

# Long-run evidence on money growth and inflation

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*We investigate the correlation between inflation and the rates of growth of narrow and broad money in the United Kingdom since the 19th century. Empirical evidence points towards a remarkable stability across monetary regimes in the correlation for longer-run trends in the data, but some instability in the short to medium term. Additional evidence from the United States confirms the overall stability of the correlation for the longer-run trends.*

## Introduction

Despite a continuing controversy over the short-run relationship between money growth and inflation, it is well known that, historically, increases (decreases) in the trend growth rate of the money supply have been very strongly associated with increases (decreases) in trend inflation.<sup>(1)</sup> In this article, we investigate the correlation between inflation and the rates of growth of narrow and broad money in the United Kingdom and in the United States since the 19th century.

## Evidence for the United Kingdom

### The correlation in the raw data

Chart 1 shows inflation and the rates of growth of base money, M3 and M4 in the United Kingdom since 1870.<sup>(2)</sup> This period encompasses several radically different monetary arrangements, including: the gold standard, until August 1914; the inter-war period, with the United Kingdom reintroducing the gold standard in 1925 and abandoning it again in 1931 to become the centre of a currency bloc known as the 'sterling area'; the period from the start of the Bretton Woods regime, in December 1946, until the floating of the pound *vis-à-vis* the US dollar, in June 1972; the period from June 1972 to the introduction of inflation targeting, characterised by a succession of different monetary arrangements and measures, culminating in UK membership of the Exchange Rate Mechanism (ERM) of the European Monetary System; and the post-October 1992 inflation-targeting regime, following sterling's abandonment of the ERM.

There was a very high correlation between inflation and the growth of base money and M3 around the time of the rapid monetary expansion associated with the outbreak of the First World War (WWI). By contrast, the correlation around the time of Second World War (WWII) was much weaker, possibly reflecting the UK government's greater use of price controls and rationing. (This is a crucial point, as 'virtual prices' — ie the prices at which agents would have willingly chosen to buy goods and services — may have been tracking movements in the monetary aggregates more closely.) The correlation between base money growth and inflation was again very strong around the time of the high inflation of the 1970s, while it appears to have broken down over the post-1992 period, with inflation at low and stable levels, and M0 growth, so far, increasing. For M4 the correlation appears to have been, overall, quite weak, with three periods — the first half of the 1970s, the second half of the 1980s, and the mid-1990s — in which the growth of M4 clearly exceeded that of prices. Only the first two of those periods were associated with a subsequent increase in inflation: under inflation targeting, the mid-1990s 'hump' in M4 growth did not produce any pickup in inflation, which remained anchored to its target.

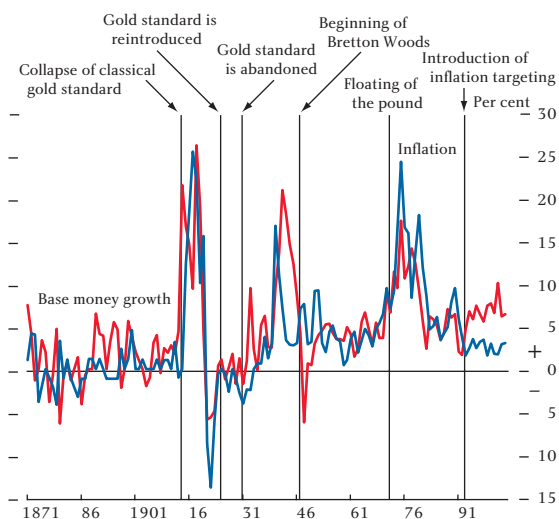
The visual impression of quite significant changes over time in the correlation between inflation and money growth is confirmed by Table A, which reports simple correlations between inflation and money growth, both contemporaneous and lagged, by regime/period.

(1) De Grauwe and Polan (2001) present evidence that challenges the existence of a long-run relationship between money growth and inflation. Nelson (2003), however, casts considerable doubts on their results.

(2) Unfortunately, M4 is available only from 1963 Q2.

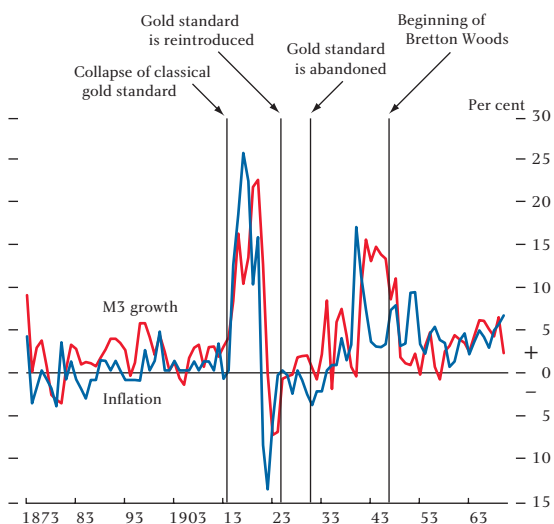
**Chart 1**  
**Inflation and money growth in the United Kingdom, raw data**

**(a) Composite price index<sup>(a)</sup> and MO (annual rates of change)**

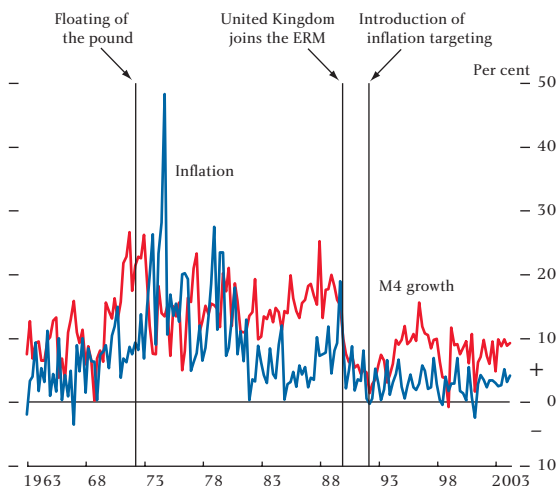


(a) See O'Donoghue, Goulding and Allen (2004).

**(b) Composite price index and M3 (annual rates of change)**



**(c) Retail price index and M4 (quarterly rates of change, annualised)**



**Table A**  
**The correlation between money growth and inflation in the raw data<sup>(a)</sup>**

Regime/period	Correlation between $\pi_t$ and $\Delta m_t$		
	Contemporaneous	Lagged one year	Lagged two years
		<i>Base money growth</i>	
Gold standard	-0.04	0.07	0.51
Inter-war period	0.64	0.06	0.35
Bretton Woods	-0.03	-0.11	0.05
1972-92	0.69	0.69	0.80
Inflation targeting	-0.16	-0.27	0.01
		<i>M3 growth</i>	
Gold standard	0.34	0.00	0.40
Inter-war period	0.64	0.12	0.34
Bretton Woods	-0.14	-0.10	0.15
		<i>M4 growth</i>	
Bretton Woods	0.17	-0.14	0.02
1972-92	0.00	0.20	0.06
Inflation targeting	0.21	-0.12	-0.09

(a) Inflation and money growth have been computed as the log-difference of the relevant index.

Although well known,<sup>(1)</sup> changes over time in the correlation between inflation and the growth of monetary aggregates are, from a conceptual point of view, quite difficult to understand. A key tenet of the quantity theory of money is that the demand for money is a demand for real money balances, so it is not clear why the correlation between money growth and inflation should be so variable over time — indeed, the correlation essentially vanishes under regimes/periods lasting several decades. Irrespective of the specific direction of causality between money growth and inflation, we would expect over the longer term that money growth and inflation would be broadly in line with each other.

One possible explanation is that in a stable, low inflation environment — like the ones prevailing under the gold standard, Bretton Woods, and the current regime — shocks to the demand for money and real output become comparatively more important, thus blurring the correlation between money growth and inflation.<sup>(2)</sup> A second explanation is that the correlation may be different at different frequencies of data — Milton Friedman himself repeatedly stressed how the correlation between money growth and inflation may be different at the trend frequency, compared with the business-cycle frequencies. The failure to detect a stable correlation in the raw data may simply reflect the fact that, under certain regimes/periods, the correlations existing at the various frequencies tend to offset one another partly (or fully). In the next section we therefore proceed to an analysis of the correlation between money growth and inflation at different frequencies.

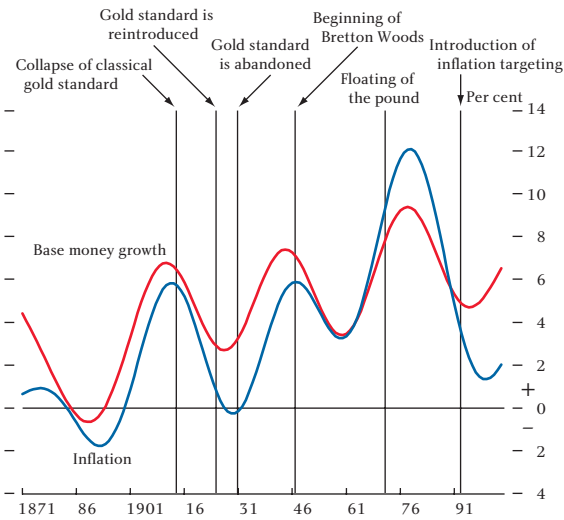
(1) Rolnick and Weber (1997), for example, report that '[...] under fiat standards, the growth rates of various monetary aggregates are more highly correlated with inflation [...] than under commodity standards'.

(2) This was originally noted by Estrella and Mishkin (1996).

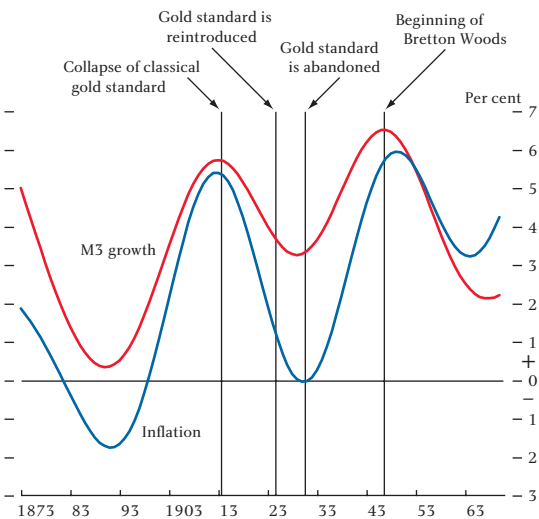
**Chart 2**  
**United Kingdom, low-frequency components of inflation and money growth**

**Components beyond 30 years**

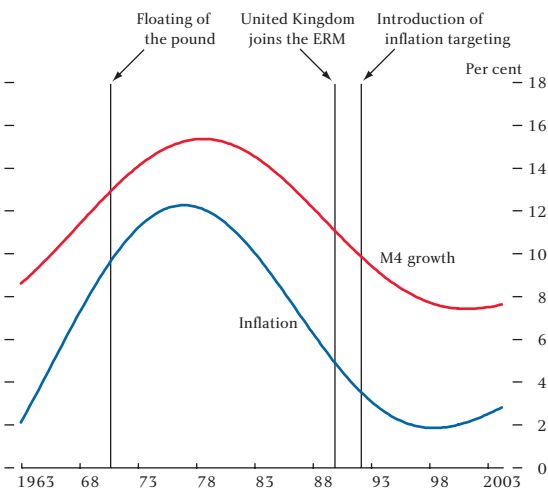
**(a) Composite price index and M0 (annual changes)**



**(b) Composite price index and M3 (annual changes)**

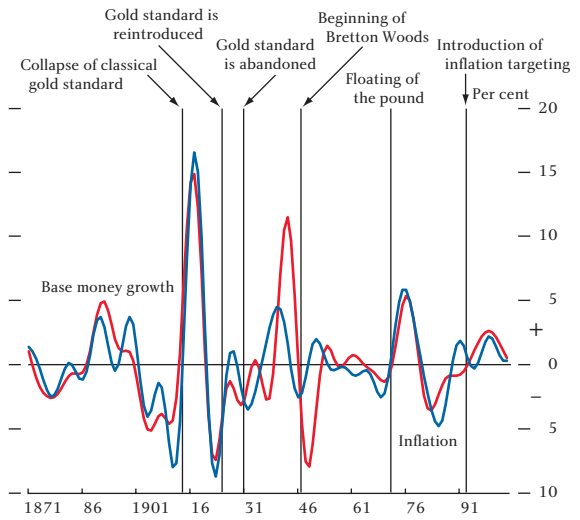


**(c) RPI and M4 (annualised quarterly changes)**

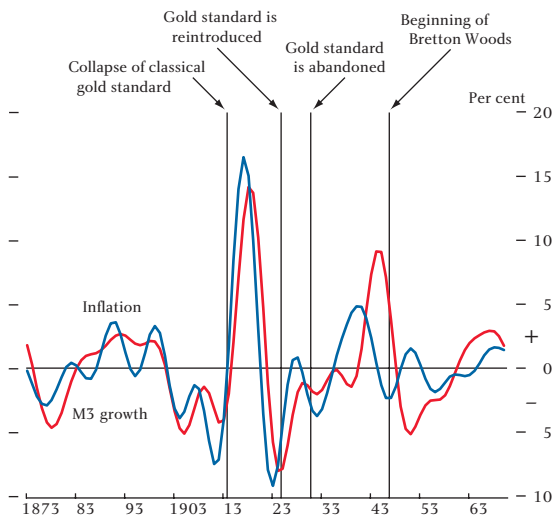


**Components between eight and 30 years**

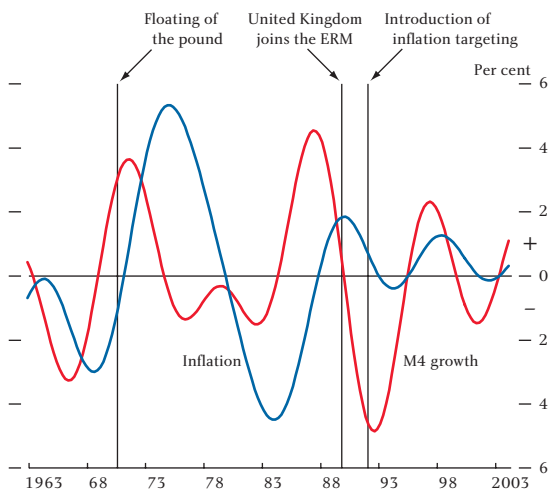
**(d) Composite price index and M0 (annual changes)**



**(e) Composite price index and M3 (annual changes)**



**(f) RPI and M4 (annualised quarterly changes)**



## An analysis by frequency components

Frequency-domain analysis offers a mathematically rigorous way of expressing the commonsense notion that (economic) time series contain components associated with different frequencies of oscillation: very slow-moving components, intuitively associated with the notion of a trend; fast-moving ones, associated with statistical noise and seasonal factors; and components ‘in-between’, traditionally associated with business-cycle fluctuations.<sup>(1)</sup>

Chart 2 shows, for the same series plotted in Chart 1, the components of those series with a time lag between two successive peaks (or troughs) beyond 30 years and between eight and 30 years, respectively.<sup>(2)</sup> These time lags are sometimes called the frequency of oscillation or periodicity of the series. Some facts are readily apparent, in particular:

- (i) The components of inflation and money growth beyond 30 years have been systematically and very strongly positively correlated across all regimes.<sup>(3)</sup> This has held for both narrow and broad monetary aggregates, with the sole exception of base money under the current regime, for which the correlation has clearly been, so far, negative (-0.73). The unreliability of the estimates for the most recent quarters is unlikely to have driven this result:<sup>(4)</sup> as panel (a) of Chart 1 clearly shows, the same result is apparent, although weaker, even in the raw data.<sup>(5)</sup> However, the more general result of strong correlations between money growth and inflation across monetary regimes has the following important implication. In a classic paper, Lucas (1980) used linear filtering techniques to extract trend components from US M1 growth and CPI inflation over the period 1955–75, uncovering a near one-for-one correlation between the trends in the two series. He interpreted his evidence as:

‘[...] additional confirmation of the quantity theory, as an example of one way in which the quantity-theoretic relationships can be recovered via atheoretical methods from time-series which are subject to a variety of other forces [...].’

In their criticism of Lucas (1980), McCallum (1984) and Whiteman (1984) pointed out how his results, being based on reduced-form methods, were in principle vulnerable to the Lucas (1976) critique, and as such they could *not* be interpreted as evidence in favour of the quantity theory of money. That is, Lucas’ results could have depended, at least in principle, on the specific policy regime prevailing over his sample period. The UK experience proves, in this respect, invaluable: the fact that the correlation between the low-frequency components of inflation and the rates of growth of both narrow and broad money aggregates has remained so remarkably stable over such an extended period of time, encompassing radically different monetary regimes, strongly suggests such a correlation to be invariant to changes in the policy regime — ie to be structural in the sense of Lucas (1976).

- (ii) Generally, the same holds for the frequency band between eight and 30 years. The exceptions are M4, for which the correlation does not exhibit any clear-cut stable pattern; M3 under Bretton Woods, for which the correlation turns negative; and base money around WWII and its immediate aftermath, when M0 growth markedly overshot, and then undershot, inflation.<sup>(6)</sup>

How should we interpret such stability across regimes in the underlying correlation between trend money growth and inflation? As stressed by Svensson (2003), the *meaning* to be attributed to the correlation between money growth and inflation depends on the nature of the underlying monetary regime.

(1) The filtering approach to business-cycle analysis was pioneered by Hodrick and Prescott (1997 — the paper was written in 1980, and remained unpublished for nearly two decades). Recent key papers in this literature are Baxter and King (1999), Stock and Watson (1999), and Christiano and Fitzgerald (2003).

(2) These components have been extracted via the algorithm described in Christiano and Fitzgerald (2003).

(3) However, components beyond 30 years are comparatively less precisely estimated than components associated with higher frequencies.

(4) In the filtering literature this is often referred to as the ‘endpoint problem’. It originates from the fact that, due to the lack of future data, the decomposition into different frequency components for the most recent quarters is comparatively imprecise.

(5) One possible (partial) explanation for the recent strong growth in base money is that, as panel (a) of Chart 1 clearly shows, during the Great Inflation of the 1970s inflation mostly exceeded base money growth, resulting in a destruction of real M0 balances. In this light, the recent excess of base money growth over inflation may reflect, at least in part, the attempt on the part of economic agents to bring real M0 balances to a level closer to equilibrium.

(6) This last episode, however, lends itself to a simple explanation, namely the price controls in place around WWII, so that base money first markedly expanded, and then contracted, only partially affecting, in either case, the rate of inflation.

For example, in the extreme case of a pure monetary-targeting regime, the central bank perfectly controls the money supply. In that instance, money growth would be exogenous, while inflation would endogenously adjust to it. Under those circumstances, we could legitimately say that ‘money growth causes inflation’.

By contrast, under a pure inflation-targeting regime in which the central bank perfectly controls inflation, the opposite would be true: inflation would now be exogenous, while money growth would endogenously adjust to it. Under those circumstances, one could argue that ‘inflation causes money growth’. In general, however, ‘money growth and inflation are both endogenous variables and there is no clear direction of causality’.<sup>(1)</sup>

However, the fact that the correlations between the trend components of inflation and money growth have remained so stable over long periods of time, encompassing radically different monetary arrangements (with the sole exception, so far, of base money growth under inflation targeting), suggests that such correlations find their origin in structural features of the economy that are largely independent of the underlying monetary regime.

A corollary of these findings is that any deviation between the trend components of inflation and money growth should necessarily be regarded as temporary. In the case of base money growth under the current regime, in particular, we can be confident that, with inflation expected to remain close to target, base money

growth will progressively decline, reaching levels more in line with the targeted rate of inflation, the sustainable rate of growth of real GDP, and long-run trends in velocity.

Chart 3 shows, for base money and M4 growth, and for RPI inflation, the components with periodicities between six quarters and eight years, traditionally regarded in the business-cycle literature as the typical length of business cycles. The overall impression is of a much lower stability in the correlation than at the low frequencies. The correlation between M4 growth and inflation, in particular, has clearly been negative until the second half of the 1980s, after which it has become positive.

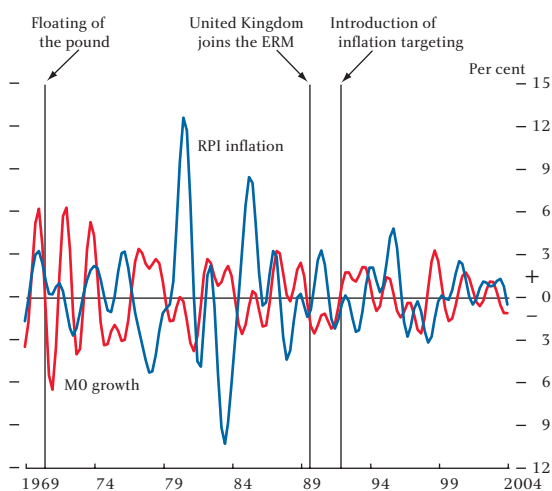
### Evidence from the United States

If the stability of the correlation between inflation and the rates of growth of monetary aggregates at the very low frequencies reflects underlying features of the economy, we might expect to find similar evidence for other countries.

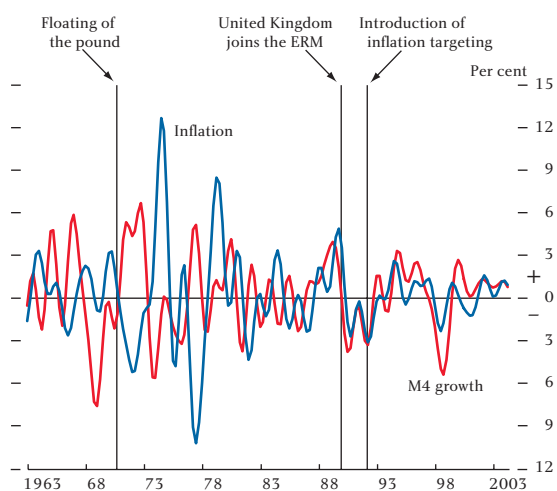
Chart 4 reports evidence for the United States since the second half of the 19th century for four monetary aggregates: base money, M1, M2, and the money stock aggregate preferred by Friedman and Schwartz (1963), defined as the sum of the currency held by the public and the deposits held at commercial banks. Specifically, the chart shows the components of inflation and the rates of growth of monetary aggregates with periodicities beyond 30 years, and is therefore exactly comparable to the top row of Chart 2 for the United Kingdom. This evidence broadly confirms, although in a less striking

**Chart 3**  
United Kingdom, business-cycle components of inflation and money growth

(a) M0 growth and RPI inflation (annualised quarterly changes)



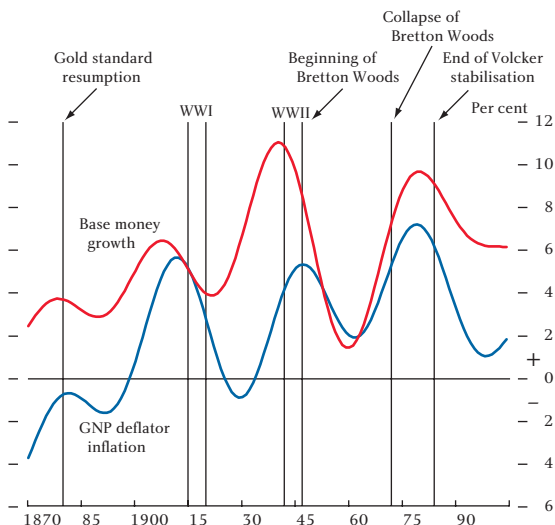
(b) M4 growth and RPI inflation (annualised quarterly changes)



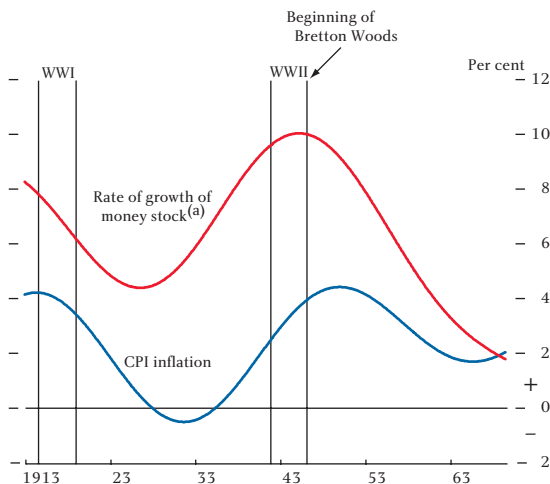
(1) Svensson (2003).

### Chart 4 United States, low-frequency components of inflation and money growth

(a) Base money growth and GNP deflator inflation (annualised quarterly changes)

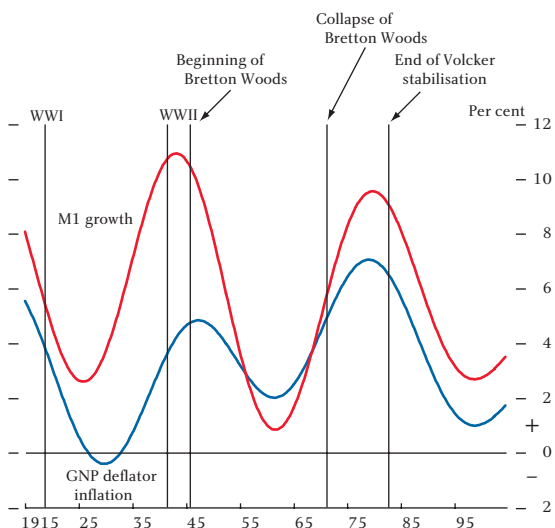


(b) Rate of growth of Friedman and Schwartz's (1963) money stock and CPI inflation (annualised quarterly changes)

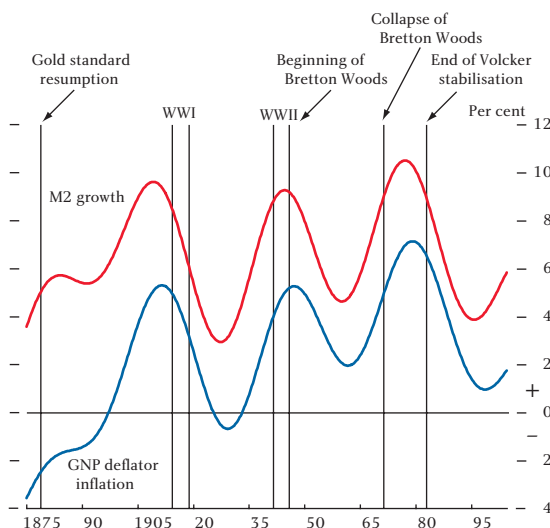


(a) Commercial banks plus currency held by the public.

(c) M1 growth and GNP deflator inflation (annualised quarterly changes)



(d) M2 growth and GNP deflator inflation (annualised quarterly changes)



way than for the United Kingdom, the overall stability of the correlation at the very low frequencies. In particular:

- (i) we replicate Lucas' (1980) finding of a very high correlation between inflation and M1 growth at the very low frequencies, and show how it essentially holds for the entire span of available data.
- (ii) In line with Christiano and Fitzgerald (2003), we detect a remarkably strong and stable correlation between inflation and M2 growth at the very low frequencies. Among all the aggregates we consider for the United States, overall M2 exhibits the greatest stability in its correlation with inflation.

- (iii) During the gold standard, at the very low frequencies the correlation appears to have been very strong for both base money and M2.

### Conclusions

In this article we have investigated the correlation between inflation and the rates of growth of narrow and broad money in the United Kingdom since the 19th century. Empirical evidence points towards a strong stability across monetary regimes in the correlation for longer-run trends in the data, but some instability in the short to medium term, including periods typically associated with the length of business cycles. Additional evidence for the United States confirms the overall stability of the correlation for longer-run trends in the data.



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