NID(0, \sigma_n^2), \quad \xi_t \sim NID(0, \sigma_\xi^2), \quad \lambda = \sigma_n^2 / \sigma_\xi^2 \end{aligned}$$

An observed series may not be generated even approximately by such a model, and even if it is, the ratio of the two innovation variances may be very different from the assumed value of  $\lambda$ . Harvey and Jaeger argue that the Hodrick-Prescott filter may create spurious cycles, distort the estimates of the components or both. King and Rebelo argue in similar vein, although they focus on the calculation of sample moments of the estimated trend and cycle components. Given these strictures, we emphasize that our use of the filter is purely for exploratory purposes outside the confines of any explicit model.

<sup>1</sup>See Hodrick and Prescott (1980).

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# Central Bank Independence and Economic Performance

**I**N RECENT YEARS MANY countries have adopted or made progress toward adopting legislative proposals removing their central banks from government control, that is, making them independent. Between 1989 and 1991, New Zealand, Chile and Canada enacted legislation that increased the independence of their central banks. The 1992 Treaty on European Union (Maastricht Treaty) requires European Community (EC) members to give their central banks independence as part of establishing the European Monetary Union. As a result, EC countries that do not yet have strongly independent central banks have introduced legislation or announced their commitment to make their central banks more independent.<sup>1</sup> Furthermore, in recent months the governments of Brazil and Mexico have announced their intentions to introduce legislation to create more independent central banks.

In view of these developments, it might seem reasonable to conclude that unambiguous links had been established between economic perfor-

mance and the degree of central bank independence. Interestingly, however, the two post-World War II star performers among the industrialized economies—Germany and Japan—have different levels of central bank independence. The German Bundesbank is viewed as one of the most independent central banks in the world, whereas the Bank of Japan is seen as more subject to government control. Thus the contrast between the movement to grant central banks more independence and widely different degrees of independence across the major economies raises several questions. Among these are: Why is the idea of an independent central bank popular? Are there economic benefits of having an independent central bank?

This paper examines empirical and theoretical studies of central bank independence to address these questions. Empirical researchers have devised measures of independence to focus on the relationship between central bank independence and a country's economic performance. Theoretical studies have modeled the strategic be-

<sup>1</sup>To meet the level of independence prescribed by the Maastricht Treaty, a central bank must be prohibited from taking instructions from the government. The term for central bank governors must be set at a minimum of five years, although it can be renewed. In addition, the central bank must be prohibited from purchasing debt instruments directly from the government (that is, in the primary market) and from providing credit facilities to the government. Both Denmark and the United Kingdom have reserved the right to decline membership in the European Monetary Union. Thus neither country has introduced

legislation to ensure conformity of their central banks with the Maastricht provisions.

For a detailed analysis of the institutional status of the central banks of the EC countries, see the Committee of Governors of the Central Banks of the Member States of the European Economic Community (1993).



havior of monetary and fiscal policymakers to be able to compare an economy's performance when policymakers cooperate in setting policies with its performance when they do not cooperate.

The next section of this paper presents a survey and evaluation of empirical studies. Next, theoretical studies are presented and evaluated. The final section examines the extent to which these studies either explain the current movement toward greater central bank independence or highlight unresolved questions in this debate.

## **EMPIRICAL STUDIES: CENTRAL BANK INDEPENDENCE AND ECONOMIC PERFORMANCE**

### ***Inflation and Central Bank Independence***

As a broad generalization, interest in central bank independence was motivated by the belief that, if a central bank was free of direct political pressure, it would achieve lower and more stable inflation.<sup>2</sup> Bade and Parkin (1985) conducted one of the first empirical studies of this link. The authors used data for 12 Organization for Economic Cooperation and Development (OECD) countries in the post-Bretton Woods era and measured the degree of central bank independence according to the extent of government influence over the finances and policies of the central bank.<sup>3</sup> The degree of financial influence on the central bank was determined by the government's ability to set salary levels for members of the governing board of the central bank, to control the central bank's budget and to allocate its profits. The degree of policy influence was determined by the government's ability to appoint the members of the central bank governing board, government representation on this board, and whether the government or the central bank was the final policy authority. Countries were given a rank of one through four in each category, with four being the highest level of central bank independence.

Bade and Parkin concluded that the degree of financial independence of the central bank was

not a significant determinant of inflation in the post-Bretton Woods period. Policy independence, however, was seen as an important determinant of inflation because the two countries with the highest degree of policy independence (Germany and Switzerland) had inflation rates significantly below those of all other countries in the sample. They found no significant differences in inflation performance among countries with lower rankings of independence in the post-Bretton Woods era.

Alesina (1988) used the Bade and Parkin (1985) index but added the following four countries: Denmark, New Zealand, Norway and Spain. He found, as hypothesized, that there was generally an inverse relationship between average inflation rates and the level of central bank independence.

Grilli, Masciandaro and Tabellini (1991) created two indexes of central bank independence—one based on economic measures of independence (with a scale ranging from zero to eight), and the other based on political measures of independence (with a scale ranging from zero to seven).<sup>4</sup> The political factors were similar to those identified by Bade and Parkin. The economic factors considered were the ability of the government to determine the conditions under which it can borrow from the central bank and the monetary instruments under the control of the central bank. The data set comprised 18 OECD countries over the period 1950–89.<sup>5</sup> For the period as a whole, Grilli, Masciandaro and Tabellini found that economic independence was negatively related to inflation. Political independence also had a negative correlation with inflation, but the relationship was not statistically significant. Breaking the data into four decade-long subperiods, they found that neither measure of independence had a significant effect on inflation in the first two decades. In the 1970s both measures of independence were significant, whereas in the 1980s only the economic independence measure was significant.

Alesina and Summers (1993) calculated a measure of central bank independence by averaging the indexes created by Bade and Parkin,

<sup>2</sup>Buchanan and Wagner (1977) point out that even an independent central bank may not be immune from political pressures and thus exhibit an inflationary bias.

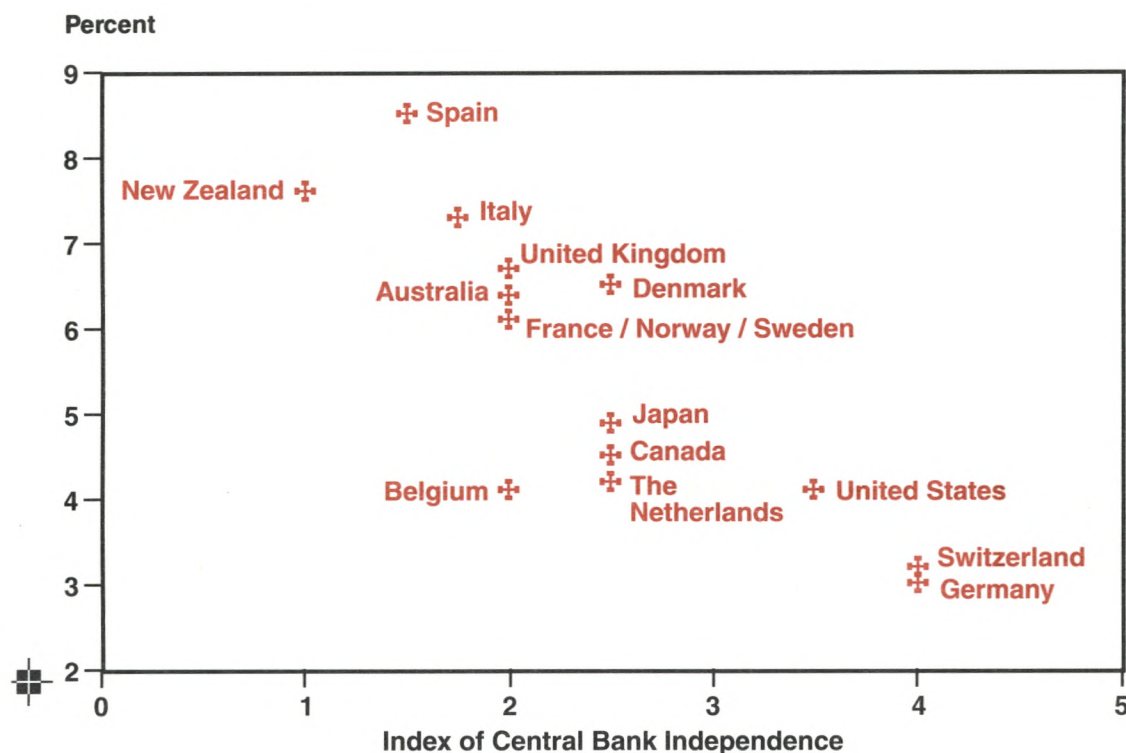
<sup>3</sup>The 12 OECD countries are Australia, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland, United Kingdom, and United States.

<sup>4</sup>In both measures the scale is increasing in the level of independence.

<sup>5</sup>Grilli, Masciandaro and Tabellini add Austria, Denmark, Greece, New Zealand and Portugal to Bade and Parkin's group of countries and eliminate Sweden.



Figure 1  
Average Inflation: 1955-1988



Source: Alesina and Summers (1993).

and Grilli, Masciandaro and Tabellini.<sup>6</sup> The countries included were the same as in Bade and Parkin with the addition of Denmark, New Zealand, Norway and Spain. The sample period was 1955–88.<sup>7</sup> As in the previous studies, they found a negative correlation between the level of central bank independence and the rate of inflation (figure 1). They also found that the more dependent a central bank was, the greater the variability in inflation (figure 2). This, they argued, was a result of a correlation between the level and variability of inflation.

Cukierman (1992) provided an extensive analysis of central bank independence and its rela-

tionship to inflation performance using data for 1950–89. Unlike previous studies, he used not only legal measures of central bank independence, but also practical measures of the level of independence. One such measure was the frequency of turnover of the central bank governors. Another measure of practical independence was based on answers from a questionnaire completed by qualified individuals at the central banks.<sup>8</sup> Cukierman's analysis is the most comprehensive to date, not only because it incorporates information about the actual level of independence a central bank enjoys in practice, but also because it includes a sample of 70 countries.<sup>9</sup> Cukierman concluded that "central

<sup>6</sup>See Bade and Parkin (1985) and Grilli, Masciandaro and Tabellini (1991).

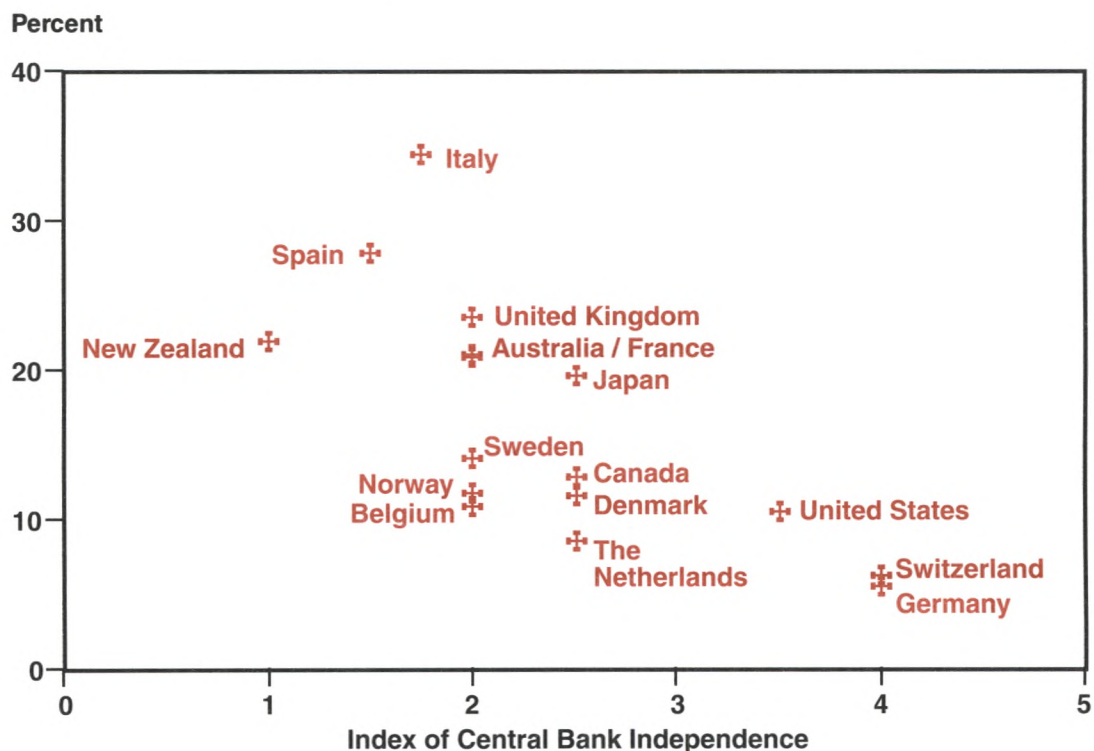
<sup>7</sup>See Alesina (1988). Alesina and Summers report that the results of their study are the same if the data period is restricted to 1973–1988, the post-Bretton Woods era.

<sup>8</sup>The sample period for the questionnaire data was 1980–89.

<sup>9</sup>The questionnaire data were available for only 24 countries.



Figure 2  
Variance of Inflation: 1955-1988



Source: Alesina and Summers (1993).

bank independence affects the rate of inflation in the expected direction."<sup>10</sup> This result was also found by Cukierman, Webb and Neyapti (1992).<sup>11</sup>

### **Central Bank Independence and the Real Economy**

Although most of the empirical work focused on the relationship between central bank independence and the rate of inflation, some studies examined the link between indepen-

dence and economic output. If an independent central bank can produce lower inflation than a dependent central bank, does this come at the cost of lower output? Conversely, are dependent central banks attempting to exploit a short-run Phillips Curve relationship, accepting higher inflation in order to achieve higher output?

Grilli, Masciandaro and Tabellini (1991) found no systematic effect of central bank independence (using either of their two indicators) on the growth rate of real output. Alesina and

<sup>10</sup>Cukierman did not actually use the rate of inflation, but the rate of depreciation of the real value of money, defined by the following formula:

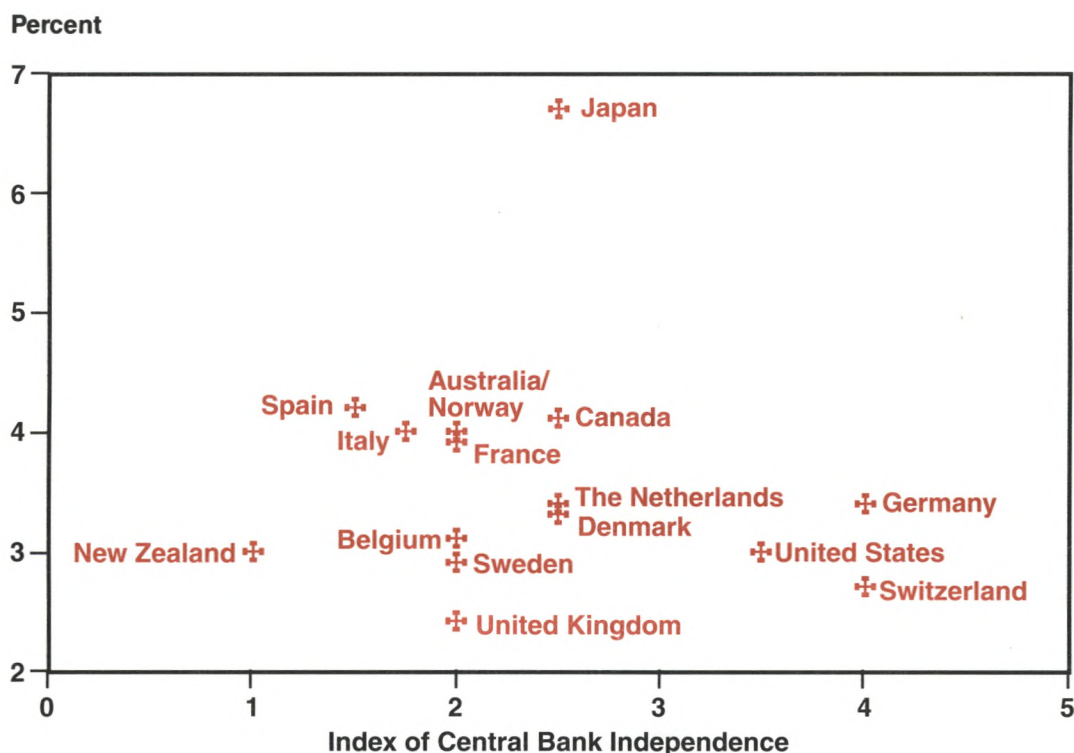
$$d_t = \frac{\pi_t}{1 + \pi_t},$$

where  $\pi_t$  is the inflation rate in period  $t$ . The use of  $d$ , as noted by Cukierman, moderates the effects of hyperinflation on the results.

<sup>11</sup>Capie, Mills and Wood (1992) also studied the link between inflation and central bank independence. Their data set consisted of 12 countries, with the data series beginning between 1871 and 1916 and ending in 1987. Central

banks were classified as either dependent or independent according to the extent of their control over monetary policy. The authors examined the relationship between the status of the central bank and inflation over the entire sample period and four subsample periods—pre-World War I, the Interwar Years, Bretton Woods and post-Bretton Woods. Periods of hyperinflation, however, were excluded from the data. In all sample periods, the countries with independent central banks were in the low inflation group. Nevertheless, some of the dependent central banks were also in this group. The authors concluded that independence may be a sufficient condition for low inflation but not a necessary one.

Figure 3  
Average Real GNP Growth: 1955-1987



Source: Alesina and Summers (1993).

Summers (1993) likewise found no correlation between average economic growth or the variability of growth and the level of central bank independence (figures 3 and 4).<sup>12</sup>

De Long and Summers (1992) looked at the relationship between central bank independence and output per worker while trying to eliminate differences between countries that were due solely to convergence effects.<sup>13</sup> To do this, they examined the growth rate of real gross domestic product (GDP) per worker during 1955–90, controlling for the level of GDP per worker in 1955.<sup>14</sup> This procedure showed a positive rela-

tionship between central bank independence and economic growth.<sup>15</sup> More precisely, they found that holding constant the 1955 level of real output per worker, a unit increase in their index of central bank independence was associated with a 0.4 percentage point increase in growth per year.<sup>16</sup>

In contrast, Cukierman, Kalaitzidakis, Summers and Webb (1993) found that output growth in industrialized countries was unrelated to central bank independence even after controlling for structural factors that might influence growth. The factors they considered were the initial level

<sup>12</sup>The results are the same if per capita gross national product (GNP) is used rather than GNP.

<sup>13</sup>Standard neoclassical growth models suggest that growth rates of economies tend to converge over time. Thus given two countries, the one with the lower per capita output will have a higher growth rate than the other until their levels of real output per capita converge.

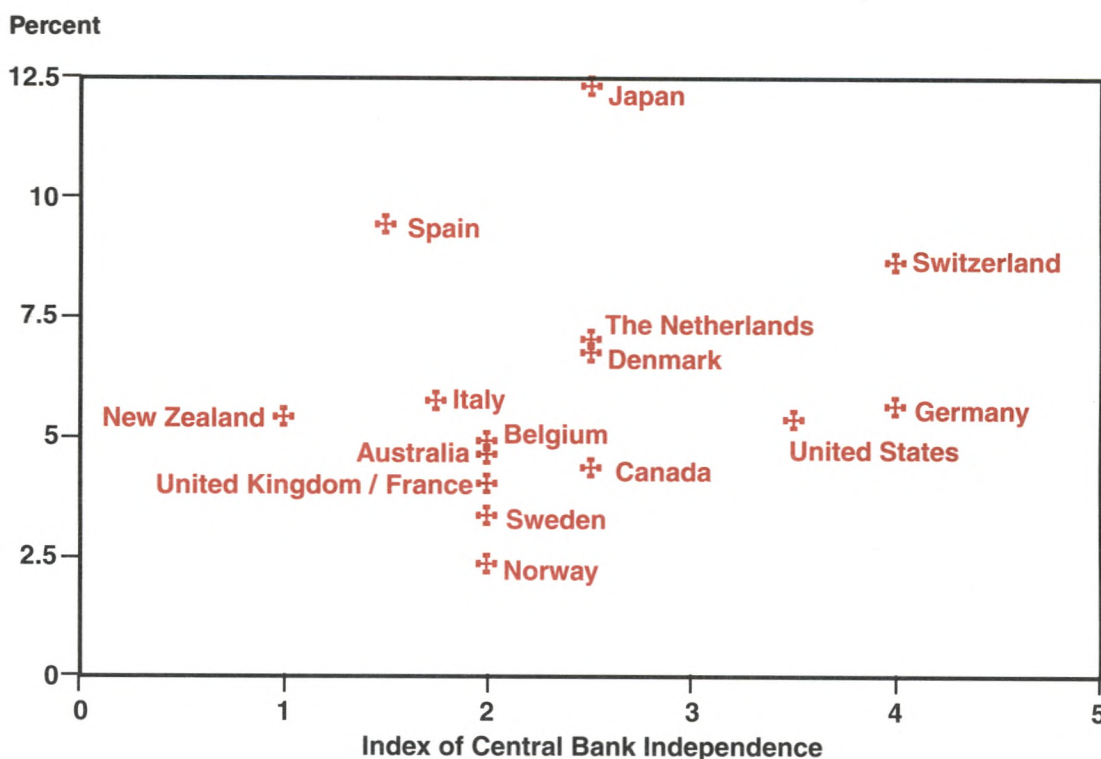
<sup>14</sup>GDP per worker levels are based on the Summers and Heston (1991) estimates, which use purchasing power parity conversions.

<sup>15</sup>This study does not take into account that the degree of independence of the central bank of New Zealand changed dramatically in 1989. Furthermore, all of the studies, with the exception of Alesina (1988), do not take into account that there was an institutional change in the structure of the Bank of Italy in 1981 that increased its independence. The latter change, however, was not as substantial as the former.

<sup>16</sup>De Long and Summers regress the average growth rate of GDP per worker over the period 1955–90 on GDP per worker in 1955 and the central bank independence index.



Figure 4  
Variance of Real GNP Growth: 1955-1987



Source: Alesina and Summers (1993).

of a country's GDP, its initial enrollment rates for primary and secondary education, and changes in its terms of trade. The authors did find, however, using the turnover rate of central bank governors as a proxy for independence, that central bank independence did have a positive effect on growth in developing countries.

The difference in the results for industrialized countries versus developing countries, they argue, may imply that "dependence on political authorities is bad for growth only when the level of independence is sufficiently high."<sup>17</sup> Central bank independence is higher in all the industrialized countries than in most of the developing countries.

### **Central Bank Independence and Fiscal Deficits**

Another area of empirical study has been the relationship between central bank independence

and fiscal deficits. The motivation for these studies is the belief that independent central banks should be better able to resist government efforts to have them monetize deficits. Thus governments realizing that there may be some limit on their ability to issue bonds continuously to finance deficits may decide to limit deficit spending.

Parkin (1987) investigated this question for the same 12 countries as Bade and Parkin for the period 1955–83.<sup>18</sup> He found that there was some evidence of a negative relationship between central bank independence and the long-run behavior of government deficits as a percent of gross national product (GNP). The deficits of Switzerland and Germany, the countries with the highest levels of central bank independence, had long-run equilibrium values near zero with little variance. However, other countries, notably France, that had low levels of central bank in-

<sup>17</sup>See Cukierman, Kalaitzidakis, Summers and Webb (1993), p. 42.

<sup>18</sup>See Bade and Parkin (1985).



dependence also had small long-run deficits as a percent of GNP.

Masciandaro and Tabellini (1988) looked at fiscal deficits as a percent of GDP in Australia, Canada, Japan, New Zealand and the United States during the period 1970–85.<sup>19</sup> They found that New Zealand, which had the lowest level of central bank independence of the five countries during this period, had the highest fiscal deficit as a percent of GDP. The United States, however, with the highest level of central bank independence among this group of countries, had a deficit/GDP ratio similar to those of the other countries.

Grilli, Masciandaro and Tabellini (1991) found that there was generally a negative correlation between the deficit/GNP ratio and the degree of central bank independence. However, if political factors, as well as central bank independence, were included in their regression, the latter variable was insignificant.<sup>20</sup> Thus they conclude that an independent monetary authority apparently does not discourage the government from running fiscal deficits.

A further examination of the relationship between fiscal deficits and central bank independence, which is consistent with the work done by Alesina and Summers and De Long and Summers, is presented here.<sup>21</sup> Using the same index of central bank independence and the same 16 countries as these previous papers, there is some evidence of a negative correlation between average deficits as a percent of GDP and central bank independence for the period 1973–89, as shown in figure 5.<sup>22</sup> The degree of independence, however, is not a statistically significant (at  $\alpha = .05$ ) determinant of the deficit/GDP ratio. The variability of deficits as a percent of GDP is also negatively correlated with central bank independence (figure 6) and

this relationship is statistically significant.

## EVALUATION OF THE EMPIRICAL STUDIES

At first glance, these studies seem to indicate that a country that wants to lower its inflation rate and do so without hurting growth should create an independent central bank. Such a central bank apparently could also help reduce fiscal deficits and increase output. These benefits would explain the recent popularity of independent central banks. Thus Grilli, Masciandaro and Tabellini commented:

Having an independent central bank is almost like having a free lunch; there are benefits but no apparent costs in terms of macroeconomic performance.<sup>23</sup>

Alesina and Summers (1993) went a step further in concluding their findings: "Most obviously they suggest the economic performance merits of central bank independence."<sup>24</sup>

A more careful analysis of these studies, however, indicates weaknesses that highlight the need for further evidence before one should believe that creating an independent central bank will improve a country's economic performance. The following four weaknesses are considered: 1) the difficulty in measuring central bank independence; 2) the possibility of a spurious relationship between independence and economic performance; 3) the possible endogeneity of central bank independence; and 4) the inclusion of the fixed exchange rate period in the sample data of some of the studies.

The measures of central bank independence used in empirical studies have been determined by establishing a set of factors thought to be relevant for independence and then analyzing central bank charters and laws for compliance with these factors. With the exception of the in-

<sup>19</sup>The deficits are as a percent of GNP for Japan.

<sup>20</sup>These political factors include the frequency of government changes, significant changes in the government and the percent of governments in a given period supported by a single majority party.

<sup>21</sup>See Alesina and Summers (1993) and De Long and Summers (1992).

<sup>22</sup>The 1989 ending date was chosen because of the change in the status of the Bank of New Zealand, which occurred in 1989. All data are from the International Monetary Fund, *International Financial Statistics*.

<sup>23</sup>See Grilli, Masciandaro and Tabellini (1991), p. 375.

<sup>24</sup>See Alesina and Summers (1993), p. 159. Even the press has picked up the banner of central bank independence. A recent headline in *The Washington Post* proclaimed: "More Independence Means Lower Inflation, Studies Show." See Berry (1993).



Figure 5  
Average Deficit as a Percent of GDP: 1973-1989

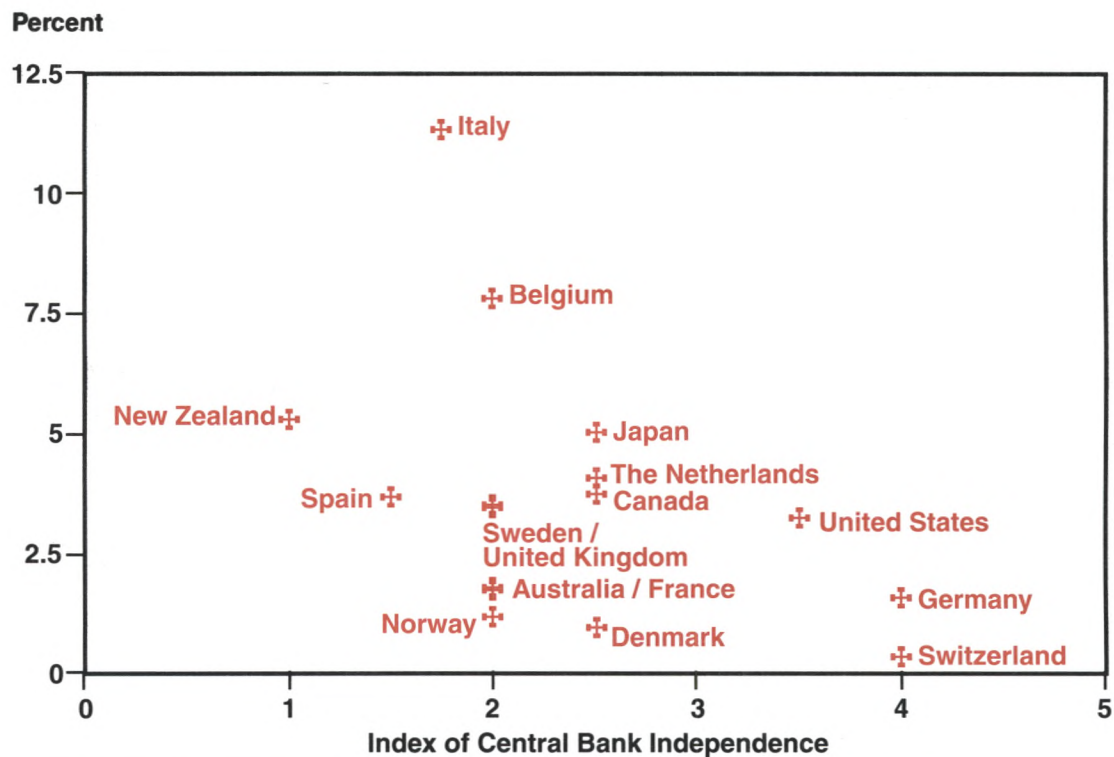
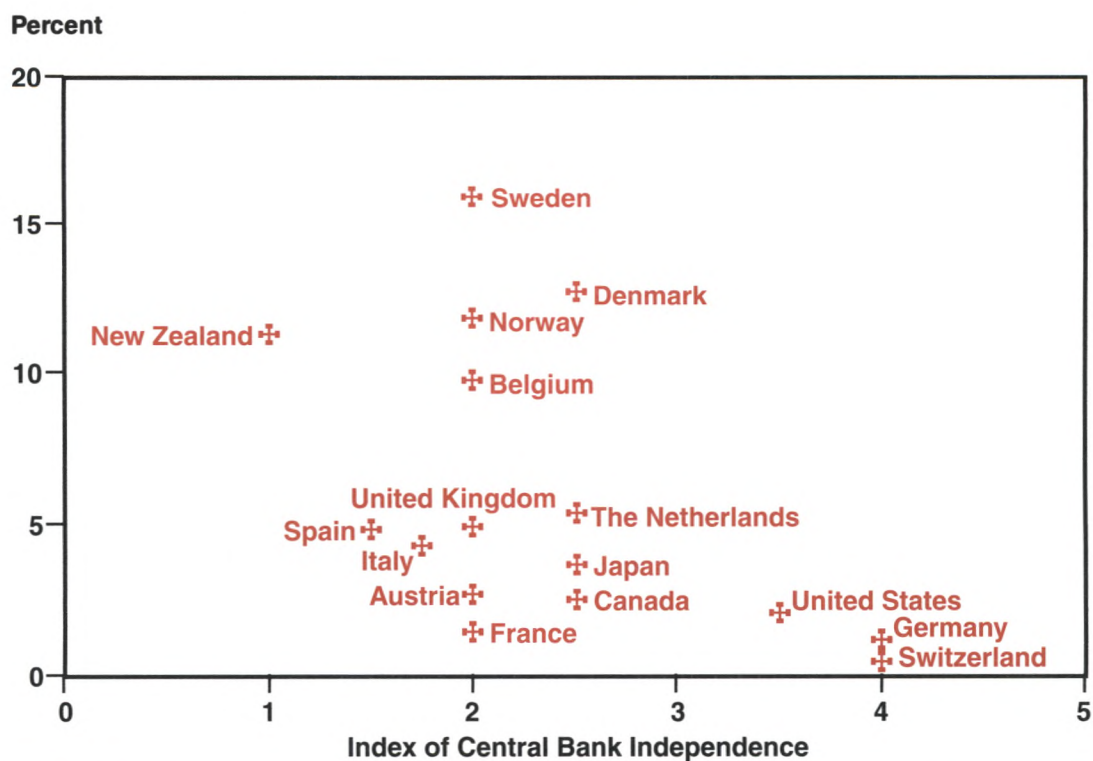


Figure 6  
Variance of Deficit as a Percent of GDP: 1973-1989



dex created by Cukierman, all of the indexes of independence apply equal weight to each factor. For instance, the Grilli, Masciandaro and Tabellini index based on political measures of independence gives a country one point if no one on the central bank board is appointed by the government and one point if the policy formulated by the central bank does not require approval by the government. Although the latter certainly places a greater constraint on the actions of the central bank than the former, the two are treated the same empirically.

Another concern is that the studies are based on a legal measure of independence that may not reflect a bank's *de facto* level of independence. If there is a difference between legal and practical independence, studies based on the former type of measures may provide misleading results. Cukierman (1992), in an attempt to address this possibility, uses central bankers' responses to a questionnaire to determine the actual degree of independence in the 1980s. He finds that the correlation between the legal index and this practical index of independence is 0.33 for developed countries, 0.06 for developing countries and 0.04 overall.<sup>25</sup> This finding indicates, as Cukierman notes, that a legal index of independence is not useful for studying developing countries. It also indicates that a legal index may be a weak measure of actual independence for the developed countries.

There also may be bias in the factors selected to measure independence. For example, Grilli, Masciandaro and Tabellini include: "statutory requirements that central bank pursues monetary stability amongst its goals" in their index.<sup>26</sup> Likewise, a central bank is more independent under Cukierman's system if price stability is its only objective than if price stability is one of a number of objectives or not an objective at all. Using the goal of price stability as a measure of central bank independence may result in a bias between the measure of independence and the inflation rate.

The problems in developing precise measures of central bank independence are less important, however, if there is a consensus in ranking central banks within broad levels of independence. Table 1 lists 16 OECD countries along with their

Table 1

### Comparison of Relative Rankings of Central Bank Independence

	Alesina	Alesina and Summers	Cukierman
Australia	14	8	7
Belgium	5	8	14
Canada	5	4	5
Denmark	5	4	4
France	5	8	9
Germany	1	1	2
Italy	13	14	12
Japan	3	4	15
Netherlands	5	4	6
New Zealand	14	16	10
Norway	5	8	16
Spain	14	15	13
Sweden	5	8	10
Switzerland	1	1	1
United Kingdom	5	8	7
United States	3	3	3

relative rankings as given by Alesina, Cukierman, and Alesina and Summers.<sup>27</sup> All agree that Switzerland and Germany have the most independent central banks of the countries studied. There are, however, a few countries which are ranked quite differently by the authors. For example, Japan has the second lowest level of independence of all 16 countries, according to Cukierman, whereas Alesina, and Alesina and Summers give it a much higher level of independence.

This discrepancy over the degree of independence of the Bank of Japan is not due solely to differences in factors considered in measuring independence. The index used by Alesina is based on the criteria of independence created by Bade and Parkin (1985). The index used by Alesina and Summers is constructed by averaging the indexes created by Alesina, and Grilli, Masciandaro and Tabellini. Bade and Parkin claim that the Bank of Japan is independent from the government in formulating and implementing monetary policy, and Grilli, Masciandaro and Tabellini claim that there are no provisions for handling policy conflicts between the Bank of Japan and the government. In contrast, Cukierman claims that the Bank of Japan and the government formulate policy jointly and

<sup>25</sup>The correlations are based on the weighted indexes. Giving each factor related to independence an equal weight in the indexes results in a correlation of 0.01 for developed countries and 0.00 for developing countries.

<sup>26</sup>See Grilli, Masciandaro and Tabellini (1991), p. 368.

<sup>27</sup>The measure of independence developed by Cukierman is based on more factors than the measure used by Alesina, and Alesina and Summers. Thus Cukierman's rankings are more delineated than the other two.



further notes that in the case of a policy conflict, the executive branch of the government has final authority.<sup>28</sup>

Since most of the empirical studies consider only central bank independence as a determinant of economic performance, it is possible that if other factors are accounted for, these results could be spurious. Grilli, Masciandaro and Tabellini attempt to account for other factors that could affect the rate of inflation by including political variables. They find that after accounting for political factors, central bank independence was still negatively related to inflation in the countries studied over the period 1950–89. The incorporation of political variables is a step in the right direction, but other factors also should be considered. As noted by Cukierman, “monetary policy is generally sensitive to shocks to government revenues and expenditures, employment, and the balance of payments.”<sup>29</sup> The types of shocks that a country experienced over the sample period and the reaction of the central bank to these shocks can affect its economic performance. A study by Johnson and Siklos (1992) found that the reactions of central banks (as measured by changes in interest rates) to shocks to unemployment, inflation and world interest rates were not closely related to standard measures of central bank independence.

Empirical use of these indexes may be problematic if central bank independence is an endogenous variable in the sense that countries with a commitment to price stability may have a greater propensity for independent central banks. If this is true, the mere establishment of an independent bank without a commitment to price stability will not bring inflation benefits to a country. In fact, a public aversion to inflation predates the establishment of many independent central banks. This was true for the creation of the Bundesbank and more recently with respect to central banks in Chile and New Zealand. New Zealand had one of the highest inflation rates of all industrialized countries in the 1980s. In 1989 legislation was passed to increase the independence of its central bank substantially. This

change is often credited with bringing inflation down to near zero. Though the legislation certainly formalized the country's commitment to price stability, New Zealand had succeeded in reducing its inflation rate from nearly 16 percent in 1987 to 6 percent before the creation of an independent central bank.

In theory, the degree of independence of a central bank should not be a determinant of a country's inflation performance under a fixed exchange rate system because monetary policy cannot be set exogenously.<sup>30</sup> During the Bretton-Woods era, it is not clear that any central bank (with the possible exception of the U.S. Federal Reserve) could be considered independent in the sense of an ability to pursue an independent monetary policy.<sup>31</sup> Thus the empirical finding of a negative relationship between independence and inflation when the sample period extends over both the Bretton Woods and post-Bretton Woods eras may indicate a flaw in these studies. To assess the effect of central bank independence on inflation, the data used in these studies could be divided into two periods. If no evidence of a relationship between independence and inflation is found in the Bretton Woods period, this would strengthen the underlying argument of these studies that central bank independence is a primary determinant of a country's inflation performance.<sup>32</sup> If, however, evidence is found of a relationship between central bank independence and inflation in the Bretton Woods period, this would conflict with theory and could indicate that the empirical findings are spurious.

## THEORETICAL MODELS OF FISCAL AND MONETARY POLICY INTERACTIONS

In contrast to the empirical studies, the theoretical studies of central bank independence and economic performance concentrate on the conflicts that can arise when monetary and fiscal policy are delegated to independent institutions. In this literature an independent central bank is one that does not cooperate with the fiscal au-

<sup>28</sup>Aufricht (1961) reproduces the Bank of Japan charter and subsequent changes in its governing regulations, which support the conclusion reached by Cukierman.

<sup>29</sup>See Cukierman (1992), p. 438.

<sup>30</sup>See McCallum (1989), pp. 285–88, for an explanation of the limitations on monetary policy under a fixed exchange rate system.

<sup>31</sup>Indeed, the primary argument in favor of a flexible exchange rate system was that such a system would permit individual countries to pursue independent monetary policies. See, for example, Friedman (1953) and Johnson (1969).

<sup>32</sup>This is Grilli, Masciandaro and Tabellini's finding (1991).



thorities in setting economic policy. A dependent central bank is one that cooperates with the fiscal authority in setting policy.

In examining the theoretical implications of central bank independence, this paper focuses on models in which the policymaking process is decentralized.<sup>33</sup> The basic framework of these models is as follows. The government controls fiscal policy, and the central bank controls monetary policy. Both parties set goals for the economy (generally inflation and output targets) and assign priority to these goals. The goals and priorities may differ across the policymakers. Each institution uses the instruments available to it in an attempt to reach its goals. In most models the central bank controls the growth rate of the monetary base and the government controls fiscal spending. There is an underlying model of the economy that indicates how fiscal and monetary policy will affect the relevant economic variables. All of the models assume that there are no stochastic shocks to the economy.

The government and the central bank can either cooperate in implementing their policies or choose not to cooperate. If they do not cooperate, they either can set policies simultaneously, or one party can set its policies first and the other then adopts its policies in reaction to these.

Consider Andersen and Schneider's (1986) simple model in which the government and the central bank establish targets for inflation and output.<sup>34</sup> The further the actual level of output and rate of inflation are from their respective targets, the more disutility each authority receives. Thus, using the following equations, each authority can be modeled as setting policy to minimize its respective loss functions:<sup>35</sup>

$$(1) L_f = a_f(y - y_f)^2 + b_f(\pi - \pi_f)^2 \quad a_f \geq b_f$$

$$(2) L_m = a_m(y - y_m)^2 + b_m(\pi - \pi_m)^2 \quad b_m \geq a_m$$

$$(3) \pi_f \geq \pi_m, y_f \geq y_m$$

where:

$L_f$  is the fiscal authority's loss function

$L_m$  is the monetary authority's loss function

$y$  is output

$\pi$  is inflation

$y_f$  is the fiscal authority's output target

$y_m$  is the monetary authority's output target

$\pi_f$  is the fiscal authority's inflation target

$\pi_m$  is the monetary authority's inflation target

$a$  is the weight placed on the output target

$b$  is the weight placed on the inflation target

Andersen and Schneider compare the economic outcomes under cooperation vs. noncooperation given three different models of the economy. The first model is Keynesian in nature. This is a short-run model with price sluggishness so that even anticipated changes in policy affect aggregate demand. The level of output and the rate of inflation prevailing in the economy are affected by both fiscal and monetary policies, which can be shown in a simple reduced form model with the following equations: where  $f$  is the fiscal policy instrument and  $m$  is the monetary policy instrument.<sup>36</sup>

$$(4) y = \gamma_0 f + \gamma_1 m \quad 0 < \gamma_1 < \gamma_0$$

$$(5) \pi = \theta_0 f + \theta_1 m \quad 0 < \theta_0 < \theta_1$$

In the second model, which Andersen and Schneider refer to as Keynesian-New Classical, anticipated monetary policy is neutral; it can affect only inflation. Thus in a world of certainty, equation (4) becomes the following:

$$(6) y = \gamma_0 f$$

In the third model, the economy is New Classical in nature, characterized by perfect price flexibility and rational expectations. Anticipated policy, both fiscal and monetary, affects only inflation, not output. The economy is modeled by the following equations:

$$(7) \pi = \eta_0 f + \eta_1 m$$

more, it is generally assumed that the inflation and output targets set by the government are greater than or equal to the targets set by the central bank.

<sup>33</sup>There have been studies concentrating solely on monetary policy that have shown that better economic outcomes result from the policymaker placing a greater weight on inflation than society as a whole. Rogoff (1985) argues that these results indicate the economic benefits of central bank independence. These studies ignore the interaction of fiscal and monetary policy in determining economic outcomes and thus are not discussed here.

<sup>34</sup>Generally it is assumed that the government places more weight on meeting its output target than its inflation target, whereas the opposite holds for the central bank. Further-

<sup>35</sup>The quadratic nature of the loss functions, which is standard in the macroeconomic game theory literature, implies that deviations on either side of the targets produce an equal loss to the policymaker.

<sup>36</sup>The restrictions in equations (4) and (5) imply that fiscal policy has a greater (lesser) effect on output (inflation) than does monetary policy.



$$(8) y = \pi - \pi^e$$

$$(9) \pi - \pi^e = \eta_0(f - f^e) + \eta_1(m - m^e),$$

where  $y$  now refers to output relative to capacity and the superscript  $e$  refers to the expectation of the variable. Output can be increased above capacity only through unanticipated inflation, and unanticipated inflation can occur only through unanticipated changes in fiscal policy, monetary policy or both.

The relevant issue for policy is the size of the loss to each policymaker under cooperation and noncooperation. Cooperation in the determination of monetary and fiscal policies is modeled by the government and the central bank choosing the policy variables ( $f$  and  $m$ ) to minimize a weighted average of their loss functions:

$$(10) \min_{f,m} L_c = \rho L_f + (1-\rho)L_m \quad 0 \leq \rho \leq 1$$

$$= \rho[a_f(y - y_f)^2 + b_f(\pi - \pi_f)^2] + (1-\rho)[a_m(y - y_m)^2 + b_m(\pi - \pi_m)^2],$$

where the weight placed on each loss function is determined by the relative bargaining strength of the two parties. Solving this minimization problem yields the equilibrium values for output and inflation, which can be substituted into the loss functions for the government, equation (1), and the central bank, equation (2), to determine the loss to each.

As noted above, noncooperation can be modeled in two ways. In the first, fiscal and monetary policies are chosen simultaneously; that is, the government selects a level of spending to minimize its loss function, equation (1), taking as given the actions of the central bank. At the same time, the central bank chooses the growth rate of the monetary base to minimize its loss function, equation (2), taking as given the actions of the government. This structure is referred to as a Nash game and the resulting equilibrium is called a Nash equilibrium. In a Nash equilibrium, neither authority, taking the actions of the other as given, can decrease its loss by unilaterally changing its policy.

In the second model of noncooperation, one policy is set before the other is determined. This process is known as a Stackelberg game, and the policymaker who moves first is known

as the Stackelberg leader, whereas the other policymaker is known as the Stackelberg follower. The leader chooses its policy, and the follower sets its policy in reaction. Furthermore, the leader, in choosing its policy, knows how the follower will react.

Although the equilibrium level of output and the rate of inflation vary depending on which model of the economy is used, in all three models the cooperative solution is Pareto superior to the noncooperative solution. This result is invariant to the structure of noncooperation—Nash or Stackelberg. The performance of the economy is better under cooperation in the sense that the losses to the government and the central bank are each lower than they are under noncooperation. This result holds even if the government and the central bank each place the same weight on meeting their inflation targets relative to their output targets ( $a_f = a_m$  and  $b_f = b_m$ ) but maintain different targets.

Andersen and Schneider summarize these results by noting the following:

When we have two independent authorities who act in their own selfish interest, then we quite often observe a conflict over the "right" policy direction. This result should be kept in mind when quite often the argument is put forward that an independent monetary authority should be created. ... Two independent policymakers do not automatically guarantee a policy outcome which is preferred to other outcomes under different institutional solutions.<sup>37</sup>

Alesina and Tabellini (1987) show that adding one more target to the loss functions of the government and the central bank also does not change the nature of the results. Noncooperation is once again suboptimal.

Adding a time dimension to the model also does not change the basic result that cooperation can improve the outcome from the perspective of both policymakers. Pindyck (1976) presents one of the first dynamic models analyzing the strategic interaction of monetary and fiscal policy. He argues that the

separation of monetary and fiscal control may considerably limit the ability of *either* authority to stabilize the economy, particularly when the conflict over objectives is at all significant.<sup>38</sup>

Petit (1989) examines the issue of policy coordination in a continuous time model. The

<sup>37</sup>See Andersen and Schneider (1986), p. 188.

<sup>38</sup>See Pindyck (1976), p. 239.



government sets targets for output and inflation, giving higher priority to output. The central bank targets inflation and the level of international reserves, giving higher priority to inflation.<sup>39</sup> As is standard, the government sets the level of public expenditures to minimize its loss function, whereas the central bank sets the growth of the monetary base to minimize its loss function.

In this model, policies are set at the beginning and are unchanged over the period considered. Once again, cooperation is Pareto superior to the Nash and the Stackelberg equilibriums. Furthermore, cooperation in this dynamic system leads to a decrease in the variability of the targets (particularly prices and international reserves), and raises the speed of adjustment of the system. The latter indicates that, given a shock to the system, the economy will return more quickly to its long-run values of output and inflation if the government and the central bank are coordinating their policies. Thus Petit concludes that policymakers should coordinate their policies.<sup>40</sup>

Other studies concentrate on the interaction of the government and the central bank in financing fiscal deficits where the deficit must be financed through bonds, seignorage or both.<sup>41</sup> Under the assumption that there is some limit on the ability of a government to continually issue bonds to finance its deficit, the need for inflation revenues becomes important.<sup>42</sup> Sargent and Wallace (1981) conducted the seminal research on this question and showed that if the government embarks on a path of unsustainable deficits, the central bank might eventually be forced to inflate to fund the deficits. If the public realizes that the government debt is on such a path, it will expect inflation to increase, which may cause inflation to increase

well before the debt limit has been reached.<sup>43</sup> This outcome is a result of the government being able to set its policies and the central bank having to react to those policies (a Stackelberg game).<sup>44</sup>

In general, a conflict over the public debt can arise at any time when the government and the central bank are allowed to adopt independent policies. Tabellini (1986) develops a dynamic model in which the central bank sets targets for changes in the monetary base and the stock of outstanding public debt while the government sets targets for the fiscal deficit net of interest payments and the stock of outstanding public debt. The target value of public debt is the same for both authorities. In choosing the level of the monetary base and the fiscal deficits, the two authorities are constrained by the government's dynamic budget constraint.<sup>45</sup> The stock of public debt as a proportion of income is considered too high by both the fiscal and monetary authorities. In the noncooperative setting, however, each authority ignores the benefit to the other of its own actions to reduce the level of debt. In the cooperative setting these benefits are internalized, resulting in a lower level of debt.

Tabellini (1987) and Loewy (1988) provide two more examples of models examining the conflict between central banks and governments over fiscal policy. Both show that such a conflict can lead to an increase in government debt. As noted by Blackburn and Christensen (1989), a conflict will always arise between a central bank whose goal is to maintain price stability and a government whose objective is to increase output and is pursuing this goal by running a stream of large deficits. Such a macroeconomic program is infeasible; one party will have to revise its strategy (give in). The conflict creates

<sup>39</sup>The target for international reserves reflects a balance of payments objective.

<sup>40</sup>Hughes Hallett and Petit (1990) also model the interaction of fiscal and monetary policy in a dynamic setting, reaching this same conclusion.

<sup>41</sup>Seignorage is the revenue received from the creation of money. It occurs because base money costs only a fraction of its face value to produce.

<sup>42</sup>As the public debt grows, there may be increasing concern among bondholders that the government will be unable to repay the bonds.

<sup>43</sup>As Sargent and Wallace note, if money demand today depends on inflationary expectations, then the price level today is a function of not only the current money supply, but also expectations of the future levels of the money supply.

<sup>44</sup>The concern that undisciplined fiscal policies could result in inflation was recognized by the EC in drafting the Treaty on European Monetary Union. In the regulations concerning the proposed European Central Bank, the bank is prohibited from financing fiscal deficits of the member countries.

As pointed out by Sargent and Wallace, and expounded on by Darby (1984), the need for the central bank to monetize government debt through an inflationary policy is based on the assumption that the rate of growth of the real economy is less than the real rate of interest.

<sup>45</sup>Note that monetary base and fiscal deficits in this model are both instruments and targets.



problems for the economy because of the uncertainty over the future course of policy: the public can expect higher inflation or higher taxes, depending on which policymaker gives in.<sup>46</sup>

## EVALUATION OF THE THEORETICAL LITERATURE

The theoretical studies indicate that noncoordination of fiscal and monetary policies will result in a suboptimal economic performance from the perspective of both the government and the central bank. Policy targets are more closely met when coordination occurs. Thus an independent central bank is not conducive to achieving better policy outcomes.

However, the theoretical work, like the empirical studies, has its weaknesses. One criticism is that the models are too simplistic. Neither the preference structures of the two authorities, nor the models of the economy, are completely specified. Furthermore, most of the models operate in a world of certainty. Policy, however, is not made in a world of certainty. Extrinsic uncertainty—shocks to the economy—can drive a wedge between the implementation of policy and its outcome. Intrinsic uncertainty—lack of knowledge of the preferences of a policymaker—is incorporated only in Tabellini and Loewy's models.<sup>47</sup> As these two models illustrate, adding uncertainty can increase the policy conflict between an independent central bank and fiscal authority.

In addition to assuming certainty, the models also omit one important player in these policy games—the public. Public perception of the credibility of a macroeconomic program is important to its results because the public can limit the ability of policymakers to take advantage of an inflation/output tradeoff. If an independent central bank can increase the public perception of the credibility of policy, this in turn should produce better economic results.<sup>48</sup>

Another deficiency of this literature is its failure to address the feasibility of the policymakers' goals. The output goals set by the govern-

ment, for example, may not be sustainable without accelerating inflation. Tax and expenditures plans, which lead to a stream of deficits, may also raise questions about the sustainability of fiscal policy. In this environment, an independent central bank could be useful if its credible commitment to price stability forced the government to evaluate the sustainability of its policy goals. In contrast, centralization of policies might reduce the long-run economic performance of a country when the government's focus is short-run performance.

## CENTRAL BANK INDEPENDENCE AND THE ECONOMY—WHAT DO WE KNOW?

This paper began with two questions: Why is the idea of an independent central bank as popular as it is? Are there economic benefits to be gained from having an independent central bank? Unfortunately, the empirical and theoretical studies surveyed do not provide clear answers. The empirical studies find that there is a negative correlation between central bank independence and long-run average inflation. They also show a negative correlation between independence and long-run average government deficits as a percent of GDP. In general, they find no evidence of a positive correlation between output growth and central bank independence. These results all point in the same direction yet do not provide unequivocal evidence that an independent central bank will lower inflation and government deficits and raise a country's output.

In sum, these empirical studies provide evidence of a negative correlation between central bank independence and inflation and central bank independence and fiscal deficits, but they do not provide evidence of causality. Countries with an aversion to inflation may formalize this aversion through the creation of an independent central bank. If this is true, it is the inflation aversion, not the independence of the central bank, that is the primary causal factor behind the low inflation result. The empirical measures themselves are biased toward the finding that

<sup>46</sup>A government may adopt a strategy of running deficits, through decreasing taxes, to force future governments to cut expenditures. Under this strategy, the government would prefer an independent central bank, which will refuse to monetize the deficits and thereby increase the likelihood that fiscal spending will be reduced. See Sargent (1985) for a discussion of this type of strategy.

<sup>47</sup>See Tabellini (1987) and Loewy (1988). In Tabellini's model the government is initially unaware of the preferences of the central bank. In Loewy's model both parties are initially unaware of the preferences of the other.

<sup>48</sup>This issue has been studied in the literature that focuses only on monetary policy. See Blackburn and Christensen (1989) for a survey of this literature.



independence promotes low inflation. This is because the measures place much weight on legal requirements that a central bank pursue price stability and place this goal above all others. Cukierman is explicit in stating that his measure of independence:

is not the independence to do anything that the central bank pleases. It is rather the ability of the bank to stick to the price stability objective even at the cost of other short-term real objectives.<sup>49</sup>

Given such a definition of independence, it is not surprising that independence is equated with low inflation.

Theoretical studies indicate that an independent central bank can increase policy conflicts with the government whenever the preferences of the two differ and, in so doing, worsen the economic performance of a country. These studies, however, do not provide overwhelming support for the idea that countries should place monetary policy in the hands of the executive or legislative branches of government. The simple structure of these models ignores some factors that affect the outcome of policy decisions—for example, the role of the public and the overall credibility of policy. Central bank independence may enhance credibility and thus the overall effectiveness of a policy program.

In sum then, in the empirical studies, emphasis on price stability and freedom to pursue this goal are primary determinants of independence. In the theoretical studies independence is equated with noncooperation between the fiscal and monetary authorities in policy implementation. These different definitions of independence may partly explain the different results. Furthermore, countries that may be classified as independent using the empirical definition may be classified as dependent using the theoretical definition. New Zealand is one such example. The 1989 Reserve Bank of New Zealand Act made price stability the *only* goal of the central bank, and the central bank is free to adopt policies to achieve that goal. Thus according to the empirical definition of independence, the 1989 act created an independent central bank in New Zealand. The central bank's inflation target, however, is established by the government for a multi-year period. The governor of the central bank signs an agreement pledging the bank to adopt policies to meet this target. Such coopera-

tion between the monetary and fiscal policy-makers is consistent with a dependent central bank in the theoretical models.

Altogether these studies indicate that we are far from fully understanding the role of central bank independence in producing favorable economic outcomes.

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<sup>49</sup>See Cukierman (1992), p. 370.



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# **Hypothesis Testing with Near-Unit Roots: The Case of Long-Run Purchasing-Power Parity**

**T**HE HYPOTHESIS THAT the purchasing power of a given currency, like the dollar, will be equal across countries has strong appeal. If the hypothesis is true, then inflation and exchange rate movements will be such that a given currency will, over time, lose equal amounts of its purchasing power in all countries. The sequence of events by which deviations from purchasing-power parity would be eliminated can best be illustrated by example: If the dollar could purchase more goods in other countries than in the United States, then U.S. consumers would purchase more goods from abroad, which would raise the demand for foreign currencies relative to the dollar and lead to a depreciation of the dollar and eventual equalization of the dollar's purchasing power across countries. Despite the intuitive appeal of such arguments for long-run purchasing-power parity, statistical tests have been mixed. This paper argues that previous test results have conflicted because tests of purchasing-power parity have relatively low power under both the null hypothesis that it holds, and the null that it fails. Hence this paper contains tests of both null hypotheses and shows that frequently neither is rejected for monthly data from five major industrialized countries. This result serves as a caution against testing only one null hypothesis, finding that the null hypothesis cannot be rejected for a broad

set of countries and concluding that there is robust evidence for or against the theory of long-run purchasing-power parity.

The theory of long-run purchasing-power parity (PPP) implies that a currency's purchasing power is equal across countries in long-run equilibrium, but does not specify how long deviations from this equilibrium can last. Large and persistent departures from PPP in the last 20 years, however, have cast doubt on the validity of PPP. As we will discuss later, there is a literature which tests whether long-run PPP holds, that is, whether departures from PPP are transitory. This article aims to reconcile some of the disparate results from previous studies by using a long-memory model, which can do more than classify deviations from PPP as temporary or permanent: it can provide specific measures of their persistence. Such measures are useful because large, persistent differences in a currency's purchasing power across countries can greatly affect trade flows and the allocation of resources.

Empirically, long-run PPP holds if the real exchange rate, which equals the nominal exchange rate multiplied by the ratio of the domestic and foreign price levels, is mean-reverting. This article will conform with the majority of the empirical PPP studies by using consumer price indexes



to calculate the real exchange rate. If price indexes measured the prices of identical baskets of goods across countries, absolute PPP would hold if  $P^* = S \times P$ , where  $P$  is the domestic price of the goods basket,  $P^*$  is the foreign price and  $S$  is the exchange rate in terms of units of foreign currency per unit of domestic currency. Because consumer price indexes do not measure the cost of identical baskets of goods across countries, however, relative PPP modifies the relationship to account for the ratio of the values of the two distinct baskets of goods:  $P^* = kSP$ , where  $k$  is the ratio of the value of the foreign basket to the domestic basket. The domestic country's real exchange rate with the foreign country is then  $1/k$  and equals  $SP/P^*$ .<sup>1</sup>

The conventional approach to testing for long-run purchasing-power parity consists of testing for a unit root in the real exchange rate: Long-run PPP holds if the real exchange rate is mean-reverting but not if it has a unit root. Previous tests have shown little power to reject whichever of the two null hypotheses is employed. Tests whose null hypothesis is that the real exchange rate contains a unit root generally fail to reject, whereas tests whose null is that long-run PPP holds also often fail to reject. These disparate findings are reconciled, however, if there is long memory in the real exchange rate, which enables both acceptance and rejection of long-run PPP at conventional significance levels.<sup>2</sup>

This paper employs long-memory models to obtain estimates of the orders of integration of real exchange rates on a continuous scale. The advantage of estimating the order of integration on a continuous scale is that we can confirm that long-memory time series behavior in real exchange rates is a possible source of the discrepancies between previous tests of long-run

PPP. The finding of long memory in real exchange rates also allows us to judge whether the real exchange rate reverts to its mean within an economically meaningful time frame.

## WHY PURCHASING-POWER PARITY MIGHT NOT HOLD

Before discussing statistical tests of PPP, it is worth repeating Engel's (1992) list of possible reasons for the empirical failure of PPP:

1. Barriers to trade such as tariffs and transportation costs.
2. Different consumption preferences across countries.
3. The presence of non-traded goods in price indexes.
4. Prices which are sticky in terms of the currency in which the good is consumed.

Barriers to trade, such as tariffs, are an obvious reason why the same goods do not sell at the same price throughout the world. Different consumption preferences, on the other hand, would lead consumers in each country to choose different baskets of goods. Because price indexes are constructed for baskets of goods designed to represent a particular country's consumption, an apparent failure of PPP could be due to different rates of price inflation across two country's distinctive baskets of consumption goods, rather than different prices for the same goods across countries. When included in price indexes, non-traded goods can also muddle the interpretation of the real exchange rate, because non-traded goods can be idiosyncratic and are thus not directly comparable across countries. Nevertheless consumer price indexes will be used in this paper, despite the presence of non-tradeables, because wholesale price indexes can fail to reflect the underlying rate of inflation accurately.<sup>3</sup> The fourth source of failure, sticky

<sup>1</sup>Summers and Heston (1991) tabulate the costs of nearly-identical baskets of goods across countries, rather than use existing price indexes. They define the PPP nominal exchange rate to be  $P^*/P$  and use this implied exchange rate, rather than the market exchange rate, to make cross-country comparisons. The Summers and Heston measures of the price levels could take the place of commonly used consumer price indexes when testing long-run PPP, as could wholesale price indexes. The Summers and Heston data, however, are only available on an annual basis and include data extrapolated between five year data collection periods. The analysis in this paper will be limited to the use of consumer price indexes to facilitate comparison with previous studies.

<sup>2</sup>Long memory, as will be discussed later, means that the order of integration of a time series process is greater

than zero. If the order of integration is greater than 0.5, the series is not covariance stationary and if the order of integration is greater than one, the series does not have a mean. Long memory is not the same as an autoregressive near-unit root, because a series with a near-unit autoregressive root is still integrated of order zero, and is not considered a long-memory process.

<sup>3</sup>For example the wholesale price index for Japan suggests that Japan has had deflation on average from 1980 to the present, whereas the GDP deflator and CPI show moderate inflation.



prices, can best be explained by an example: Japanese autos sold in Japan and also exported to the United States have sticky prices in yen when sold in Japan and sticky prices in dollars when sold in the United States. Any exchange rate fluctuations would cause the yen (or dollar) price of the same model of car to differ across the Pacific. Thus autos might contribute to the failure of PPP in the true sense: the same good being sold at different prices (net of taxes) across countries.

## PREVIOUS TESTS OF PURCHASING-POWER PARITY

Tests of PPP in the literature can be classified according to many criteria. In this brief review of a large literature, three features will receive attention: 20th century annual data vs. post-1973 monthly data; the use of consumer price indexes versus wholesale price indexes in the calculation of the real exchange rate; and whether or not price levels are assumed to be measured with error.<sup>4</sup> The aim of this review is to illustrate the lack of consensus that has emerged from studies of long-run PPP and identify which modeling choices might have influenced the outcomes of those tests.

Coughlin and Koedijk (1990) conduct unit-root tests on real exchange rates using post-1973 monthly data and consumer prices and find that the unit-root null hypothesis cannot be rejected. They also examine whether the real exchange rates are cointegrated with factors thought to determine the real exchange rate. Cheung and Lai (1993b) use post-1973 monthly data on consumer prices and allow for measurement error in prices. They use a Johansen (1991) likelihood ratio test for cointegrating vectors, in which long-run PPP is the null hypothesis, and generally fail to reject long-run PPP.<sup>5</sup> Thus the studies of Coughlin and Koedijk (1990) and Cheung and Lai (1993b) illustrate the importance of the null hypothesis in testing long-run PPP. Edison and Fisher (1991) and Fisher and Park (1991) represent another pair of studies that differ in the null hypothesis employed and the general conclusions about long-run PPP. Cheung and

Lai (1993a) study 20th century annual data and find evidence that the real exchange rate has long memory, but not a unit root for most countries studied. Pippenger (1993) uses wholesale price indexes and finds evidence that PPP between Switzerland and various countries appears to hold in the long run.

Overall a lack of consensus emerges from empirical tests of long-run PPP. The choice of null hypothesis is one source of discrepancy, and it appears that results from a long-memory model can reconcile the apparently conflicting results of several previous studies of long-run PPP, which differ primarily in their choice of null hypothesis. Consequently, tests of each null hypothesis will be highlighted in the estimation results below.

## TESTING PURCHASING-POWER PARITY

Much research on whether PPP holds in the long run consists of performing a unit-root test on the real exchange rate. It is well known, however, that unit-root tests, especially those having a unit root as the null hypothesis, like Dickey-Fuller, have little power against long-memory alternatives. Such unit-root testing consists of classifying economic variables as either integrated of order zero  $I(0)$  or one  $I(1)$ .<sup>6</sup> In contrast, we use a parametric long-memory model in which data series, like the real exchange rate, are modeled as integrated of order  $d$ , denoted  $I(d)$ , where  $d$  does not have to be an integer. Any series that is integrated of order  $d < 1$  will return eventually to its mean (or its deterministic trend), so shocks to the real exchange rate are not permanent if the real exchange rate is integrated of order  $d < 1$ .

This paper also provides information about the sources of PPP failure by examining the components of the real exchange rate. The ratio of the price levels may have a higher order of fractional integration than the nominal exchange rate, or vice versa. If  $r$  is the real exchange rate,  $s$  is the nominal exchange rate,  $p$  is the domestic price level, and  $p^*$  is the foreign price level (all in natural logs), then  $r = s + (p - p^*)$ . If  $s$  is  $I(d_1)$ ,  $(p - p^*)$  is  $I(d_2)$ , then  $r$  will generally be in-

<sup>4</sup>For a thorough introduction to what the authors call the purchasing-power parity assumption, see Caves, Frankel and Jones (1990).

<sup>5</sup>Provided that the hypothesis of zero cointegrating vectors has been rejected, the null hypothesis for subsequent hypothesis tests using the Johansen procedure is that there is at least one cointegrating vector.

<sup>6</sup>Integration of order one means that a variable's first differences are stationary, whereas its levels are not.



egrated of order  $\max\{d_1, d_2\}$ . If  $r$  is  $I(b)$  where  $b < \max\{d_1, d_2\}$ , then the nominal exchange rate and the price ratio ( $p-p^*$ ) are fractionally cointegrated, that is, they share the same stochastic trend to some extent.<sup>7</sup> The real exchange rate does not have a unit root if  $b < 1$ .

We can also examine the point estimates of  $d_1$  and  $d_2$  and see which component appears to have the strongest trend. This comparison answers critics of flexible exchange rates who argue that floating rates actually have caused the real exchange rate to be less stable than it would have been under fixed nominal exchange rates.<sup>8</sup> If  $d_1 > d_2$ , then shocks to the nominal exchange rate are more persistent than shocks to the relative price levels. The latter is somewhat curious, because proponents of the switch to a flexible exchange rate regime envisioned flexible exchange rates as sources of real exchange rate stability in a world in which countries might have persistent differences in inflation rates. Yet if shocks to the nominal exchange rate are more persistent than shocks to the relative price levels, then the nominal exchange rate has persistence above what is potentially useful in reducing the variance of the real exchange rate. In the empirical results that follow, the possibility of excess persistence in the nominal exchange rate will be examined.

## BACKGROUND ON LONG-MEMORY MODELS

For many time series, autoregressive moving-average (ARMA) models serve as a parsimonious way to summarize the autocovariance structure of the data. One limitation of such models is that ARMA processes are integrated of order zero, and the autocovariances die off relatively quickly, even when a root in the autoregressive polynomial is near one. Thus ARMA models can be called short-memory models, because a shock affects the level of the series for a relatively short time.

Long-memory models, in contrast, are suitable for data that have slowly decaying coefficients

in their moving-average representations. The fractional ARMA model can serve as a long-memory model, yet it adds only one parameter to a standard ARMA model. To illustrate, we begin with a simple ARMA(1,1) applied to the first difference of a data series  $y$ , where  $L$  is the lag operator,  $\varepsilon$  is a mean-zero disturbance,  $\rho$  is the AR coefficient, and  $\theta$  is the MA coefficient:

$$(1) (1 - \rho L)(1 - L)y = (1 + \theta L)\varepsilon$$

A fractional ARMA model is simply an ARMA model applied to fractionally differenced data:

$$(2) (1 - \rho L)(1 - L)^d y = (1 + \theta L)\varepsilon$$

The fractional differencing operator is evaluated by taking a Taylor series expansion around  $L=0$ :<sup>9</sup>

$$(3) (1 - L)^d = 1 - dL + \frac{d(d-1)L^2}{2} - \frac{d(d-1)(d-2)L^3}{3!} + \dots$$

Two characteristics of fractionally integrated data are worth noting. First, a series that is integrated of order  $d$  ( $I(d)$ ) with  $d < 1$  reverts to its mean (or at least to its deterministic trend). Second, if  $d < .5$ , the series is covariance stationary. At first glance, it might seem counter-intuitive that a mean-reverting series can fail to be covariance stationary. With long memory, however, the departures from the mean can be sufficiently persistent that the variance of the series is infinite.

Furthermore, two commonly assumed data-generating processes fit within the subset of fractional integration: trend and difference stationarity. Fractional integration offers a bridge between the controversial assignment of a data series as either trend or difference stationary, so that questions about stationarity assumptions

<sup>7</sup>For reasons outlined below, the restriction that the coefficients on  $s$  and  $(p-p^*)$  equal one is relaxed, so that the order of integration of a general linear (cointegrating) combination of  $s$ ,  $p$  and  $p^*$  is assumed to be the order of integration of the real exchange rate. The concept of cointegration has been generalized [Granger (1986)] to include cases in which series have stochastic trends that only partially offset each other. This is called fractional cointegration. Originally, cointegration meant that a partic-

ular linear combination of two strongly trending series was  $I(0)$ .

<sup>8</sup>For example, Aliber (1993) notes that "the U.S. dollar appreciated from 1979 to 1985 even though the U.S. inflation rate was higher than the inflation rates in Germany and Japan."

<sup>9</sup>The concept of fractional differencing was developed by Granger and Joyeux (1980) and Hosking (1981).



may be avoided. For example, if  $y$  is trend stationary, we might model  $y$  as

$$(4) y_t = \mu t + \varepsilon_t$$

In differences, equation (4) looks like

$$(5) (1-L)y_t = \mu + (1-L)\varepsilon_t$$

If  $y$  is difference stationary, then

$$(6) (1-L)y_t = \mu + \varepsilon_t$$

Now suppose that  $y$  is fractionally integrated of order  $d$ . The first differences of  $y$  are then equal to

$$(7) (1-L)y_t = \tilde{\mu} + (1-L)^{1-d}\varepsilon_t$$

where  $\tilde{\mu}$  is proportional to  $\mu$ . Clearly trend stationarity ( $d=0$ ) and difference stationarity ( $d=1$ ) are bridged by fractional integration, which allows for intermediate cases. An intuitive way to understand why fractional integration is an intermediate case between trend and difference stationarity is to interpret each shock in a difference-stationary process to be a permanent shift away from any previous trend; a shock in a trend-stationary process is a short-lasting shift from the trend; a shock in a fractionally integrated process is a long-lasting shift from the trend. This paper uses estimates of the order of fractional integration to discriminate, if possible, between long-lasting shifts from the mean real exchange rate and permanent shifts in the real exchange rate (the unit-root case).

## ESTIMATES OF LONG MEMORY IN REAL EXCHANGE RATES

The data used in this article consist of 234 monthly observations of the nominal exchange rates and consumer price indexes for the United States, Great Britain, Germany and Japan from June 1973 to November 1992.<sup>10</sup> Thus six bilateral relationships will be examined.

Fractional ARMA models are used to estimate the orders of integration of the nominal exchange rates, the ratios of the price levels and

the real exchange rates. The general form of the fractional ARMA model is

$$(8) A(L)(1-L)^d y_t = B(L)\varepsilon_t$$

where  $y$  is  $I(d)$  and  $\varepsilon$  is assumed to have zero mean, no serial correlation and variance  $\sigma^2$ .  $A(L)$  is an autoregressive polynomial of order  $p$  and  $B(L)$  is a moving-average polynomial of order  $q$ :

$$(9) A(L) = 1 - \rho_1 L - \rho_2 L^2 - \dots - \rho_p L^p$$

$$(10) B(L) = 1 + \theta_1 L + \theta_2 L^2 + \dots + \theta_q L^q$$

Estimation was carried out using the Fox and Taqqu (1986) frequency-domain estimator of fractional ARMA models. The estimator is based on an approximation to the likelihood. Dahlhaus (1988, 1989) has analyzed the Fox and Taqqu estimator and has shown that it shares the same asymptotic efficiency as exact maximum-likelihood estimation. Further details regarding the estimator appear in the appendix.

Before presenting estimation results, we must discuss how the real exchange rate was calculated. Any mismeasurement of the price levels can lead to spurious changes in the mean of the real exchange rate and bias tests toward rejection of long-run PPP. To minimize the possibility of spurious rejections of long-run PPP, the real exchange rate was calculated by estimating a fractionally cointegrating relationship between the nominal exchange rate ( $s$ ), the domestic price level ( $p$ ) and the foreign price level ( $p^*$ ):<sup>11</sup>

$$(11) s_t = \alpha_0 - \alpha_1 p_t + \alpha_2 p_t^* + \varepsilon_t$$

The residuals from equation (11) were then treated as the real exchange rate for unit-root testing with the fractional ARMA model. Cheung and Lai (1993b) and Pippenger (1993) also estimate a general cointegrating relationship, rather than impose  $\alpha_1 = \alpha_2 = 1$ . They both argue that, because of measurement error in price indexes and unequal weights attached to the same good in different indexes, it is undesirable to impose unit coefficients on the price indexes when studying whether the real exchange rate is mean-reverting. The Phillips and Hansen (1990)

<sup>10</sup>Koedijk and Schotman (1989) find that the real exchange rates between 15 industrialized countries are fairly well spanned by the real exchange rates between the United States, Japan, Germany and Great Britain.

<sup>11</sup>Cheung and Lai (1993a) discuss the asymptotic theory behind estimating regressions where the residuals are fractionally integrated.



Table 1  
Estimated Orders of Integration

Countries	Real exchange rate (b)	t-statistic for 1-b	Nominal exchange rate (d1)	Price ratio (d2)
United States–United Kingdom	1.06 (.039)	–1.54	1.12 (.031)	1.60 (.043)
United States–Germany	.903 (.067)	1.45	1.17 (.028)	1.21 (.081)
United States–Japan	1.24 (.067)	–3.58	1.22 (.070)	1.62 (.080)
United Kingdom–Germany	.872 (.047)	2.72	1.01 (.052)	1.57 (.079)
United Kingdom–Japan	1.19 (.034)	–5.59	1.15 (.039)	1.12 (.039)
Germany–Japan	1.13 (.207)	–.628	1.19 (.142)	1.50 (.091)

NOTE: Standard errors are in parentheses.

method of estimating cointegrating relationships was used for equation (11). This method accounts for simultaneity in the determination of left- and right-hand side variables. Cheung and Lai (1993b) suggest using estimation procedures that take into account interactions between left- and right-hand side variables. In fact, the Phillips-Hansen estimates of  $\alpha_1$  and  $\alpha_2$  indicate that they should not be restricted to equal one. For example, for the nominal exchange rate between Britain and the United States, the estimates of  $\alpha_1$  and  $\alpha_2$  are 1.45 and 1.22, respectively.

The next point of focus is the null hypothesis to be tested: PPP holds as the null hypothesis if the hypothesis that  $b < 1$ , where  $b$  is the order of integration of the real exchange rate, is not rejected; the alternative null hypothesis that PPP fails is not rejected if the null that  $b \geq 1$  is not rejected. Using the fractional ARMA model, it is easy to test both null hypotheses and show how the results depend on the choice of the null.

Table 1 contains the main results on the estimated orders of integration of the relevant series. Simple t-tests can be used to test for long-run PPP by dividing one minus the estimated order of integration of the real exchange rate by its standard error. Doing this, we see that the null hypothesis that  $b < 1$ , where  $b$  is

the order of integration of the real exchange rate, is rejected for only two of the six pairs: United States/Japan and Britain/Japan. These are the significantly negative t-statistics in table 1. Thus long-run PPP is not rejected as a null hypothesis in four of six cases. If we reverse the null, however, we can reject the null that  $b \geq 1$  for only one pair: Britain/Germany.<sup>12</sup> This is the significantly positive t-statistic in table 1. The results for United States/Germany are borderline with a t-statistic of 1.45, but this is not significant at the usual 5 percent level of significance in a one-tailed t-test, where the critical value is 1.658.

Overall, the orders of integration of real exchange rates are often close enough to one that neither null hypothesis is rejected. This explains some discrepancies between past tests of long-run PPP. Coughlin and Koedijk (1990) used Dickey-Fuller unit-root tests on real exchange rates and could not reject the null that long-run PPP fails to hold. Cheung and Lai (1993b), on the other hand, tested the null that long-run PPP holds and did not find many rejections of long-run PPP. The results from the long-memory model reconcile these findings.

The estimates from the long-memory models do more than give unit root tests, however, by

<sup>12</sup>Orders of integration greater than one for data in logs imply that the growth rates of the series have long memory.



providing an estimate of the order of integration of the real exchange rate on a continuous scale. Whichever null is used, one result is clear: Even if long-run PPP holds, it is very slow in developing. Assuming that the order of integration of the real exchange rate is 0.9, 73 percent of a shock is still present after 12 months; 68 percent after 24 months; 65 percent after 36 months; and 63 percent after 48 months. As a practical matter, it seems fair to conclude that PPP does not hold within a time horizon that is economically relevant. Uncovering this type of information is the chief advantage of estimating the order of integration on a continuous scale. With other unit-root testing methods, we are forced to view a series as being either  $I(0)$  or  $I(1)$ . Such a polar characterization may not provide practical information about the persistence of the shocks.

Table 1 also provides information about the persistence of shocks to the nominal exchange rate relative to shocks to the ratio of the price levels. In five of six cases, point estimates suggest that the nominal exchange rate has a lower order of integration than the price ratio.<sup>13</sup> For Britain/Japan the point estimate of the order of integration is 1.15 for the nominal exchange rate vs. 1.12 for the price ratio, but this difference does not appear to be statistically significant.<sup>14</sup> Thus the conjecture that nominal exchange rates in the post-Bretton Woods era have shown excess persistence appears to be false. In general, greater persistence in the nominal rate would be needed to offset the persistence in the price ratios for the real exchange rate to be rendered  $I(0)$ . This is because no  $I(0)$  linear combination can exist, for example, between a series that is  $I(.8)$  and one that is  $I(.2)$ . The series that is  $I(.2)$  does not have enough of a trend with which to offset the relatively strong trend in the variable that is  $I(.8)$ .

Another finding from table 1 is that inflation differentials are fractionally cointegrated in some cases. For example, the estimates indicate that  $(p_{US} - p_{JPN})$  is  $I(1.62)$  and  $(p_{US} - p_{UK})$  is  $I(1.60)$ , but the difference  $(p_{UK} - p_{JPN})$  is only  $I(1.12)$ . This means that the inflation differentials between the United States and Britain and between the

United States and Japan appear much more persistent than the inflation differential between Britain and Japan. In other words, inflation rates in Britain and Japan come closer to sharing a common trend with each other than with inflation in the United States.

Tables 2 through 4 report the fractional ARMA parameter estimates fully only for the bilateral relationships for the United States for the sake of brevity. The key result in these tables is that in fractional ARMA models the fractional differencing parameter can capture the long-run behavior of the data, freeing AR parameters to match the short-run dynamics. If, on the other hand, an ARMA model instead of a fractional ARMA model were fit to the data, the autoregressive polynomial would be forced to have a near-unit root.

In table 2 several AR parameters are negative, and the largest equals 0.53 in the fractional ARMA model of the ratio of the price levels between the United States and Britain. In table 3 both estimated AR parameters for the nominal exchange rate between the United States and Germany are negative, implying that all positive dependence in the exchange rate beyond the first lag is due to the large positive value of the fractional-differencing parameter. The largest root in an AR polynomial in table 3 is 0.37, which is far from the unit circle, in the real exchange rate between the United States and Germany. Estimates of the model of the real exchange rate between the United States and Japan, found in table 4, also show two negative AR coefficients. In fact all of the AR polynomials in table 4 have roots with real parts that are very far from the unit circle. They are  $-.05$ ,  $-.03$ , and  $.08$ , respectively, for the real exchange rate, the nominal exchange rate and the price ratio. With the inclusion of the fractional differencing parameter, the AR parameters can take values which allow the fractional ARMA model to capture both long-run dependence and short-run dynamics in the data. The shaded insert and figures 1 through 3 provide a visual check of the match between the covariance structure of the data and that implied by the estimated fractional ARMA model.

<sup>13</sup>An order of integration above one for variables in logs means that the growth rates display long memory. In the case of the price ratio, the corresponding growth rate is the inflation differential across the two countries. For the nominal exchange rate, it is the rate of exchange rate appreciation.

<sup>14</sup>A formal test would require joint estimates of the two fractional ARMA models, however.



Table 2

**Fractional ARMA Models: United States-United Kingdom**

Real Exchange Rate			
	Parameter	Parameter value	Standard error
Order of integration	$b$	1.06	.039
AR	$\rho_1$	-.228	.096
	$\rho_2$	.012	.063
MA	$\theta_1$	.534	.084
Nominal Exchange Rate			
Order of integration	$d_1$	1.12	.031
AR	$\rho_1$	-.161	.100
	$\rho_2$	.002	.045
MA	$\theta_1$	.452	.090
Ratio of Price Levels			
Order of integration	$d_2$	1.60	.043
AR	$\rho_1$	.529	.051
	$\rho_2$	-.089	.043
MA	$\theta_1$	-.809	.027

Table 3

**Fractional ARMA Models: United States-Germany**

Real Exchange Rate			
	Parameter	Parameter value	Standard error
Order of integration	$b$	.903	.067
AR	$\rho_1$	.508	.132
	$\rho_2$	-.050	.060
MA	$\theta_1$	-.176	.140
Nominal Exchange Rate			
Order of integration	$d_1$	1.17	.028
AR	$\rho_1$	-.332	.099
	$\rho_2$	-.017	.039
MA	$\theta_1$	.463	.105
Ratio of Price Levels			
Order of integration	$d_2$	1.21	.081
AR	$\rho_1$	.326	.162
	$\rho_2$	.044	.071
MA	$\theta_1$	-.127	.134



Table 4

**Fractional ARMA Models: United States-Japan**

Real Exchange Rate			
	Parameter	Parameter value	Standard error
Order of integration	$b$	1.24	.067
AR	$\rho_1$	-.105	.126
	$\rho_2$	-.191	.066
MA	$\theta_1$	-.224	.172
Nominal Exchange Rate			
Order of integration	$d_1$	1.22	.070
AR	$\rho_1$	-.065	.113
	$\rho_2$	-.174	.073
MA	$\theta_1$	.226	.150
Ratio of Price Levels			
Order of integration	$d_2$	1.62	.080
AR	$\rho_1$	.159	.108
	$\rho_2$	-.288	.058
MA	$\theta_1$	-.749	.019

## A Visual Check of the Results

Once a fractional ARMA model has been estimated, a visual diagnostic check of the adequacy of the specification and estimates can be obtained by looking at a plot of the periodogram of the data alongside a plot of the spectral density implied by the specified fractional ARMA model. If the model fits the data well, the two graphs will have the same general turning points. The area under the spectral density equals the variance. Thus the height of the spectral density at any point indicates how much of the variance is due to cycles of that frequency. In this way, the spectral density summarizes the autocovariance structure. Figures 1 through 3 provide a look at the three data series for the United States/Germany: the real exchange rate, the nominal exchange rate and the price ratio. The figures show that the estimated fractional ARMA models roughly envelope the smoothed

periodograms. Figure 1 shows why the outcome of the unit root test on the U.S./Germany real exchange rate is borderline: It is unclear whether the upturn in the smoothed periodogram at very low frequencies is significant or whether the point estimate of a negative order of integration for the differenced real exchange rate is correct.<sup>1</sup> One other thing to note is that without ARMA parameters the model would be able to fit only series that have globally concave (or globally convex) spectral densities.<sup>2</sup> With ARMA parameters, however, figure 1 illustrates that a fractional ARMA can generate turning points in the spectral density. The best-fitting globally concave spectral density would obviously provide a much less satisfactory fit of the U.S./Germany real exchange rate than the one with turning points shown in figure 1.

<sup>1</sup>In theory the distinction is clear: A series with a negative order of fractional integration will have a spectral density value of zero at frequency zero; a series with a positive order of fractional integration will have a spectral density value of infinity at frequency zero. For figures 2 and 3, it is clear from the periodogram that the series have positive orders of integration. This is not clear for the real exchange rate in figure 1.

<sup>2</sup>Without ARMA parameters, the fractional ARMA model is called the fractional noise model. Its spectral density is globally concave if the fractional differencing parameter from equation (2) is negative; it is globally convex if the fractional differencing parameter is positive.



Figure 1

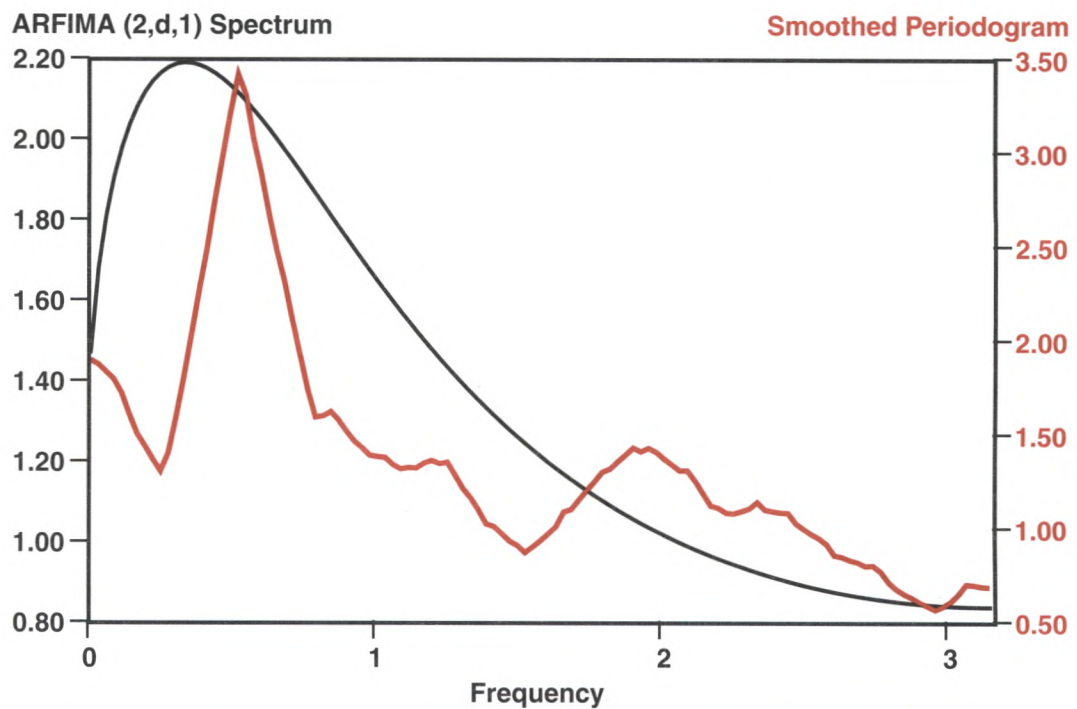
**Spectrum of Differenced Real Exchange Rate: U.S./Germany**

Figure 2

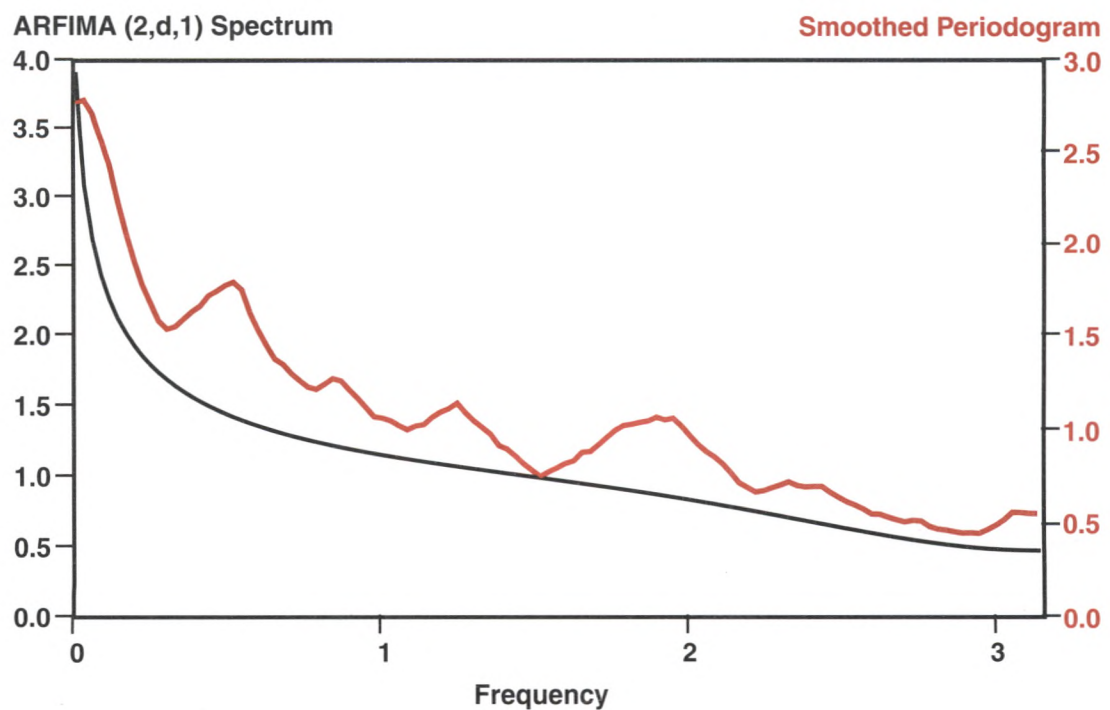
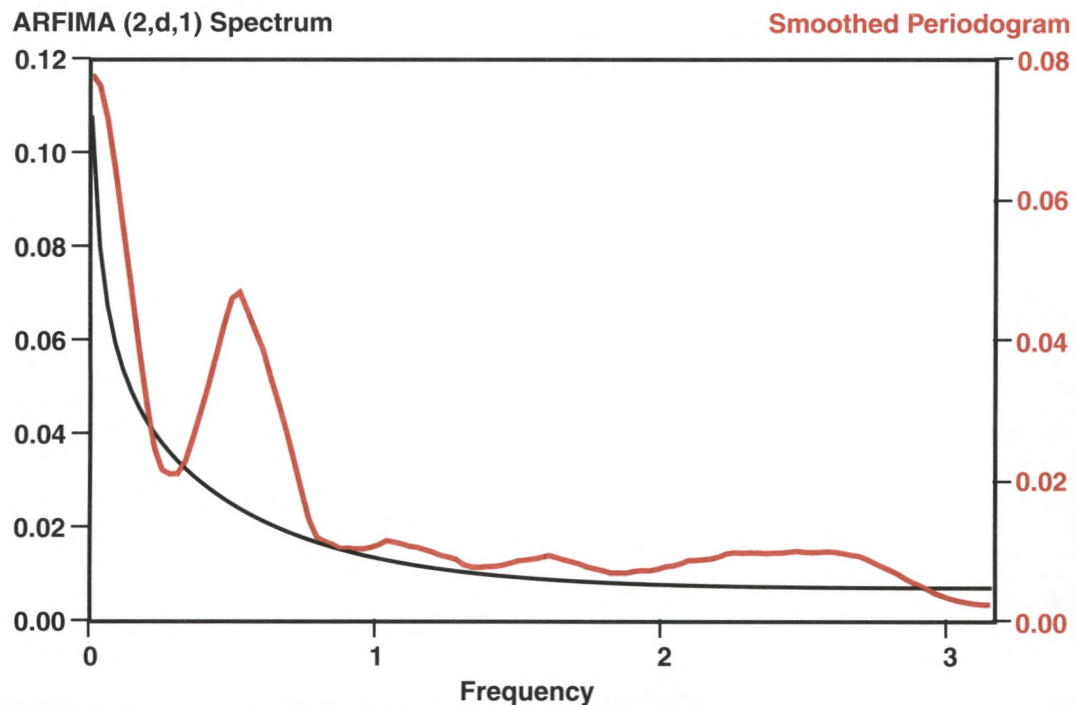
**Spectrum of Differenced Nominal Exchange Rate: U.S./Germany**



Figure 3  
Spectrum of Differenced Price Level Ratio: U.S./Germany



## CONCLUSIONS

This article illustrates the key role played by the null hypothesis in testing for unit roots in real exchange rates. If  $b$  is the order of integration of the real exchange rate, then the null that  $b \geq 1$  is difficult to reject, in which case one would presume that long-run purchasing-power parity does not hold. When the null is that  $b < 1$ , we also find few rejections, so long-run PPP apparently holds. When this type of ambiguity appears, it is helpful to estimate the order of integration on a continuous scale. The fractional ARMA models presented here do this and the standard errors on  $b$  for the six real exchange rates studied show that even if  $b < 1$ , it is not far enough away from one to make a strong case that purchasing-power parity is empirically relevant.

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## Appendix: The Fox and Taqqu Estimator

Dahlhaus (1988) discusses why the Fox and Taqqu (1986) frequency domain estimator is an approximate maximum-likelihood estimator, sharing the same optimality properties as exact maximum-likelihood estimation. The Fox and Taqqu estimator is derived from the following minimization problem:

$$(12) \min \sum_k \left[ \ln(\sigma^2 f(\lambda_k; \theta)) + \frac{I(\lambda_k)}{\sigma^2 f(\lambda_k; \theta)} \right]$$

where  $I(\lambda_k)$  is the vector of periodogram ordinates of the data and  $\sigma^2 f(\lambda_k)$  is the spectral

density function implied by the parameterized model. For the fractional ARMA model in equation (8), the spectral density equals

$$(13) f(\lambda) = \frac{|B(e^{i\lambda})|^2}{|A(e^{i\lambda})|^2} (1 - e^{i\lambda})^{-d} (1 - e^{-i\lambda})^{-d},$$

where  $A$  and  $B$  are polynomials defined in equations (9) and (10). The objective function is minimized with respect to  $\theta$  and  $\sigma^2$ . An intuitive description of the objective function is that one wants to choose parameters that will make the spectral density function implied by the model look like the periodogram of the data.



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# ***The Effect of Mortgage Refinancing on Money Demand and the Monetary Aggregates***

**M**ONEY SERVES AS A medium of exchange for transactions involving financial instruments as well as real goods and services. Unfortunately, the total volume of transactions in the economy is not observable. As a result, economic analyses of money demand typically focus on the relationship between the quantity of money demanded and the production of new goods and services, measured by either gross domestic product or personal consumption expenditures. Because aggregate volumes of financial and nonfinancial transactions likely move in parallel with the output of new goods and services, the use of output rather than the volume of transactions may cost little in terms of understanding movements in the monetary aggregates. In some periods, however, events occur which remind us that this is not always the case. This article examines the effect of one such ongoing recent event—the refinancing of residential mortgages—on money demand.<sup>1</sup>

Simple models of the demand for money as a medium of exchange often implicitly assume that the purchase or sale of a good or service is completed within a relatively brief period. Unlike the transactions in these models, the refinancing of a residential mortgage that has been securitized in the secondary market initiates a sequence of transactions that may continue for four to six weeks, or more. During this time, the quantity of liquid deposits demanded increases. When the last transaction in the sequence is concluded, the quantity of deposits demanded falls back *ceteris paribus* to its earlier level.

Mortgage refinancing is an important phenomenon in the United States because most homes are financed with long-term, fixed-rate amortized mortgages that contain a “put” option, allowing the borrower to repay the outstanding principal amount of the loan at any time without penalty. Homeowners typically exercise that option when mortgage rates fall significantly (1-2 percentage

<sup>1</sup>Other recent examples include the Tax Reform Act of 1986, which boosted household liquid deposits in late 1986 and early 1987, and the closure of large numbers of thrifts by the Resolution Trust Corporation. Recognizing that special factors can significantly distort growth of the monetary aggregates, the Bach commission recommended that the Federal Reserve regularly undertake and publish studies of the effects of special factors; see Report of the Advisory

Committee on Monetary Statistics (1976). The Bank of England regularly publishes such analyses; see Pepper (1992, 1993) and Topping and Bishop (1989).



points) below recent previous levels by taking out a new mortgage loan to repay the old. As shown in figure 1,<sup>2</sup> extensive mortgage refinancing has occurred during two periods in the last decade, 1986–87 and 1991–93. In the former, an initial surge in refinancing during 1986 was interrupted by a pause, before fears of rising market rates launched a second round in 1987. In the latter, three waves of refinancing—of increasing magnitude—mirrored the halting fall in long-term market interest rates. During 1992, for example, nearly one-fifth of all homeowners refinanced their mortgages.<sup>3</sup> In 1993, the volume of refinancing activity will surpass 1992's record pace.

The next section of this article describes the changes in the growth and volatility of liquid deposits and M1 that have occurred during periods of extensive mortgage refinancing. The article then examines the extent to which these changes may be related to increases in mortgage securitization. Finally, it explores whether recent fluctuations in the growth of other checkable deposits (OCDs) since 1991 also may be related to mortgage refinancing.

## MORTGAGE REFINANCING AND MONEY DEMAND

The increases in liquid deposits that have accompanied accelerations in mortgage refinancing since mid-1990 are shown in figure 2. The link between mortgage refinancing and liquid deposit growth is a stock adjustment process wherein the stock of liquid deposits responds to changes in the flow of refinancings. When the pace of mortgage refinancing increases, as it did

during late 1991, the third quarter of 1992 and the second quarter of 1993, liquid deposit growth accelerates. As refinancings continue at the higher rate, deposit levels converge to the new desired level and deposit growth slows. When refinancing activity subsides—as in mid-1992 and early 1993—liquid deposit growth slows further and deposits may run off.

Through its effect on liquid deposits, mortgage refinancing sharply increased the volatility of M1 during both 1986–87 and 1991–93, as shown in figure 3.<sup>4</sup> At the same time, the volatility of the broader aggregate M2, shown in figure 4, apparently was only slightly affected. In large part, the lower sensitivity of M2 to mortgage refinancing reflects the much smaller share of transaction deposits in M2 (about 20 percent) than in M1 (about 70 percent). The small changes that do appear in the volatility of M2 closely resemble changes in its non-M1 component.<sup>5</sup>

The ability of increases in mortgage refinancing to affect the level and volatility of liquid deposits and M1 is in part due to the borrowed reserves operating procedure used by the Federal Reserve to control the growth of M2. During the last decade, this operating procedure has largely evolved into one that closely stabilizes the federal funds rate about a level thought to be consistent with the desired amount of discount window borrowing and the growth of M2. To maintain the desired levels of the federal funds rate and discount window borrowing, transitory increases in the demand for reserves are automatically accommodated with increases in the supply of nonborrowed reserves.<sup>6</sup>

<sup>2</sup>In the figure, the volume of refinancing activity is proxied by liquidations of mortgage-backed securities. This concept is explored further in this article.

<sup>3</sup>Nineteen percent of the homeowners interviewed in Fannie Mae's 1993 national housing survey had last refinanced their mortgage between January 1992 and March 1993. An additional 3 percent had refinanced during 1991 and 1990.

<sup>4</sup>The coefficient of variation shown in the figure equals the ratio of the standard deviation to the mean of the series, each calculated from the most recent 12 months of data. The coefficient of variation indicates whether the variability of the data has increased or decreased over time relative to its average level.

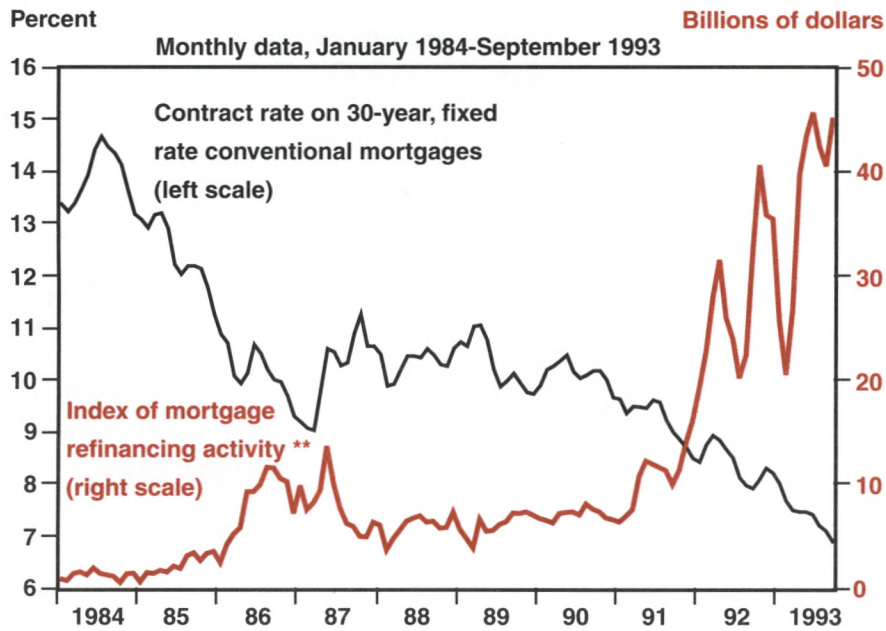
<sup>5</sup>The volatility of M2 differs little from that of its non-M1 component. It is feasible that banks' cash management practices might account for the insensitivity of M2 volatility. Increases in liquid deposits provide additional funds to banks. If bank cash managers respond by reducing their issuance of overnight repurchases (RPs), the change in the volatility of M2 might be considerably less than that of M1.

No such correlations between refinancing-related deposit inflows and nontransaction funding sources are apparent in the data, however.

<sup>6</sup>For an analysis of the borrowed reserves procedure and its relationship to federal funds rate targeting, see Thornton (1988). For a careful discussion of why and how reserves-based targeting procedures evolve into federal funds rate targets, see Meulendyke (1990).

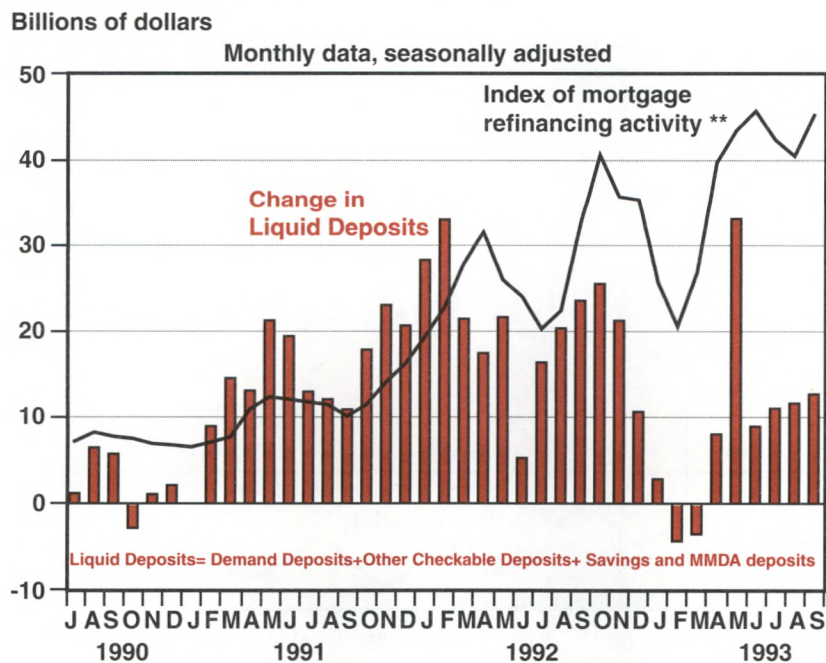


Figure 1  
Mortgage Interest Rate and Refinancing Activity



\*\* Liquidations of federal-agency-guaranteed mortgage-backed securities.

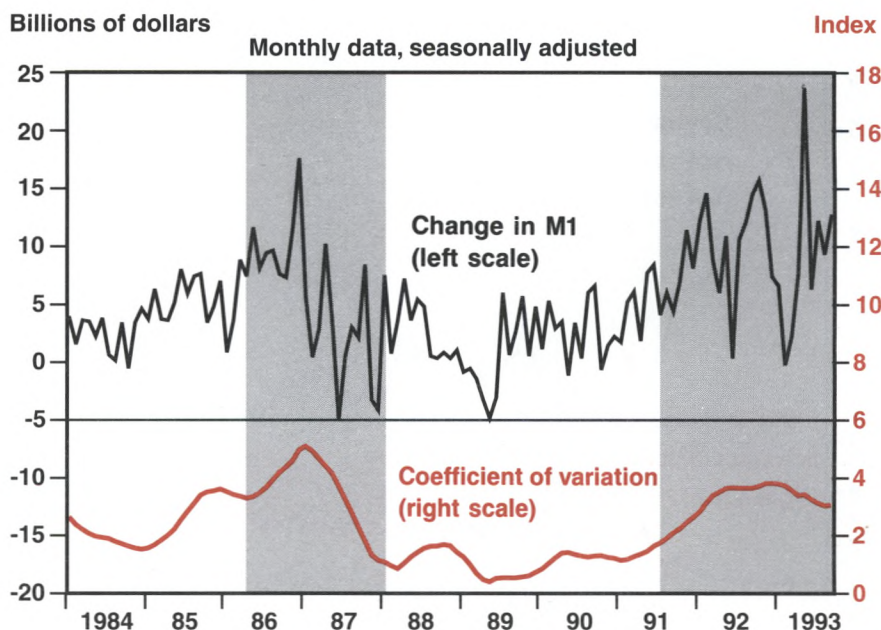
Figure 2  
Refinancing Activity and Liquid Deposits



\*\* Liquidations of federal-agency-guaranteed mortgage-backed securities.

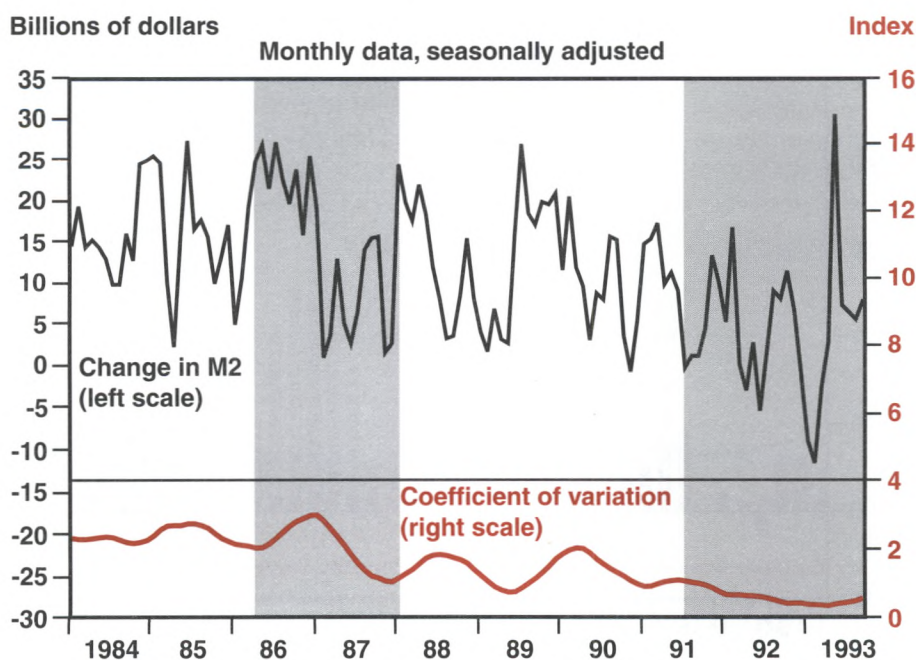


Figure 3  
Refinancing and the Volatility of M1



Shaded areas are periods of heavy refinancing activity.

Figure 4  
Refinancing and the Volatility of M2



Shaded areas are periods of heavy refinancing activity.



## THE ROLE OF MORTGAGE SECURITIZATION

The increase in mortgage securitization during the last decade has increased the potential for mortgage refinancing to affect the growth of the monetary aggregates.<sup>7</sup> The sale of mortgages in the secondary market creates an additional financial instrument—the mortgage-backed security, or MBS—and involves a number of additional firms in the mortgage process, including the originators of the mortgages, the assembler of the mortgage pool (who also issues the MBSs), the servicer of the mortgage pool (who collects monthly payments and disburses funds to investors) and, typically, at least one government agency. The refinancing of securitized mortgages thus becomes a circuitous calling and refunding of relatively large amounts of long-term, publicly held debt. Elevated levels of liquid deposits may persist for four to six weeks or more, until all related transactions are settled.

Legally, mortgage securitization entails combining a fixed pool of mortgages into a trust. The mortgages serve as collateral for MBSs sold against the trust. The servicer of the MBSs, as a trustee, collects payments from homeowners and passes them through without taxation to the holders of the MBSs. Liquidity of the MBSs is enhanced by obtaining a third-party guarantee covering the payments that will be due to investors if homeowners pay at the scheduled, minimum contract rate. Three federal-government-sponsored enterprises, known as “agencies,” dominate that business.<sup>8</sup> For a fee, these agencies guarantee the payment of principal and interest on securities backed by pools of specified mortgages. The Government National Mortgage Association (Ginnie Mae, or GNMA),

a part of the Department of Housing and Urban Development, guarantees payments on MBSs backed by pools of Federal Housing Administration (FHA) and Veterans Administration (VA) mortgages. The Federal National Mortgage Association (Fannie Mae, or FNMA), a federally chartered, privately owned stock corporation, and the Federal Home Loan Mortgage Corporation (Freddie Mac, or FHLMC), a wholly owned subsidiary of the federally chartered Federal Home Loan Bank System, guarantee payments on MBSs backed by pools of conventional mortgages.<sup>9</sup>

Absent refinancings or home sales, MBS investors receive a monthly payment that includes the scheduled amortization of the pool's mortgage principal plus the accumulated interest. Refinancings, home sales and an occasional extra payment by a homeowner return additional (or unscheduled) principal pro rata to the holders of the MBSs backed by that mortgage pool. The monthly liquidation for a mortgage pool is the sum of the scheduled and unscheduled principal payments returned to investors. Note that MBSs aren't “called” in the traditional sense associated with corporate bonds, but rather are only proportionately liquidated or repaid.

As shown in the upper panel of figure 5, the outstanding stock of MBSs increased about six fold during the last decade, much more rapidly than M1 or M2. With few changes in mortgage servicing rules and practices during the last decade, the rapid growth of securitization suggests that the transactions incurred in refinancing securitized mortgages will have larger effects on the monetary aggregates in the 1990s than they did in the mid-1980s. Annual liquidations of MBSs, shown in the lower panel of the figure,

<sup>7</sup>See Duca (1990) for an analysis of the interactions between demand deposits and mortgage refinancing during 1986–87.

<sup>8</sup>A small amount of MBSs is issued without agency guarantees. Bank of America issued the first such private mortgage pool in 1977. In 1992, private mortgage pools represented only 8 percent of all outstanding pools. For background, see Downs (1985) and Pavel (1986).

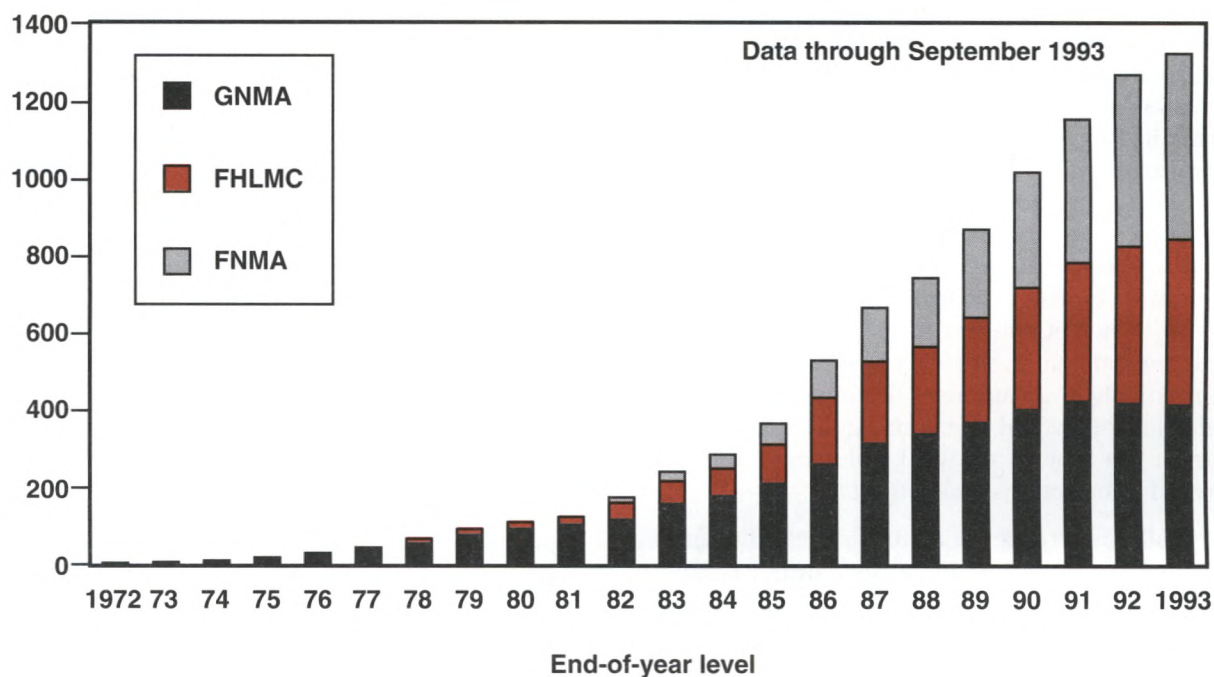
<sup>9</sup>The precise nature of the guarantee varies somewhat by agency. GNMA and FNMA guarantee timely (within the month) payment of principal and interest, regardless of payments by the borrower. FHLMC guarantees timely payment of interest and eventual (within the year) payment of principal. In addition to issuing guarantees on MBSs backed by privately assembled mortgage pools, FNMA and FHLMC may purchase mortgages outright and market MBSs backed by pools of those mortgages. In 1992, for example, FNMA “issued” (guaranteed) \$194 billion in MBSs. Of that amount, about \$13 billion were originated by FNMA itself;

the balance was originated by private lenders under a FNMA guarantee plan. FNMA's 1992 *Annual Report* emphasizes the off-balance-sheet contingent risk nature of these securities: “MBS are not assets of the corporation [FNMA], except when acquired for investment purposes, nor are the related outstanding securities recorded as liabilities. However, the corporation is liable under its guarantee to make timely payment of principal and interest to investors. The issuance of MBSs creates guaranty fee income with Fannie Mae assuming credit risk, but without assuming any debt refinancing risk on the underlying pooled mortgages.” In 1992, FNMA recorded \$834 million in guaranty fees.



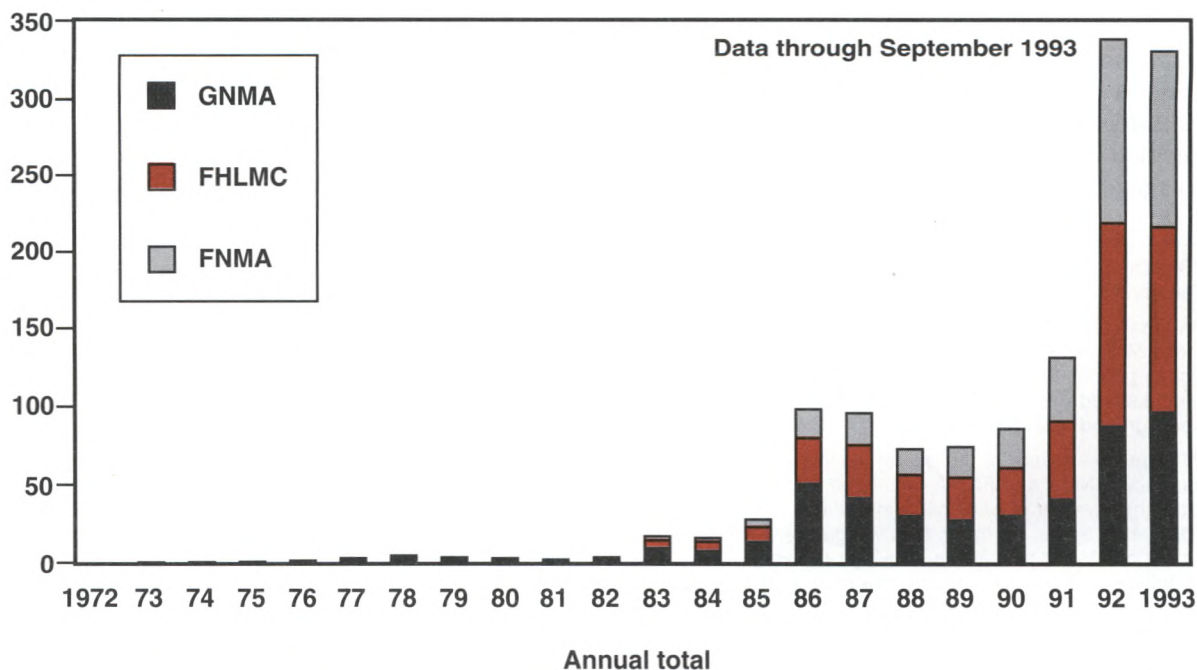
Figure 5  
Mortgage-Backed Securities Outstanding at Year-End

Billions of dollars



### Annual Liquidations of Mortgage-Backed Securities

Billions of dollars





have on balance increased in proportion to the outstanding stock except for significant surges during periods of refinancing. Annual liquidations jumped to about 17 percent of the outstanding stock of MBSs during 1986–87 and 19 percent during 1991–92. More recently, liquidations during June through September 1993 averaged nearly \$44 billion a month, almost a 40 percent annual rate. Recent further decreases in mortgage rates portend continuing high liquidation rates during late 1993 and early 1994.<sup>10</sup>

The increase in deposits that follows an increase in mortgage refinancing activity may in part be traced to the mechanics of mortgage securitization and servicing. Mortgage servicers' handling of the unscheduled principal payments associated with refinancings is governed by the rules of the federal agency that guarantees the MBSs issued against the mortgage pool. In general, these rules require that mortgage servicers hold unscheduled principal payments in special custodial accounts during the interval between receipt from homeowners and disbursement to MBS investors. GNMA requires that these custodial accounts be non-interest-bearing demand deposits. FNMA allows funds to be held in interest-bearing accounts as long as they are immediately available without prior notice of withdrawal. FHLMC's rules are similar to FNMA's.

A surge in refinancing greatly increases the monthly average amount of funds held in liquid deposits by a mortgage servicer. In a typical month without refinancing, a servicer holds a homeowner's mortgage payment for a relatively brief period of time (up to 15 days) before remittance to investors. Following a mortgage refinancing, however, the servicer will hold the unpaid principal balance of the extinguished mortgage loan—an amount perhaps 10 to 100 (or more) times as large as the homeowner's regular monthly principal payment—in a custodial account for a much longer period, often

two to six weeks (see the shaded insert).<sup>11</sup>

Estimates of the size of this effect on monthly growth rates of demand deposits, M1 and M2, are shown in figure 6.<sup>12</sup> When MBS liquidations accelerate, the growth rates of demand deposits and M1 after removing the MBS effect are smaller than the published growth rates. Conversely, when MBS liquidations slow, the MBS-adjusted growth rates are larger than the published rates. Overall, the estimated differences in growth rates equal in some months as much as one-half of the change in M1. From December 1991 to March 1992, for example, inflows to mortgage servicers' custodial accounts are estimated to have added between 5 to 10 percentage points to the monthly growth rates of demand deposits. The largest estimated effects were in October 1992 and May 1993, when MBS-related inflows likely accounted for four-fifths and three-fifths, respectively, of demand deposit growth. In both cases, deposit growth slowed sharply in later months when deposit levels had increased enough to support the accelerated pace of mortgage activity. Subsequently, during the first quarter of 1993, runoffs of servicers' custodial balances likely depressed monthly average deposit growth by as much as 10 percentage points.

These patterns show through to M1 (see the center panel of figure 6) but are muted. Currency and OCDs, which comprise two-thirds of M1, are unlikely to be affected by MBS activity.<sup>13</sup> Nonetheless, the distortions to demand deposits are sufficient that monthly growth rates of M1 since mid-1992 appear to have been distorted by as much as 5 to 7 percentage points. Similar estimates for M2 that include estimated effects on money market demand account (MMDA) balances are shown in the bottom panel of the figure.

Overall, fluctuations in mortgage servicers'

<sup>10</sup>While it is always risky to forecast financial market activity, recent decreases in mortgage rates (through October 1993) are likely to trigger substantial further increases in refinancing and MBS activity during late 1993 and early 1994. In addition to older mortgages issued during the 1980s, mortgages that were issued as little as 12 to 18 months ago at 7 to 7-1/2 percent rates now may profitably be refinanced. Rather than the pace of refinancing slowing and related distortions to the monetary aggregates diminishing as the outstanding stock of seasoned MBSs are rolled over, recent rate decreases have placed nearly the entire outstanding stock of MBSs "in the money" for rollover.

<sup>11</sup>Homeowners typically make monthly mortgage payments between the 1st and 15th of the month, with the servicer remitting these funds to MBS investors on the 15th. Follow-

ing a refinancing, the funds received by the servicer from the homeowner (at any time within the month) are placed in a custodial account. These funds are remitted by the servicer to MBS investors after the middle of the following month. The exact date, however, depends on the contract specifications of the agency guarantee program under which the MBSs backed by the mortgage pool that contained the extinguished mortgage were issued. See, for example, Karcher (1989).

<sup>12</sup>Construction of these estimates is discussed in the appendix.

<sup>13</sup>The next section raises the possibility that OCD balances also might have been affected by refinancing since 1991, albeit not through MBS-related transactions.



## Extra Deposits: Where Do They Come From? Where Do They Go?

The impact of surges in refinancing-related transactions on the demand for liquid deposits and the monetary aggregates depends on the monetary control operating procedure being used by the Federal Reserve. The refinancing of securitized mortgages generates temporary increases in the demand for liquid deposits. Since these deposits are subject to non-zero reserve requirement ratios, the Federal Reserve accommodates this demand under its current monetary control procedures by furnishing additional reserves as necessary to maintain the federal funds rate near the level expected to be consistent with desired longer-run growth of M2. When final payments to MBS investors are completed, both the quantity of liquid deposits demanded and banks' required reserves fall. To again maintain the desired level of the federal funds rate, the Federal Reserve withdraws the now-surplus reserves from the market.

Consider, for example, a 10 percent mortgage with an unpaid principal balance of \$100,000. Assume that the homeowner

deposits some funds (a paycheck, for example) into a demand deposit account on the first day of a typical month. On the fifth day of the month, the homeowner mails a check for \$877 to his mortgage servicer. The servicer receives the check on the 10th and places the funds in a demand deposit account. On the 15th, the funds are paid to MBS investors who immediately move the funds out of demand deposits and into new earning assets. The extent to which this transaction affects the average daily levels of demand deposits and M1 depends on what type of asset/deposit was held by the firm prior to paying the employee and on what type of asset/deposit is held by the MBS investor after receipt of the funds. Assuming that the firm held the funds prior to the first of the month in an asset not included in M1, and assuming that investors move funds promptly into assets not included in M1 on the 15th, this single transaction contributes about \$439 to the average monthly level of demand deposits.<sup>1</sup>

<sup>1</sup>\$877\*15/30. The implied intramonthly pattern of fluctuations in transaction deposits and reserves is characteristic of liquid deposits. Aggregate transaction deposits tend to increase sharply at the beginning of each month

and run off during the latter weeks of the month. The implied fluctuations in reserve demand are accommodated by the Federal Reserve, perhaps through an RP by the Open Market Desk.

custodial deposits likely account for about one-half of the recent increase in M1 volatility. It is unlikely that these estimates are too large, since they are based on legal restrictions imposed on mortgage servicers by federal agencies and realistic but conservative assumptions regarding intra-month patterns of mortgage closings and deposit behavior.

The estimates may be biased downward, however, for a number of reasons. The most important perhaps is the omission of any increase in deposits held by issuers of new MBSs. As some issuers draw on bank warehouse credit lines to fund the purchase of mortgages to be assembled into new MBS pools, they may offset part of the bank charges for these lines via earnings credits based on their deposit lev-

els. Also omitted are any increases in liquid deposits that arise because of the significant volume of additional transactions used to purchase and sell large quantities of mortgages and MBS.

### HOUSEHOLD DEPOSITS AND REFINANCING

In addition to demand deposits, changes in OCDs since mid-1991 also have reflected the ebbs and flows in the pace of mortgage refinancing (see the upper panel of figure 7). The apparent increase in the correlation of OCDs with demand deposits contrasts with its behavior before 1991 and during 1986-87, the latter shown in the lower panel of figure 7.



To illustrate the magnitude of refinancing-related payments, suppose that the homeowner now refinances the mortgage on the 25th day of the month, with the servicer receiving funds on the 30th and holding them (as a fiduciary) in a demand deposit custodial account until remittance to investors around the middle of the following month. The refinancing, when it closes on the 25th, creates \$100,000 of demand deposits that didn't previously exist, reflecting the new mortgage loan extended to the homeowner. If the transaction is subject to Regulation Z's right-of-rescission provisions, the \$100,000 deposit likely will be held by the settlement agent or new lender for the first three days following the mortgage closing. If the mortgage has been securitized via federal-agency-guaranteed MBSs, the funds subsequently will be remitted to the servicer of the extinguished mortgage. If not, the funds will be paid to the current owner of the original mortgage. Since the outstanding MBSs backed by the old mortgage

have not yet been extinguished, the new mortgage (and new deposits) represent a temporary net increase in the amount of outstanding credit in the economy. Both the new deposit and the MBSs backed by the old mortgage continue to exist until about the middle of the following month.<sup>2</sup>

The mortgage refinancing of \$100,000 contributes \$16,666 to the average level of demand deposits during the current month and \$50,000 to the average level of the following month, assuming that the servicer remits funds to investors on the 15th and investors immediately transfer the funds from demand deposits.<sup>3</sup> When investors do so, the aggregate level of demand deposits drops and the Federal Reserve will drain reserves from the market if necessary to maintain discount window borrowings and the federal funds rate near the desired levels.

<sup>2</sup>Note that financial market participants (and federal agencies) record an MBS as being liquidated on the last day of the month in which the refinancing occurred, even though investors will not receive the underlying funds until after the middle of the following month.

<sup>3</sup>What asset might investors buy with the demand deposit? One possibility is new MBSs backed by the new mortgages. What happens to the demand deposits that they use to purchase these new MBSs? They vanish, in textbook multiple-expansion-of-deposits fashion, accompanied by the Fed's withdrawal of reserves.

Should some portion of the OCD fluctuations during 1991–93 be attributed to mortgage refinancing activity? If so, and if the impact of refinancing on OCDs were similar to its effect on demand deposits, then their combined effects could account for as much as three-quarters of M1's growth during a number of months since 1991.

The recent parallel monthly movements in these two types of liquid accounts is compelling but puzzling. Any evidence linking these deposits

to mortgage activity is necessarily less direct and more circumstantial than that for demand deposits. Tracing direct links between household deposits and economic activity is generally not possible, since the Federal Reserve collects deposit data from the issuers of deposits such as banks and thrifts rather than from the owners of deposits, including households and firms.<sup>14</sup>

Why might a household increase its OCD balances following a mortgage refinancing? One possibility could be the conversion of home eq-

<sup>14</sup>Although the Federal Reserve Board's flow of funds accounts present a fairly complete balance sheet for the household sector, few items are directly observed. Most entries are calculated as residuals, inferred from the double-entry nature of the accounts and from balance sheet data

for firms and government. See *Guide to the Flow of Funds Accounts*, p. 120.



Figure 6  
Published Growth Rates Less Rate Adjusted for MBS Activity

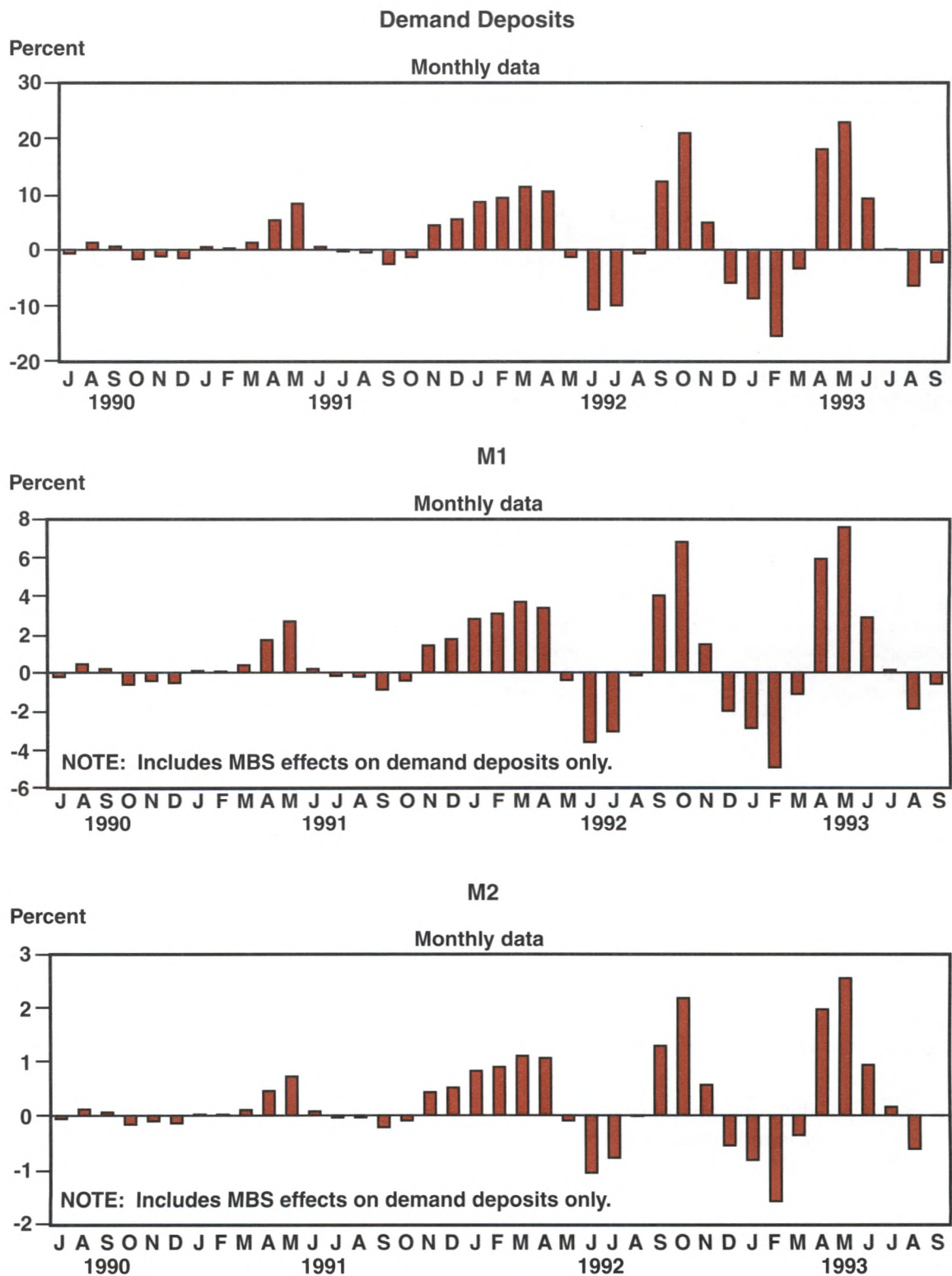
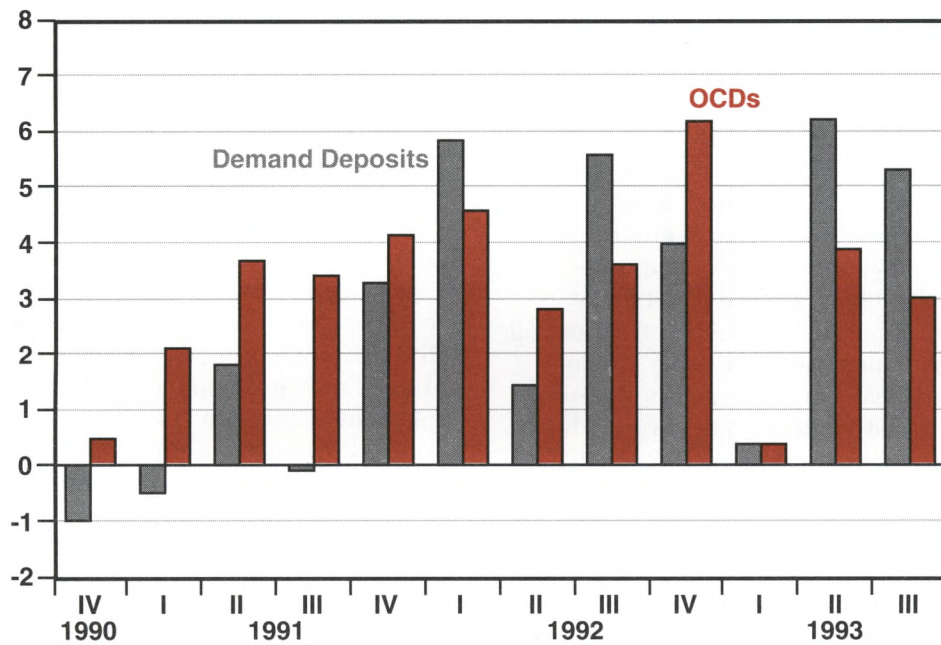




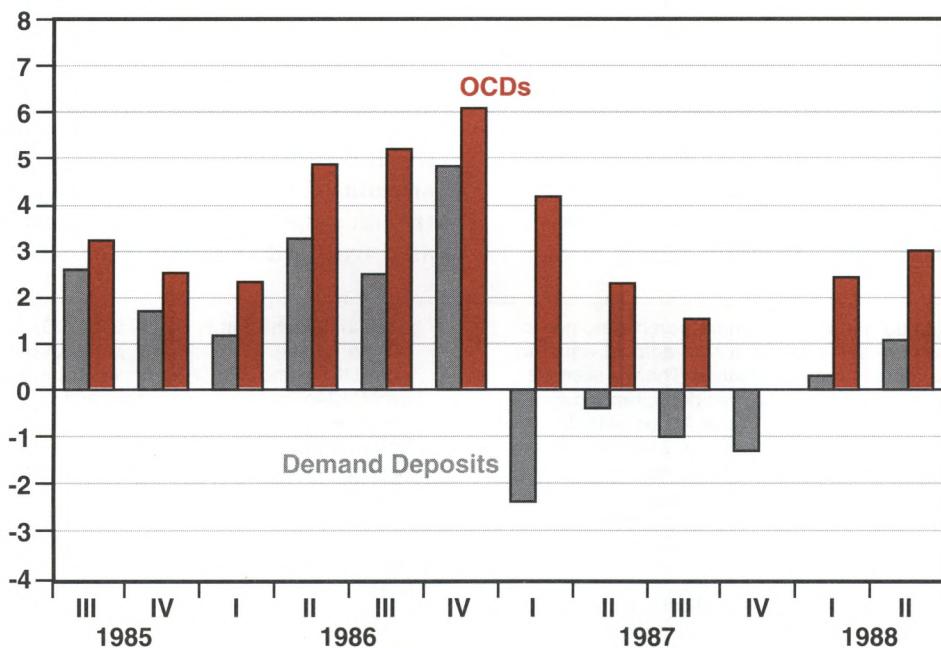
Figure 7  
Average Monthly Change in Demand Deposits and OCDs,  
by Quarter

Billions of dollars



Average Monthly Change in Demand Deposits and OCDs,  
by Quarter

Billions of dollars





uity into cash at the time of refinancing. If operative, this factor should be much stronger during the 1990s than during 1986–87, for two reasons. First, many households have been restructuring their balance sheets, seeking to reduce the levels of debt (and debt service) that they took on during the 1980s. Home equity converted to cash at refinancing allows them to repay other outstanding debt and reduce monthly debt service. Second, households generally experienced large capital gains on houses during the 1980s. For many, capital gains in housing appeared largely as a windfall, accruing more rapidly than had been anticipated when the home was purchased and without any overt effort by the homeowner. As such, these increases in wealth likely were not optimally deployed (from a portfolio standpoint) across all household asset categories. For other homeowners who might have preferred to consume the increased wealth rather than save it, the capital gain appears as a type of forced saving in the form of home equity. While a home equity loan may increase the liquidity of home equity, it doesn't permit the household to consume a windfall increase in home equity, since the loan must be repaid. Hence, there may be some pent-up demand by homeowners for redirecting part of their home equity toward balance sheet restructuring (reducing other consumer debt), consumption or perhaps redeployment into more liquid assets.

Although no direct data on cash withdrawals at mortgage refinancings are available, recent evidence is supportive. Fannie Mae's 1993 national housing survey asked households whether their primary motivation in refinancing was to shorten the maturity of the loan (thereby building equity more quickly) or to reduce their monthly payments. While a shorter maturity was the motive more frequently stated, in fact

at refinancing more households tended to forego a shorter maturity in favor of lower monthly payments, consistent with reducing the importance of home equity in their portfolios. (Unfortunately, the survey did not ask about the withdrawal of home equity at refinancing.) Home equity lending at banks, shown in figure 8, also has been weak since mid-1991, with reports suggesting that homeowners are indeed repaying outstanding home equity loans with cash withdrawn at the time of a mortgage refinancing.

While the growth in OCDs likely reflects changes in households' deposits, some professionals and small businesses also may account for a portion of the increase. Some real estate payment practices tend to increase the demand for OCDs when mortgage activity increases. The 1969 Truth in Lending Act, for example, implemented through the Federal Reserve's Regulation Z, requires a three-day, right-of-rescission period for any new credit transaction secured by the borrower's principal residence.<sup>15</sup> During this period, settlement agents typically hold funds in a liquid deposit, or perhaps in the form of cashier's and officers' checks. If the funds are held solely for the beneficial interest of the household, they may be placed in an OCD account.<sup>16</sup> Cashier's and officers' checks issued by banks are included as demand deposits in M1, while such checks issued by thrifts typically are included in OCDs.

This supportive yet largely circumstantial evidence leaves a number of unanswered questions. If a household extracts funds at refinancing to repay a home equity loan, how long will it keep the funds in a liquid deposit? And isn't the amount of funds almost surely far smaller than the amounts held by mortgage servicers, associated with MBS refunding activity? If so, can the

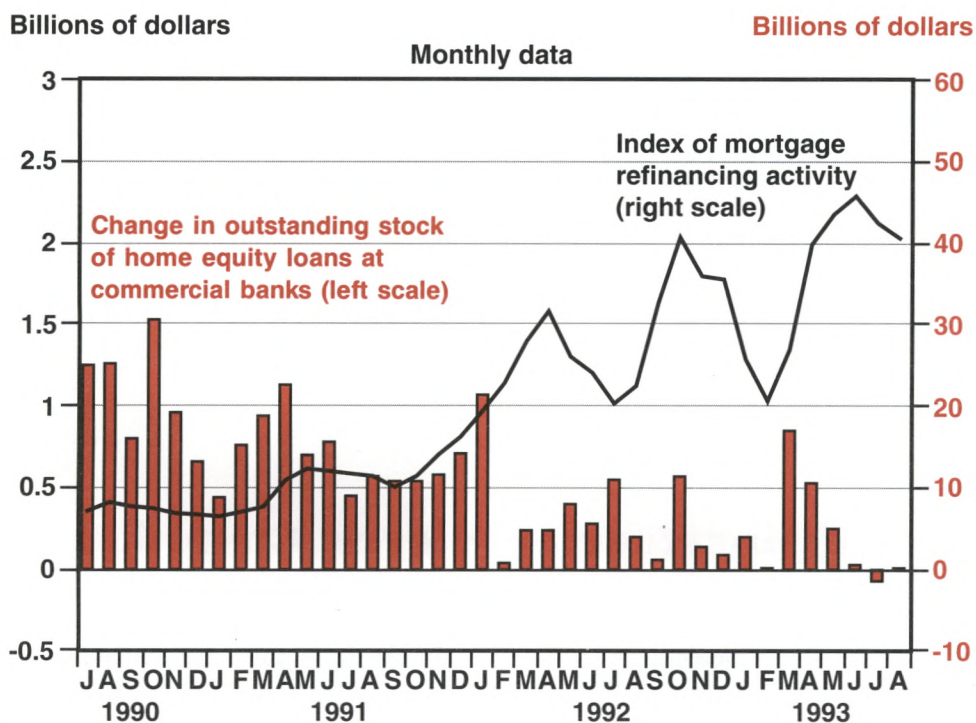
<sup>15</sup>These provisions do not apply to home purchases, nor to refinancings with the same lender for an amount equal to or less than the unpaid principal balance. The Act exempts from right-of-rescission provisions "residential mortgage transactions," which are defined in the Act as extensions of credit to acquire a principal residence. In May 1987, at the request of mortgage market participants, refinancings with the same lender were exempted from Regulation Z. At the time, it was felt that this change likely would significantly reduce the number of refinancings subject to right-of-rescission provisions.

<sup>16</sup>On the eligibility of lawyers to hold a client's funds in OCD deposits, see section 2-341 of the Fed's Regulation D in *Federal Reserve Regulatory Service* (1993). Client funds also may be placed in MMDA deposits, although the rulings contained in section 2-341 perhaps suggest a prefer-

ence to hold the funds as OCDs. OCDs have no restrictions on the number of third-party withdrawals per month. While both OCDs and MMDA deposits are included in M2, data on MMDAs have not been collected by the Federal Reserve System since September 1990. Banks and thrifts began reporting that month only a combined total for all savings and MMDA deposits. Hence, no separate analysis of MMDA deposits is shown in this article.



Figure 8  
Refinancing Home Equity Lending



increasingly parallel movements in OCDs reasonably be attributed to refinancing activity? On balance, while the sharp increase in the correlation between the changes in OCDs and demand deposits since 1991 suggests an underlying relationship to mortgage refinancing, the magnitude of any effect on the monetary aggregates remains uncertain and a convincing explanation elusive.

## SUMMARY

Any factors that increase the demand for transaction deposits can distort the growth of the monetary aggregates over significant periods of time. Recent waves of mortgage refinancing activity have caused significant fluctuations in liquid deposits and M1. Under current Federal Reserve operating procedures for controlling the growth of M2, such transitory changes in the demand for liquid deposits, like those associated with mortgage refinancing, are automatically accommodated through changes in bank reserves, leading to increased volatility of M1.

A large portion of this increased volatility of demand deposits can be traced to fiduciary

rules governing the custodial accounts of mortgage servicers. The mechanism generating parallel high-frequency movements in OCDs, however, is far less clear. The coincidence of its timing with changes in refinancing activity and the onset of unusual weakness in home equity lending in 1992 suggest that it may be related to the ongoing restructuring of household balance sheets during the 1990s.

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## Appendix

### Estimates of Mortgage Servicers' Custodial Account Balances

This appendix employs methodology suggested by Duca (1990) to estimate the impact of refinancing on the amount of liquid deposits held by mortgage servicers.<sup>1</sup> At refinancing, the outstanding principal of an extinguished securitized mortgage is returned to the mortgage servicer. Following rules established by the federal agency that guaranteed the MBSs issued against the pool containing the mortgage, servicers place incoming unscheduled payments in custodial accounts (liquid deposits) until remitted to the holders of the MBSs around the middle of the following month. Since the servicing rules of the three agencies differ, the overall increase in custodial deposits that follows an increase in refinancing depends on the agency composition of MBS liquidations. Differences in this composition during 1991-93 relative to earlier periods have attenuated the deposit impact of recent MBS liquidations from what might have been expected. GNMA-guaranteed issues made up about one-half of aggregate liquidations during 1986-87,

for example, but only one-quarter in 1991-93. The largest volume of liquidations during 1991-93, on balance, has been FHLMC issues that have a smaller impact, dollar for dollar, on liquid deposits than liquidations of GNMA- or FNMA-guaranteed MBS.

The increase in liquid deposits due to MBS liquidations is estimated from a simple simulation. The parameters are:

The proportion of MBS liquidations during a month that result from scheduled amortization of principal (*norm* — *liq*). Separation of scheduled from unscheduled payments matters for reasons explained in the text. Estimates in this article assume that scheduled principal payments equal 1 percent (at an annual rate) of the outstanding stock of MBSs.<sup>2</sup>

The average number of days, expressed as a proportion of the month, that unscheduled principal payments are held in custodial accounts during the month in which the refinancing occurred (*GNMA* — *this* — *month*, *FNMA* — *this* —

<sup>1</sup>The model in this appendix differs from Duca's in some respects, including assuming a more uniform rate of mortgage closings during each month and that funds remain in liquid deposits somewhat longer during the month following the refinancing before they are withdrawn by investors.

<sup>2</sup>The exact monthly scheduled amortization rate is a function of the outstanding balances, rates and terms on the mortgages in the pool. Such calculations require extensive databases well beyond the scope of this study. An alterna-

tive set of estimates that assumed scheduled monthly amortization equal to 2 percent of outstanding aggregate principal had a relatively large number of months wherein actual principal payments were less than estimated scheduled payments and, hence, was rejected as implausible.



month, *FHLMC* — *this* — month). Payments received by servicers early in the month have larger impacts on month-average deposit levels than payments received late in the month. Herein it is assumed that mortgages close at a uniform rate during the month. Under this assumption, the weighted average holding period for payments received by GNMA and FNMA servicers is 0.50 months, i.e., *GNMA* — *this* — month = *FNMA* — *this* — month = 0.50. For FHLMC servicers, who generally hold unscheduled principal payments for five days or less, an average holding period of 0.15 months is assumed.

The average number of days, expressed as a proportion of the month, that funds due to MBS investors are held in liquid deposits during the month following the refinancing (*GNMA* — *last* — month, *FNMA* — *last* — month). Under GNMA and FNMA servicing rules, unscheduled principal payments received by servicers during the preceding month are remitted to investors on the 15th and 18th of the current month, respectively. Funds may be on deposit longer if investors do not withdraw them immediately. Values of 20 days and 23 days, corresponding to *GNMA* — *last* — month = 0.67 and *FNMA* — *last* — month = 0.77, are used in the calculations below. These somewhat longer periods were suggested by examination of daily deposit data reported to the Federal Reserve by several large banks. For FHLMC, this is set equal to zero.

For FNMA servicers, the proportion of incoming funds placed in MMDAs rather than demand deposits (*MMDA* — *share*). A value of 0.25 is assumed below.<sup>3</sup> Funds in MMDAs are assumed to remain on deposit for the same number of days as funds placed in demand deposit accounts.

Monthly liquidation of GNMA-guaranteed MBSs equals, by definition, the amount of GNMA-guaranteed MBSs issued during the month minus the change in the amount of GNMA-guaranteed MBSs outstanding as of the end of each month:

$$GNMA \text{ — } liq = GNMA \text{ — } iss - \Delta GNMA \text{ — } stk.$$

In turn, the amount of unscheduled principal payments received by GNMA servicers during a month is assumed to equal the liquidations of GNMA-guaranteed MBSs minus 1 percent of the amount of GNMA-guaranteed MBSs outstanding at the end of the previous month:

$$GNMA \text{ — } un = GNMA \text{ — } liq - norm \text{ — } liq * \\ GNMA \text{ — } stk \text{ — } lag.$$

Liquidations and unscheduled principal payments for FNMA and FHLMC are calculated in the same manner.

The amount of demand deposits that are custodial account balances due to GNMA mortgage servicers is calculated as:

$$GNMA \text{ — } dda = GNMA \text{ — } this \text{ — } month * GNMA \\ \text{ — } un + GNMA \text{ — } last \text{ — } month * GNMA \text{ — } un \\ \text{ — } lag.$$

For FNMA servicers, the amount is:

$$FNMA \text{ — } dda = (1 - MMDA \text{ — } share) * (FNMA \text{ — } this \text{ — } month * FNMA \text{ — } un + FNMA \text{ — } last \text{ — } month * FNMA \text{ — } un \text{ — } lag);$$

and for FHLMC it is:

$$FHLMC \text{ — } dda = FHLMC \text{ — } this \text{ — } month * \\ FHLMC \text{ — } un$$

A similar calculation is made for the holdings of MMDAs by FNMA servicers.

An MBS-adjusted, not seasonally adjusted (n.s.a.) demand deposit series is obtained by subtracting the sum (*GNMA* — *dda* + *FNMA* — *dda* + *FHLMC* — *dda*) from published n.s.a. monthly levels of demand deposits. The resulting demand deposit series is seasonally adjusted using the seasonal factors for demand deposits published by the Federal Reserve Board staff in *Money Stock Revisions* (1993). (Seasonal factors are recovered from the published data by dividing the n.s.a. level by the s.a. level.) The differences in growth rates of demand deposits and M1 shown in the upper two panels of figure 6 are calculated from published and these adjusted data.

An MBS-adjusted, non-M1 component of M2 is obtained by subtracting the estimated amount of MBS-related MMDA deposits from the published, seasonally adjusted, non-M1 component of M2. (Since the non-M1 component of M2 is seasonally adjusted by the Federal Reserve Board staff as a whole, and separate data on MMDA are not available, the seasonally adjusted series was adjusted by MBS effects.) The growth rates shown in the lower panel of figure 6 are calculated from published M2 and from the sum of the MBS-adjusted M1 and non-M1 components of M2.

<sup>3</sup>The value of 0.25 is from Duca (1990).





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