EUROPEAN CENTRAL BANK

EUROSYSTEM

THE 'GREAT MODERATION' IN THE UNITED KINGDOM

by Luca Benati

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IN THE UNITED KINGDOM [1]
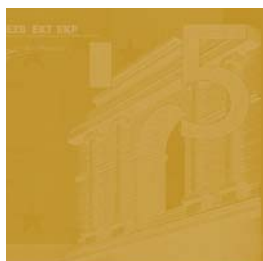
by Luca Benati [2]

In 2007 all ECB
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taken from the
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Abstract

We use a Bayesian time-varying parameters structural VAR with stochastic volatility for GDP deflator inflation, real GDP growth, a 3-month nominal rate, and the rate of growth of M4 to investigate the underlying causes of the Great Moderation in the United Kingdom.

Our evidence points towards a dominant role played by shocks in fostering the more stable macroeconomic environment of the last two decades. Results from counterfactual simulations, in particular, show that (1) the Great Inflation was due, to a dominant extent, to large demand non-policy shocks, and to a lesser extent—especially in 1973 and 1979—to supply shocks; (2) imposing the 1970s' monetary rule over the entire sample period would have made almost *no* difference in terms of inflation and output growth outcomes; and (3) mechanically 'bringing the *Monetary Policy Committee* back in time' would only have had a limited impact on the Great Inflation episode, at the cost of lower output growth.

These results are quite striking in the light of the more traditional, narrative approach, which suggests that the monetary policy regime is an important factor in explaining the Great Moderation in the United Kingdom. We discuss one interpretation which could explain both sets of results, based on the 'indeterminacy hypothesis' advocated, for the United States, by Clarida, Gali, and Gertler (2000) and Lubik and Schorfheide (2004).

Non Technical Summary

As we documented in previous research—see Benati (2004) and especially Benati (2006)—under inflation targeting the United Kingdom has enjoyed, so far, the most stable macroeconomic environment in its recorded history, with the volatilities of the business-cycle components of real GDP, national accounts aggregates, and inflation measures having been, post-October 1992, systematically lower than for any of the previous monetary regimes/historical periods since the metallic standards era.

Where does such a remarkable and historically unprecedented stability come from? Providing an answer to this question is of obvious, crucial importance. If the bulk of the stability of the post-1992 era were attributable to the impact of the new monetary framework, we then might be reasonably confident that macroeconomic instability was a memory of the past—with the right monetary policy in place, the 1970s could never return. If, on the other hand, the current stable macroeconomic environment found its origin in the fact that, in recent years, the U.K. economy has been spared the large shocks of previous decades, having the best possible monetary framework in place would not necessarily shield the United Kingdom from a reappearance of macroeconomic turbulence.

In this paper we use a Bayesian time-varying parameters structural VAR with stochastic volatility to shed some light on the deep underlying causes of the Great Moderation in the United Kingdom. Our main objective is to evaluate the comparative likelihood of two main rival explanations/stories which have been advanced in the context of the debate on the stabilization of the U.S. economy under Alan Greenspan's tenure—the 'good luck' versus 'good policy' debate. Our main results may be summarised as follows.

The evolution of the coefficients of the structural monetary rule in the VAR is broadly in line with the narrative evidence, with, e.g., a comparatively weaker long-run response to inflation before 1979-1980, a marked increase under Margaret Thatcher, and a further increase under inflation targeting. Interestingly, the period during which the United Kingdom was a member of the Exchange Rate Mechanism of the European Monetary System was characterised by significant temporary decreases in the long-run coefficients on inflation, output growth, and the rate of growth of M4, thus dramatically highlighting how during that period U.K. monetary policy—being 'done in Frankfurt'—was virtually disconnected from domestic economic conditions. When seen under this perspective, the crisis of 'Black Wednesday' appears, in a sense, all but inevitable.

Exactly in line with the U.S. literature, however—see especially Primiceri (2005), Sims and Zha (2006), Gambetti, Pappa, and Canova (2006), and Benati and Mumtaz (2007)—our evidence points towards a dominant role played by shocks in fostering the more stable macroeconomic environment of the most recent period. Results from counterfactual simulations, in particular, show that

(1) the Great Inflation was due, to a dominant extent, to large demand non-policy

shocks, and to a lesser extent—especially in 1973 and 1979—to supply shocks.

(2) Imposing the 1970s' monetary rule over the entire sample period would have made almost no difference in terms of inflation and output growth outcomes.

(3) Alternatively, mechanically 'bringing the Monetary Policy Committee back in time' would only have had a limited impact on the Great Inflation episode.

Although in line with the literature on the U.S., these results are quite striking, in particular in the light of the more traditional, narrative approach which suggests that the monetary policy regime has been an important factor in explaining the Great Moderation in the United Kingdom. One interpretation that could reconcile the two sets of results is based on the 'indeterminacy hypothesis' advocated, for the United States, by Clarida, Gali, and Gertler (2000) and Lubik and Schorfheide (2004). In a nutshell, the idea is that monetary policy was not sufficiently stabilising around the time of the Great Inflation, and therefore allowed self-fulfilling sunspot shocks. As our work in progress shows, this could have generated results qualitatively in line with those produced herein, as well as in the related work for the United States.

1 Introduction

On October 8, 1992, three weeks after sterling's departure from the Exchange Rate Mechanism of the European Monetary System, the Chancellor of the Exchequer, Norman Lamont, established the first direct inflation target in the history of the United Kingdom, as a range of 1-4% for annual RPIX[1] inflation. Since then, U.K. macroeconomic performance has been characterized by low and stable inflation, historically low interest rates, and, as of 2006 Q4, 56 quarters of uninterrupted output growth.

In previous research—see Benati (2004)—we used tests for multiple structural breaks at unknown points in the sample, and band-pass filtering techniques, to investigate changes in U.K. economic performance since the end of WWII. Empirical evidence suggests the inflation targeting regime to have been, in a very broad sense, significantly more stable than the previous post-WWII era. First, for both real GDP growth, and three alternative measures of inflation, we identified break dates around the time of the introduction of inflation targeting, in October 1992. For all four series, the estimated variance of reduced-form innovations over the most recent sub-period has been, so far, the lowest of the post-WWII era. Second, the volatility of the business-cycle components of macroeconomic indicators has been, after October 1992, almost always lower than either under Bretton Woods, or during the 1971-1992 period, often—as in the case of inflation and real GDP—markedly so.

Benati (2006) extends the analysis backwards in time to the metallic standard era, documenting how the inflation targeting regime has been characterised, to date, by the most stable macroeconomic environment in recorded U.K. history, with the volatilities of the business-cycle components of real GDP, national accounts aggregates, and inflation measures having been, post-1992, systematically lower than for any of the previous monetary regimes/historical periods.

Where does such a remarkable and historically unprecedented stability come from? Providing an answer to this question is of obvious, crucial importance. If the bulk of the stability of the post-1992 era were attributable to the impact of the new monetary framework, we then might be reasonably confident that macroeconomic instability was a memory of the past—with the right monetary policy in place, the 1970s could never return. If, on the other hand, the current stable macroeconomic environment found its origin in the fact that, in recent years, the U.K. economy has been spared the large shocks of previous decades, having the best possible monetary framework in place would not necessarily shield us from a reappearance of macroeconomic turbulence.

In this paper we use a Bayesian time-varying parameters structural VAR with stochastic volatility along the lines of Primiceri (2005), Canova and Gambetti (2005), and Gambetti, Pappa, and Canova (2006), to shed some light on the deep underlying causes of the Great Moderation in the United Kingdom. Our main objective is to evaluate the comparative likelihood of two main rival explanations/stories which been

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[1]'Retail prices index, all items excluding mortgage interest payments'.

advanced in the context of the debate on the stabilization of the U.S. economy under Alan Greenspan's tenure—the 'good luck' versus 'good policy' debate. Our main results may be summarised as follows.

- The evolution of the coefficients of the structural monetary rule in the VAR is broadly in line with the narrative evidence,[2] with, e.g., a comparatively weaker long-run response to inflation before 1979-1980, a marked increase under Margaret Thatcher, and a further increase under inflation targeting. Interestingly, the period during which the United Kingdom was a member of the Exchange Rate Mechanism of the European Monetary System was characterised by significant temporary decreases in the long-run coefficients on both inflation, output growth, and the rate of growth of M4, thus dramatically highlighting how during that period U.K. monetary policy—being 'done in Frankfurt'—was virtually disconnected from domestic economic conditions. When seen under this perspective, the crisis of 'Black Wednesday' appears, in a sense, all but inevitable.

- Overall, our evidence points towards a dominant role played by shocks in fostering the more stable macroeconomic environment of the most recent period. Results from counterfactual simulations, in particular, show that (1) the Great Inflation was due, to a dominant extent, to large demand non-policy shocks, and to a lesser extent—especially in 1973 and 1979—to supply shocks; (2) imposing the 1970s' monetary rule over the entire sample period would have made almost *no* difference in terms of inflation and output growth outcomes; and (3) alternatively, mechanically 'bringing the Monetary Policy Committee back in time' would only have had a limited impact on the Great Inflation episode.

Although in line with the literature on the U.S., these results are quite striking, in particular in the light of the more traditional, narrative approach—detailed, first and foremost, in the work of Ed Nelson and his co-authors[3]—which suggests that the monetary policy regime has been an important factor in explaining the Great Moderation in the United Kingdom. One interpretation that could reconcile the two sets of results is based on the 'indeterminacy hypothesis' advocated, for the United States, by Clarida, Gali, and Gertler (2000) and Lubik and Schorfheide (2004). In a nutshell, the idea is that monetary policy was not sufficiently stabilising (technically: passive, i.e., such as to give rise to a multiplicity of equilibria) around the time of the Great Inflation, and therefore allowed self-fulfilling sunspot shocks, while it has become stabilising (technically: active, i.e., such as to give rise to a unique equilibrium) over the most recent period. As our work in progress[4] shows, this could have generated results qualitatively in line with those produced herein, as well as in the related work for the United States.

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[2]See e.g. Batini and Nelson (2005).
[3]See especially Nelson and Nikolov (2004) and Batini and Nelson (2005).
[4]Benati and Surico (2007).

As we stress, for the specific purpose of understanding the causes of the Great Moderation, the U.K. experience is especially interesting because, compared with the United States, it is *so extreme*: over the last several decades, the United Kingdom has moved from a situation in which monetary policy was regarded as essentially *useless* for the purpose of controlling inflation, to one in which, on the contrary, it is regarded as *the crucial instrument*. Further, such a sea change in the overall intellectual attitude towards inflation and monetary policy has been enshrined in the U.K. 'monetary constitution', with inflation targeting being introduced in October 1992, and with the *Bank of England* being granted independence, and the *Monetary Policy Committee* being created, in May 1997. The SVAR-based evidence produced herein is therefore all the more striking ...

From a methodological point of view, our paper improves upon the three previously mentioned studies along several dimensions. Primiceri (2005) only considers a Cholesky decomposition—which allows him to identify only a monetary policy shock—and in computing impulse-responses disregards the uncertainty originating from future time-variation in the VAR's coefficients, which we instead tackle *via* Monte Carlo integration. Both Canova and Gambetti (2005) and Gambetti, Pappa, and Canova (2006), on the other hand, do not have a time-varying covariance structure. While it is true that random-walk time-variation in the VAR's coefficients introduces a form of heteroskedasticity in the model, a key problem is that, by construction, it induces a close correlation between changes in the VAR's coefficients and changes in the covariance structure, which a comparison between Cogley and Sargent (2002) and Cogley and Sargent (2005) clearly shows not to be in the data, and which, in general we have no reason to assume to hold.[5]

The paper is organised as follows. Section 2 discusses the reduced-form specification for the time-varying parameters VAR with stochastic volatility which we use throughout the paper. Section 3 discusses evidence of time-variation in the reduced-form properties of the U.K. economy since the beginning of the 1970s, while section 4 turns to structural analysis. Section 5 discusses a possible *caveat* to interpretating our results as clearly pointing towards good luck. Section 6 concludes.

2   A Time-Varying Parameters VAR with Stochastic Volatility

In what follows we work with the following time-varying parameters VAR(p) model:

$$Y_t = B_{0,t} + B_{1,t}Y_{t-1} + ... + B_{p,t}Y_{t-p} + \epsilon_t \equiv X_t^{'}\theta_t + \epsilon_t \tag{1}$$

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[5] In his comment on Cogley and Sargent (2002), Stock (2002) stresses how, if the data generation process is characterised by a time-varying volatility structure, imposition of a constant covariance stucture automatically induces an upward bias in the estimated extent of parameters' drift in the VAR, as the algorithm compensates for lack of time-variation in the covariance by 'blowing up' time-variation in the VAR's coefficients.

where the notation is obvious, and Y_t is defined as $Y_t \equiv [r_t, \ \pi_t, y_t, m_t]'$, with r_t, π_t, y_t, m_t being a short-term rate, GDP deflator inflation, and the rates of growth of real GDP and nominal M4,[6] respectively (for a description of the data, see Appendix A).[7] The overall sample period is 1959:3-2005:4. For reasons of comparability with other papers in the literature[8] we set the lag order to p=2. Following, e.g., Cogley and Sargent (2002), Cogley and Sargent (2005), Primiceri (2005), and Gambetti, Pappa, and Canova (2006) the VAR's time-varying parameters, collected in the vector θ_t, are postulated to evolve according to

$$p(\theta_t \mid \theta_{t-1}, Q) = I(\theta_t) \ f(\theta_t \mid \theta_{t-1}, Q) \tag{2}$$

with $I(\theta_t)$ being an indicator function rejecting unstable draws—thus enforcing a stationarity constraint on the VAR—and with $f(\theta_t \mid \theta_{t-1}, Q)$ given by

$$\theta_t = \theta_{t-1} + \eta_t \tag{3}$$

with $\eta_t \sim N(0, \ Q)$. The VAR's reduced-form innovations in (1) are postulated to be zero-mean normally distributed, with time-varying covariance matrix Ω_t which, following established practice, we factor as

$$\mathrm{Var}(\epsilon_t) \equiv \Omega_t = A_t^{-1} H_t (A_t^{-1})' \tag{4}$$

The time-varying matrices H_t and A_t are defined as:

$$H_t \equiv \begin{bmatrix} h_{1,t} & 0 & 0 & 0 \\ 0 & h_{2,t} & 0 & 0 \\ 0 & 0 & h_{3,t} & 0 \\ 0 & 0 & 0 & h_{4,t} \end{bmatrix} \qquad A_t \equiv \begin{bmatrix} 1 & 0 & 0 & 0 \\ \alpha_{21,t} & 1 & 0 & 0 \\ \alpha_{31,t} & \alpha_{32,t} & 1 & 0 \\ \alpha_{41,t} & \alpha_{42,t} & \alpha_{43,t} & 1 \end{bmatrix} \tag{5}$$

with the $h_{i,t}$ evolving as geometric random walks,

$$\ln h_{i,t} = \ln h_{i,t-1} + \nu_{i,t} \tag{6}$$

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[6]An important point to stress is that during the period of monetary targeting, at the beginning of the 1980s, the targeted aggregate was M3, rather than M4. The problem with M3, unfortunately, is that no quarterly series is available on a consistent basis since the beginning of the 1960s: Capie and Webber (1985) contains an M3 series for the period 1870:1-1982:4, while an M3 series from the *Bank of England* web site (acronym is LPQVWYZ) is available only since 1986:4. So, although unwillingly, we have basically been compelled to use M4: given that M2, again from the *Bank of England* web site (acronym is LPQVWYH), is only available since 1986:3, the only feasible alternative would have been the monetary base.

[7]GDP deflator inflation and the rates of growth of real GDP and nominal M4 have been computed as the non-annualised quarter-on-quarter rates of growth of the relevant series. The interest rate has then been rescaled in order to make it conceptually comparable with the other three series. Specifically, by defining the quarter-on-quarter and the annualised quarter-on-quarter figures for the interest rate as r_t and r_t^A, we have $r_t = (1+r_t^A)^{1/4}$-1.

[8]See e.g. Cogley and Sargent (2002), Cogley and Sargent (2005), Primiceri (2005), and Gambetti, Pappa, and Canova (2006).

For future reference, we define $h_t \equiv [h_{1,t},\ h_{2,t}, h_{3,t}, h_{4,t}]'$. Following Primiceri (2005), we postulate the non-zero and non-one elements of the matrix A_t—which we collect in the vector $\alpha_t \equiv [\alpha_{21,t},\ \alpha_{31,t},\ ...,\ \alpha_{43,t}]'$—to evolve as driftless random walks,

$$\alpha_t = \alpha_{t-1} + \tau_t \ , \tag{7}$$

and we assume the vector $[u_t',\ \eta_t',\ \tau_t',\ \nu_t']'$ to be distributed as

$$\begin{bmatrix} u_t \\ \eta_t \\ \tau_t \\ \nu_t \end{bmatrix} \sim N\left(0, V\right), \text{ with } V = \begin{bmatrix} I_4 & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & Z \end{bmatrix} \text{ and } Z = \begin{bmatrix} \sigma_1^2 & 0 & 0 & 0 \\ 0 & \sigma_2^2 & 0 & 0 \\ 0 & 0 & \sigma_3^2 & 0 \\ 0 & 0 & 0 & \sigma_4^2 \end{bmatrix} \tag{8}$$

where u_t is such that $\epsilon_t \equiv A_t^{-1} H_t^{\frac{1}{2}} u_t$. As discussed in Primiceri (2005), there are two justifications for assuming a block-diagonal structure for V_t. First, parsimony, as the model is already quite heavily parameterized. Second, 'allowing for a completely generic correlation structure among different sources of uncertainty would preclude any structural interpretation of the innovations'.[9] Finally, following, again, Primiceri (2005) we adopt the additional simplifying assumption of postulating a block-diagonal structure for S, too—namely

$$S \equiv \operatorname{Var}\left(\tau_t\right) = \operatorname{Var}\left(\tau_t\right) = \begin{bmatrix} S_1 & 0_{1\times 2} & 0_{1\times 3} \\ 0_{2\times 1} & S_2 & 0_{2\times 3} \\ 0_{3\times 1} & 0_{3\times 2} & S_3 \end{bmatrix} \tag{9}$$

with $S_1 \equiv \operatorname{Var}(\tau_{21,t})$, $S_2 \equiv \operatorname{Var}([\tau_{31,t}, \tau_{32,t}]')$, and $S_3 \equiv \operatorname{Var}([\tau_{41,t}, \tau_{32,t}, \tau_{43,t}]')$, thus implying that the non-zero and non-one elements of A_t belonging to different rows evolve independently. As discussed in Primiceri (2005, Appendix A.2), this assumption drastically simplifies inference, as it allows to do Gibbs sampling on the non-zero and non-one elements of A_t equation by equation.

We estimate (1)-(9) *via* Bayesian methods. Appendix B discusses our choices for the priors, and the Markov-Chain Monte Carlo algorithm we use to simulate the posterior distribution of the hyperparameters and the states conditional on the data.

3   Reduced-Form Evidence

3.1   The evolution of the VAR's covariance matrix

The top-left panel of Figure 1 provides a dramatic illustration of the Great Moderation phenomenon, by plotting the median of the time-varying distribution of $\ln|\Omega_t|$, which, following Cogley and Sargent (2005),[10] we interpret as a measure of the total

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[9] Primiceri (2005, pp. 6-7).

[10] In turn, they were following Whittle (1953)—see Cogley and Sargent (2005, Section 3.5).

amount of noise 'hitting the system' at each point in time—together with the 16th and 84th percentiles.[11] $\ln|\Omega_t|$ is estimated to have reached a peak in 1973:1, just a few months after the floating of the pound *vis-a-vis* the U.S. dollar, in June 1972, and to have systematically fallen ever since, reaching a minimum towards the end of the sample. Such evidence is compatible with two radically different views of the Great Moderation in the United Kingdom. First, with the 'good luck' hypothesis, with the U.K. economy being hit by comparatively large shocks during the 1970s, and by progressively smaller ones starting from the end of the 1970s. Second, given that the bulk of the reduction in $\ln|\Omega_t|$ took place starting from the end of the 1970s-beginning of the 1980s, with the 'good policy' hypothesis, with monetary policy decisively turning counter-inflationary with the arrival of Margaret Thatcher, and even more so after the introduction of inflation targeting, in October 1992. In order to be able to discriminate between these two rival hypotheses, however, we will need to wait until the structural analysis of Section 4.

Turning to the other components of Ω_t, the remaining four panels in the top row of Figure 1 show the evolution of the standard deviations of the VAR's residuals, in basis points.[12] For three series out of four—inflation, output growth, and M4 growth—the volatility of reduced-form shocks reached a peak around the time of the floating of the pound *vis-a-vis* the U.S. dollar, while for the fourth series, the short-term rate, the peak was reached just a few years later, in 1976:3. Since then, all series' volatilities experienced near-monotonic declines, with minima reached either at the very end, or towards the end of the sample. Especially interesting is the dramatic fall in the volatilities of reduced-form shocks for inflation and output growth—from peaks of 187 and 197 basis points (based on median estimates), respectively, in 1972, to lows of 44 and 26 basis points, respectively, in the last quarter of the sample—thus clearly testifying to the exceptional reduction in the U.K. economy's volatility compared to the Great Inflation period.

3.2 Evolving predictability

In the spirit of Cogley (2005), in this section we measure changes in the four series' predictability by computing, for each of them, a time-varying multivariate R^2 statistic

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[11]Under normality, the 16th and 84th percentiles are the bounds of a one standard deviation confidence interval, so that on average, for the normal distribution, the interval between these two percentiles encloses 68% of the distribution of the object of interest.

[12]In order to correctly interpret the information contained in the Figure, the reader should keep in mind that inflation and the rates of growth of output and M4 have been computed as the non-annualised quarter-on-quarter rate of change of the relevant series, and that the short-term rate has been rescaled accordingly.

on a quarter-by-quarter basis as[13]

$$R^2_{x,t|T} = 1 - \frac{\sigma^2_{\epsilon,t|T}}{\sigma^2_{x,t|T}} \tag{10}$$

with $x = r_t, \pi_t, y_t, m_t$, where

$$\sigma^2_{x,t|T} = \int_{-\pi}^{\pi} f_{x,t|T}(\omega)d\omega \tag{11}$$

is variable x's estimated overall time-varying variance; $f_{x,t|T}(\omega)$ is the time-varying estimate of the spectral density of x based on the estimated time-varying VAR; and

$$\sigma^2_{\epsilon,t|T} = 2\pi \exp\left\{\frac{1}{2\pi}\int_{-\pi}^{\pi} \ln\left[f_{x,t|T}(\omega)d\omega\right]\right\} \tag{12}$$

is variable x's estimated time-varying innovation variance, based on Kolmogorov's formula.

Figure 2 shows, for the four series, the medians of the distributions of the time-varying multivariate R^2 statistics, together with the 16th and 84th percentiles, while Table 1 reports the same objects for four selected quarters. As it was to be expected, given the (near) unit root behaviour of the short-term rate, its predictability has remained essentially unchanged at values very close to one over the entire sample period, fluctuating, based on median estimates, between 0.88 and 0.95. By contrast, the predictability of output and M4 growth increased and, respectively, decreased very slightly over the sample period, reaching, at the very end of the sample, values slightly below 0.2 and 0.4, respectively. The most interesting pattern of variation, however, pertains inflation: in line with the analogous evidence for the United States of Stock and Watson (2007) and Benati and Mumtaz (2007), U.K. inflation's predictability is estimated to have peaked around the time of the Great Inflation, oscillating (based on median estimates) between 0.53 and 0.60 over the period 1975-1980; to have significantly decreased around the start of the Thatcher disinflation; and to have fluctuated at comparatively low levels ever since, reaching 0.16 at the very end of the sample, in 2005:4. Interestingly, inflation predictability experienced temporary increases corresponding, first, to the so-called 'Lawson boom' of the second half of the 1980s; and second, to the economic slowdown at the very end of the century.

Having discussed time-variation in the economy's predictability, let's now turn to the extent of uncertainty associated with future projections, as captured by model-generated 'fan charts' for the four series of interest.

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[13]Given the enormous computational burden associated with re-estimating the model every single quarter, both this section's exercise, and next section's one, have been performed based on the smoothed (i.e, two-sided) output of the Gibbs sampler *conditional on the full sample*. This implies that both this section's predictability measures, and next section's k-step ahead projections, should only be regarded as approximations to the authentic out-of-sample objects that would result from a proper recursive estimation. (Unfortunately, it is not clear how to even gauge an idea of the goodness of such approximation.)

3.3 Evolving uncertainty

The 'fan charts' for inflation and output growth published in the *Bank of England*'s quarterly *Inflation Report*—showing the deciles of the *Monetary Policy Committee*'s collective, subjective probability distribution for the two variables at horizons up to three years—play a crucial role in the *Bank*'s communication strategy with the markets, and as such are widely discussed in the financial press. Given the marked changes in some of the reduced-form properties of the U.K. economy since the beginning of the 1970s documented in the previous sections, it is of interest to see how the fan charts for the four variables in the VAR have evolved along the sample.[14]

Figure 3 shows, for the four variables, the standard deviations (in basis points) of k-step ahead projections at horizons up to 20 quarters,[15] computed by stochastically simulating the VAR into the future 1,000 times.[16] Given the enormous computational burden associated with recursive estimation of the model for every single quarter, this section's exercise, exactly as the previous section's, has been performed based on the smoothed (i.e, two-sided) output of the Gibbs sampler conditional on the full sample. This implies that, once again, the k-step ahead projections should only be regarded as approximations to the authentic out-of-sample objects that would result from a proper recursive estimation. In order to make the original results from the stochastic simulations visually more appealing and easier to read, we have smoothed them along the time dimension with the Christiano and Fitzgerald (2003) band-pass filter.[17]

For all variables, and at all horizons, the standard deviations exhibit a broadly similar declining pattern over the sample period, with peaks at the time of the Great Inflation, and a near-monotonic decrease since then. Focussing on the two-year horizon—the one traditionally associated with monetary policy decisions—the

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[14]Strictly speaking, the fan charts generated by our VAR are not comparable to those found in the *Bank of England*'s *Inflation Report*. First, the *Inflation Report*'s fan charts reflect the subjective collective judgement of the *Monetary Policy Committee*, while, as we discuss below, our fan charts have been generated by stochastically simulating the VAR into the future. Second, and crucially, our fan charts uniquely reflect the information contained in the four series we analyse, while those of the *MPC* distill the much wider range of information which the *Bank of England* tracks on a continuous basis.

[15]Once again, as in Section 3.1, in order to correctly interpret the information contained in the Figure, the reader should keep in mind that inflation and the rates of growth of output and M4 have been computed as the non-annualised quarter-on-quarter rate of change of the relevant series, and that the short-term rate has been rescaled accordingly.

[16]Specifically, for every quarter, and for each of the 1,000 simulations, we start by sampling the current state of the economy from the Gibbs sampler's output for that quarter, by drawing a random number from a uniform distribution defined over [1; 1,000]. Conditional on this draw for the current state of the economy at t, we then simulate the VAR 20 quarters into the future.

[17]Specifically, Figure 3 shows the components with periodicity beyond eight years. Given that the original, raw results only displayed strong trends plus some noise, but not much in the way of business-cycle components, the difference between the original raw results and those shown in Figure 3 is just some high-frequency noise. (The original, raw results are however available from the author upon request.)

standard deviations of the distributions of the projections for the short rate, inflation, output growth, and M4 growth have decreased from peaks of 86, 301, 264, and 353 basis points during the 1970s[18] to 37, 82, 68, and 172 basis points,[19] respectively, in the last quarter of the sample, 2005:4, thus testifying to the dramatic fall in macroeconomic uncertainty across the board intervened since the time of the Great Inflation.

Summing up, in line with the analyses of Benati (2004), Cogley, Morozov, and Sargent (2003), and Benati (2006), our reduced-form evidence points towards a dramatic stabilisation of the U.K. economy since the times of the Great Inflation, with significant decreases in both the VAR's total prediction variance and the volatility of reduced-form innovations for both inflation and output growth.[20] In order to understand the deep, underlying causes of this remarkable stabilisation we turn now to a structural analysis.

4 Structural Analysis

In the spirit of Primiceri (2005), Canova and Gambetti (2005), and Gambetti, Pappa, and Canova (2006), in this section we impose, on the estimated time-varying reduced-form VAR, identifying restrictions on a period-by-period basis. We identify four structural shocks—a monetary policy shock (ϵ_t^M), a supply shock (ϵ_t^S), a demand non-policy shock (ϵ_t^D), and a money demand shock (ϵ_t^{MD})—by imposing the following sign restrictions on the contemporaneous impacts of the structural shocks on the endogenous variable.

	Shock:			
Variable:	ϵ_t^M	ϵ_t^D	ϵ_t^S	ϵ_t^{MD}
short rate	+	+	?	+
inflation	−	+	−	−
output growth	−	+	+	−
M4 growth	−	+	?	+
? = left unconstrained				

It can be trivially shown that these restrictions are sufficient to uniquely identify the four shocks. We compute the time-varying structural impact matrix, $A_{0,t}$, via

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[18] Specifically, in 1979:2, 1974:4, 1972:1, and 1972:1, respectively.

[19] Corresponding to decreases of -57.0, -72.8, -74.2, and -51.3 per cent, respectively.

[20] Benati (2004), Cogley, Morozov, and Sargent (2003) and Benati (2006) extensively document a further important change in the reduced-form properties of the U.K. economy under inflation targeting, i.e. the complete disappearance of inflation persistence. Benati (2006), in particular, shows how, under the current monetary regime, U.K. inflation has been, so far, slightly *negatively* serially correlated, which is compatible with the notion that the current regime is, *de facto*, a *hybrid* between inflation and price level targeting.

the procedure recently introduced by Rubio-Ramirez, Waggoner, and Zha (2005).[21] Specifically, let $\Omega_t = P_t D_t P'_t$ be the eigenvalue-eigenvector decomposition of the VAR's time-varying covariance matrix Ω_t, and let $\tilde{A}_{0,t} \equiv P_t D_t^{\frac{1}{2}}$. We draw an $N \times N$ matrix, K, from the $N(0,1)$ distribution, we take the QR decomposition of K—that is, we compute matrices Q and R such that $K = Q \cdot R$—and we compute the time-varying structural impact matrix as $A_{0,t} = \tilde{A}_{0,t} \cdot Q'$. If the draw satisfies the restrictions we keep it, otherwise we discard it and we keep drawing until the restrictions are satisfied, as in the Rubio-Waggoner-Zha code `SRestrictRWZalg.m` which implements their algorithm.

4.1 The evolution of the monetary policy stance

Figure 4 shows the evolution of the U.K. monetary policy stance since the beginning of the 1970s, by plotting the medians of the time-varying distributions of the long-run coefficients on inflation, output growth, and M4 growth in the structural monetary policy rule,[22] together with the 16th and 84th percentiles.[23] In what follows we disregard the significant extent of econometric uncertainty associated with the estimates, which unfortunately is quite common with time-varying parameters models, and we exclusively focus on median estimates.

4.1.1 The Great Inflation

Starting from the Great Inflation episode, until the very end of 1970s, coinciding with the beginning of the Thatcher disinflation, the coefficients on both inflation and output growth are estimated to have been quite remarkably low, fluctuating between 0.2 and 0.3, and between -0.1 and 0, respectively. In the light of such a weak-to-non-existent responsiveness of U.K. monetary policy to macroeconomic fluctuations, it is therefore not surprising that the 1970s saw high and highly volatile inflation—peaking, on an annual basis, at 28.1 per cent in 1975:3—and highly volatile output growth. An important point to stress is that the large fluctuations in inflation, output growth, and money growth during the Great Inflation episode suggest that the parameters of the structural monetary rule are most likely well-estimated—under this respect it is interesting to notice how uncertainty concerning the long-run coefficient on inflation reached historical lows during the second half of the 1970s ... As we argue below, on the other hand, the remarkable macroeconomic stability of the inflation targeting era creates, under this respect, crucial problems: since, post-October 1992, nothing basically moves much, it can be reasonably argued that, for this period, the parameters of the structural monetary rule might have been poorly estimated.

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[21] See at http://home.earthlink.net/~tzha02/ProgramCode/SRestrictRWZalg.m.

[22] For each quarter t, and each single iteration of the Gibbs sampler, the long-run coefficients can be trivially computed *via* simple manipulations of the estimated structural monetary rule.

[23] We do not report the corresponding objects for the lagged interest rate as they are not especially interesting, but they are available from the author upon request.

4.1.2 The 1980s

The launch of the Thatcher disinflation in 1979 was accompanied by clear, although not dramatic, increases in the coefficients on both inflation and M4 growth, and by a gradual, mild increase in the coefficient on output growth. A comparison with the Volcker disinflation in the United States is, under this respect, illuminating. Based exactly on the same methodology adopted herein, Benati and Mumtaz (2007) estimate the long-run coefficients on inflation and M2 growth to have increased from slightly below one and slightly below zero, respectively, around mid-1979, to about 3 and 0.6 in 1985. The coefficient on output growth, on the other hand, is estimated to have become slightly *negative*, around -0.5, during the Volcker recession, thus capturing in the starkest possible way the FED's determination to eradicate inflation 'no matter what'. The comparison with the disinflation which was taking place, exactly at the same time, across the Atlantic therefore clearly suggests the shift towards a counter-inflationary stance on the part of the U.K. monetary authority to have been a comparatively mild one ... After peaking in 1983:3, the coefficient on M4 growth systematically decreased during subsequent years,[24] reaching towards the end of the 1980s values comparable to those of the second half of the 1970s. The most striking feature of those years, however, concerns the long-run coefficient on inflation, which during the *entire* decade of the 1980s is estimated to have fluctuated between 0.7 and 0.8, significantly below unity.[25] This reinforces the point we just made in our comparison with the U.S. experience during the Volcker disinflation, and clearly suggests that, even after the arrival of Margaret Thatcher, U.K. monetary policy was not decisively counter-inflationary yet.

These results cast an intriguing light on the United Kingdom's search, during the second half of the 1980s and the beginning of the 1990s, for an external, exchange-rate based nominal anchor, first by shadowing the Deutsche Mark, and then by entering the Exchange Rate Mechanism of the European Monetary System (henceforth, ERM and EMS, respectively). In a sense, it looks like as if, for *some* reason, U.K. policymakers were incapable of providing the economy a strong nominal anchor, and therefore had to look for it across the Channel.

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[24]Monetary targeting was abandoned in 1985.

[25]According to the 'Taylor principle' a unitary value discriminates between a stabilising and a non-stabilising monetary rule—i.e. between monetary rules such as to generate determinacy and, respectively, indeterminacy. It is however important to stress that the most recent literature—see in particular Lubik and Schorfheide (2004)—has highlighted how equilibrium (in)determinacy is, strictly speaking, a *system* property, as it depends on the interaction between *all* of the parameters of the monetary rule and *all* of the structural parameters. A unitary value of the long-run coefficient on inflation should therefore be regarded as a broad yardstick of the looseness/toughness of the monetary stance, and nothing more. So while the remarkably low values taken by the coefficients of the structural monetary rule in the 1970s clearly point towards the possibility of indeterminacy, for the 1980s evidence is much less clear-cut ...

4.1.3 The period of ERM membership

The United Kingdom joined the ERM in October 1990, and suspended ERM membership on 'Black Wednesday', September 16, 1992, following a massive wave of currency speculation. The most striking feature of that period is represented by the large, temporary decreases in the long-run coefficients on inflation and output growth, and to a lesser extent by that on M4 growth,[26] thus dramatically highlighting how during those months U.K. monetary policy—being 'done in Frankfurt'—was virtually disconnected from domestic economic conditions. When seen through these lenses, the crisis of 'Black Wednesday' appears, in a sense, all but inevitable ...

4.1.4 The inflation-targeting regime

Three weeks after suspension of EMS membership, on October 8, 1992, the Conservative government led by John Major introduced an inflation-targeting regime.[27] When seen through the lenses of the evolution of the structural monetary rule, the inflation-targeting era has exhibited, to date, two major characteristics:

- the long-run coefficient on M4 growth has been fluctuating at historically low values, between 0 and 0.3, thus pointing towards the diminished role played by monetary aggregates within the current monetary framework, especially when compared with the first half of the 1980s.

- The long-run coefficients on inflation and output growth, on the other hand, have dramatically increased when compared with the lows of the ERM period—reaching, based on median estimates, maxima of about 1.4 and 0.9, respectively, during the first years of the century—thus clearly testifying to the markedly more aggressively counter-inflationary stance which has been adopted under the current regime.

Under this respect, an important point which we already briefly mentioned in Section 4.1.1 concerns *how reliable* the estimated structural monetary rule can be regarded under the current regime. From a strictly *logical* point of view, indeed, if inflation and output growth don't move around sufficiently, there is *no way* that the

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[26] According to the estimates reported in Figure 4, the decrease in the long-run coefficients on the three variables started *before* the United Kingdom joined the ERM. The simplest and most logical explanation for this result is that the estimates produced by the Gibbs sampler are, by construction, two-sided, and in the case of processess experiencing sharp breaks they therefore tend to inevitably smooth the break, thus 'mixing the future with the past', and giving the misleading impression that the change took place before it actually did.

[27] Since October 1992, the most significant change in the U.K. monetary framework has been the granting of operational independence to the *Bank of England*, with the contemporaneous creation of the *Monetary Policy Committee*, on May 6, 1997, five days after Labour's election victory.

coefficients in the structural monetary rule can reliably be identified.[28] Given that, after October 1992, the U.K. economy has been just strikingly stable, it might reasonably be argued that the estimates of the rule's coefficients on inflation and output growth are biased towards zero.[29] Quite obviously, this has important implications for the reliability of counterfactual simulations in which the *Monetary Policy Committee* structural monetary rule is imposed over the entire sample period: irrespective of Lucas critique-type arguments, if, because of the just-mentioned problem, the estimated 'MPC monetary rule' is *weaker* than in it is reality, when you impose it over the entire post-WWII sample period you're obviously going to get potentially non-sensical results. Because of this, in the next two Section we are going to consider three alternative counterfactuals: one in which the structural shocks are set to zero one at a time; one in which the *MPC* monetary rule is imposed over the entire sample period; and one in which the 1970's monetary rule—which, as we previously argued, is most likely much more reliably estimated than the post-October 1992 one—is imposed over the entire sample period.

4.2 Counterfactual histories

4.2.1 Setting to zero one shock at a time

Figure 5 reports results from a set of counterfactual simulations in which we set to zero one shock at a time, and we then 're-run history' by keeping all remaining estimated objects at their historical values.[30] The key results emerging from the figure can be summarised as follows.

- The monetary policy shock does not appear to have played much of a role, with the single notable exception of M4 growth during the period between mid-1980s and mid-1990s.

- The money demand shock only appears to have had a positive impact on inflation around the first half of the 1970s.

- As expected, the supply shock had a significant positive impact on inflation around the time of the two oil shocks, and a mild positive impact on interest rates around the time of the second oil shock (but not of the first). To put it

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[28]I wish to thank Charlie Bean for an extremely helpful discussion on this issue. In his words, given that, under the current regime, inflation is, to a first approximation, a 'controlled process', it is not clear to which extent you can actually identify the parameter on inflation in the structural monetary rule.

[29]Indeed, an estimate close to zero for the coefficient on inflation in a Taylor rule is what you get if you estimate DSGE models for inflation targeting countries *via* maximum likelihood. These results—which were part of the preliminary work for Benati (2007), and didn't end up in the final version of the paper—are available upon request.

[30]By 'historical values' we mean the Gibbs sampler output.

differently, without the second oil shock interest rates would have been about 100 basis points lower than they actually turned out to be.

- Finally, as the second row clearly shows, historically the bulk of the action appears to have come from demand non-policy shocks. If they had been uniformly equal to zero over the entire sample period, (i) the 1970s' Great Inflation would have never happened; (ii) M4 growth would have been uniformly lower during the entire period up to ERM membership; (iii) output growth would have been higher around the time of the Great Inflation; and (iv) interest rates would have been uniformly lower during the entire period before inflation targeting, and marginally higher during the most recent years.

Summing up, based on this exercise—which, it is important to stress, *is not vulnerable to the Lucas critique*, because we are only manipulating shocks—the Great Inflation was due, first and foremost, to demand non-policy, and, to a lesser extent, to supply shocks.

Let's now turn to two alternative sets of counterfactual simulations which are, instead, vulnerable to the Lucas critique.

4.2.2 Bringing the *Monetary Policy Committee* back in time

Figure 6 reports results from 1,000 counterfactual simulations[31] in which we 'bring the *Monetary Policy Committee* back in time', imposing the post-May 1997 monetary rule over the entire sample period.[32] As the second row clearly shows, with the MPC monetary rule in place over the entire sample period (i) money growth would have been significantly lower during the 'Great Inflation' episode; (ii) inflation would have been lower, but not significantly so, with a peak impact equal to about minus four percentage points around mid-1970s; (iii) output growth would have been marginally lower during the 1970s-1980s; and (iv) interest rates would have been slightly higher, up to a maximum of about two percentage points, around the time of the Great Inflation.

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[31] As it has been well known for a long time, structural VAR-based counterfactual simulations are vulnerable to the Lucas critique, so the results of this section should necessarily be taken with a grain of salt. It has to be stresed, however, that in spite of this well-known *caveat*, counterfactual simulations are routinely used in the structural VAR literature. The counterfactual we are performing here, for example, is conceptually akin to what Sims and Zha (2006) do (see their Section VII, 'Historical Counterfactuals').

[32] Specifically, for each simulation j=1, 2, ..., N, at each quarter t=p+1, p+2, ..., T we draw three random numbers, τ, indexing the post-May 1997 quarter from which we draw the elements of the structural monetary rule; and κ_t and κ_τ, indexing the iterations of the Gibbs sampler at times t and, respectively, τ from which we draw the state of the economy. (All three numbers are defined over appropriate uniform distributions.) We then take all of the elements of the monetary rule from iteration κ_τ of the Gibbs sampler for quarter τ, while we take everything else from iteration κ_t for quarter t. We start each counterfactual simulation conditional on the first p actual historical values of the vector Y_t.

Overall, it's not really that much of an impact ...

There are, however, two *caveats* to these results. The former one, which has been well known for years, has to do with the Lucas critique. We'll not discuss it here, as, first, as we said, it has been well known for a long time. And second, within the SVAR framework there's not really much that we can do about it—the only way to effectively deal with it would be to use a structural (DSGE) model.

The latter *caveat*, on the other hand, has to do with the point we discussed in sections 4.1.1 and 4.1.4, namely the comparatively greater reliability of the estimates of the parameters of the structural monetary rule for the 1970s, and the comparatively lesser reliability of the estimates for the most recent years. Because of this, we now turn to the alternative counterfactual in which we impose the 1970s' monetary rule over the entire sample.

4.2.3 Imposing the 1970's monetary rule over the entire sample

Figure 7 reports results from this alternative counterfactual. The two striking results from this exercise are that, with the 1970s 'monetary rule imposed over the entire sample period,

- inflation would have been essentially the same as what it has historically been, and

- output growth would have been marginally higher during the 1980s.

Apart from this, interest rates would have been marginally lower during the 1980s, and M4 growth would have been higher during the 1980s and the first half of the 1990s, and lower during the most recent years.

Given that the 1970s 'monetary rule is most likely precisely estimated, these results provide—up to Lucas critique-type arguments—the strongest possible evidence that the luck of the draw—as opposed to good or bad policy—has been the dominant force in post-WWII U.K. macroeconomic history. It is worth stressing how these results are conceptually *exactly* in line with those obtained for the United States by Stock and Watson (2002), Primiceri (2005), Sims and Zha (2006), Canova and Gambetti (2005), Gambetti, Pappa, and Canova (2006), and Benati and Mumtaz (2007).

4.3 Changes in the transmission of monetary policy shocks

Finally, Figure 8 plots, for the four series, the time-varying median generalised impulse-response functions (henceforth, IRFs) to a 25 basis points monetary policy shock, while Figure 9 shows the same objects, together with the16th and 84th percentiles of the distributions, for four selected dates. Generalised IRFs have been computed *via* the Monte Carlo integration procedure described in Appendix C, which allows to

effectively tackle the uncertainty originating from future time-variation in the VAR's structure. Due to the computational intensity of such a procedure, IRFs have been computed only every four quarters, starting from 1972:1.

Both figures, especially Figure 8, point towards several interesting changes in the economy's response to a monetary policy shock. Specifically (*i*) the response of the nominal rate does not exhibit much time-variation over the sample period, with the single notable exception of the period of ERM membership, thus testifying, once again, to the uniqueness of that period in post-WWII U.K. macroeconomic history; (*ii*) intriguingly, inflation's response exhibits a clear 'price puzzle' around the time of the Great Inflation, but nothing before, and essentially nothing after; and (*iii*) the response of M4 growth appears to have progressively become stronger as time went by. None of these findings, however, questions the previously discussed main result of a dominant role played by good luck in fostering the more stable macroeconomic environment of the last 15-20 years.

5 A *Caveat*: The 'Indeterminacy Hypothesis'

Taken at face value, our results clearly point towards good luck as the most plausible explanation for the remarkable macroeconomic stability enjoyed by the British economy over the most recent era. But are there any *caveats* to our *interpretation* of these results? We believe that there is an important one, which is currently being investigated in our related work in progress.[33] In order to provide the reader with a better and fuller understanding of our position, however, let's start by briefly discussing evidence coming from an alternative approach.

5.1 Evidence from a narrative approach: the crucial role of the U.K. experience

Although the literature on the Great Moderation has been dominated, so far, by a strictly econometric approach—based on either reduced-form techniques, as in the case of Ahmed, Levin, and Wilson (2004), or on structural methods, as in (e.g.) Primiceri (2005), Gambetti, Pappa, and Canova (2006) and Sims and Zha (2006)—a key point to stress is that econometric evidence is not the *only* kind of evidence we can rely on. Historical and 'narrative' evidence—detailing, in particular, the evolution of the overall intellectual climate surrounding (monetary) policymaking over the last several decades—may provide useful and, as we will argue, sometimes crucial additional insights on the comparative likelihood of 'good luck' as opposed to 'good policy' as the explanation for the greater macroeconomic stability of recent years.[34]

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[33] Benati and Surico (2007).

[34] For the more technically oriented readers, who may be tempted to just shrug such arguments off, we would like to point out that one of the single most influential macroeconomic books of the XX

Although for the United States narrative accounts of the Great Inflation and of the subsequent stabilisation[35] are, in our opinion, very far from providing decisive evidence in favor of either hypothesis, evidence for the United Kingdom—coming, first and foremost, from the work of Ed Nelson and his co-authors[36]—is on the other hand extremely sharp.

As pointed out by Nelson and Nikolov (2004) in their extensive analysis of the broad intellectual climate surrounding monetary policymaking in the United Kingdom in the 1960s and 1970s, during those years

> *[m]onetary policy was not seen as essential for inflation control*; the latter, instead, was largely delegated to incomes policy (wage and price controls). [...] Essentially, *UK policymakers viewed monetary policy as disconnected from inflation* for two reasons. First, inflation was perceived as largely driven by factors other than the output gap; secondly, policymakers were highly sceptical about the ability of monetary policy to affect aggregate demand or the output gap appreciably. [This] led to a combination of easy monetary policy and attempts to control inflation through other devices, and contributed heavily to the breakout of inflation in the 1960s and 1970s. (emphasis added)

Alec Cairncross, who served as a Treasury official[37] during that period, provides support to the position of Nelson and Nikolov (2004), by stressing how[38]

> [i]n the effort to limit inflation there was little thought of reliance on monetary policy, much less *exclusive* reliance on monetary policy [...]. The prevailing view was that of the Radcliffe Committee [...]: monetary policy itself had limited usefulness in controlling inflation. [...] Even after the IMF seminar in 1968, the Treasury remained sceptical [...] of the influence of monetary policy on the rate of inflation, *and was anxious to keep rates as low as possible in the interests of holding down interest on government debt and encouraging fixed investment.* (emphasis added)

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century, Friedman and Schwartz's *Monetary History*, was *entirely* based on the narrative approach. For more recent examples of this approach, see the work of Christina and David Romer.

[35] See in particular the work of DeLong (1997).

[36] To be precise, the work of Ed Nelson and co-authors is not *uniquely* based on the narrative approach. Although Batini and Nelson (2005) presents a purely narrative analysis, Nelson and Nikolov (2004) (e.g.) also presents econometric work based on an estimated DSGE model. Interestingly—and in line with this section's main point—the authors find 'that inaccurate estimates of the degree of excess demand in the economy contributed significantly to the outbreak. But [they] also find a major role for the failure at the time to recognize the importance of monetary policy, as opposed to nonmonetary devices, in controlling inflation.'

[37] An important point to stress that, until May 1997, U.K. monetary policy had been formulated by the Treasury. For a brief history of U.K. monetary arrangements, see Benati (2006, section 2).

[38] See Cairncross (1996), as quoted in Nelson and Nikolov (2004).

The italicised portion of the last sentence is especially revealing of the broader intellectual context within which policymaking was then formulated in the United Kingdom and of the specific objectives towards which monetary policy was then directed, and provides clear support for Nelson and Nikolov's previously mentioned assertion that such intellectual climate led to a combination of lax monetary policy and attempts to control inflation *via* nonmonetary means.

In their painstaking reconstruction of the U.K.'s long and winding 'rocky road to stability', Batini and Nelson (2005) conclude that there were three crucial steps in the process leading from the old boom-and-bust to the stability of the more recent era.

> The first was the acceptance of monetary policy as the key tool for managing aggregate demand; this acceptance took place in the early 1970s. The second was the shaking-off of cost-push views of inflation in favor of a monetary view, allowing monetary policy to become the government's anti-inflation weapon; this shift occurred in 1979. The third was the discarding of ineffective monetary policy instruments, which had given U.K. policymakers the false notion that they could alter the stance of monetary policy without affecting short-term interest rates or the monetary base. This process culminated [...] in 1985.

To sum up, over the last several decades the United Kingdom has moved from a situation in which monetary policy was regarded as essentially *useless* for the purpose of controlling inflation, to one in which, on the contrary, it is regarded as *the crucial instrument*. Further, such a sea change in the overall intellectual attitude towards inflation and monetary policy has been enshrined in the U.K. 'monetary constitution', with inflation targeting being introduced in October 1992, and with the *Bank of England* being granted independence, and the *Monetary Policy Committee* being created, in May 1997. Given such dramatic changes in both macroeconomic thinking and monetary policymaking since the beginning of the 1960s, we would be naturally led to expect that econometric methods, when applied to U.K. post-WWII data, would point towards good policy as the explanation of the transition from the Great Inflation to the Great Moderation. As this paper has clearly shown, however, this is definitely not the case, with structural VAR methods strongly and consistently pointing, on the contrary, towards good luck.

But so, how can we reconcile the narrative and VAR evidence?

5.2 Reconsidering the VAR evidence: the 'indeterminacy hypothesis'

Based on DSGE models, the work of Clarida, Gali, and Gertler (2000) and Lubik and Schorfheide (2004) has suggested that, in the post-WWII U.S., the move from the Great Inflation to the Great Moderation was caused by the switch from

passive to active monetary policy—more precisely, from an indeterminate to a determinate equilibrium. In a nutshell, the argument is that, before Paul Volcker's October 1979 'Saturday Night Special', U.S. monetary policy was not sufficiently strongly counter-inflationary, thus allowing for equilibrium *indeterminacy*, i.e. for a multiplicity (technically, an infinity) of possible solutions, while after October 1979 a more decisively counter-inflationary policy stance effectively ruled out the possibility of multiple solutions, thus guaranteeing equilibrium *determinacy* (i.e., solution uniqueness). Given that—as shown by Clarida, Gali, and Gertler (2000) and Lubik and Schorfheide (2004)—under indeterminacy macroeconomic fluctuations are characterised by greater persistence and *volatility*, the 'indeterminacy hypothesis' provides a simple and theoretically elegant explanation of the transition from the Great Inflation to the Great Moderation in line with the narrative evidence of, e.g. DeLong (1997) and Romer and Romer (2002).

In order to reconcile the evidence coming from the two approaches, in Benati and Surico (2007) we therefore consider the following, simple experiment.

> *Suppose that Clarida, Gali, and Gertler (2000) and Lubik and Schorfheide (2004) are right, so that the truth was, for the United States, 'bad policy' (i.e., indeterminacy) before October 1979, and 'good policy' (i.e., determinacy) thereafter. Would structural VARs be capable of uncovering the truth?*

Specifically, we take the simple New Keynesian workhorse model of Clarida, Gali, and Gertler (2000), we simulate it conditional on the monetary rules they estimated for the two regimes, and we apply structural VAR methods to the simulated data.[39] In order to make our results as sharp as possible, (*i*) we keep the volatilities of *all* the structural shocks—including the monetary policy shocks—constant across the two regimes; (*ii*) we set the volatility of the sunspot shock under indeterminacy equal to zero; and (*iii*) we keep all the remaining structural parameters (the Phillips curve slope and the elasticity of intertemporal substitution) constant. By construction, in our experiment *everything* is therefore *uniquely* driven by a move from passive to active monetary policy. Our results suggest that evidence similar to that produced within the structural VAR-based literature—including the present work—can be generated within a framework in which everything is driven by a move from bad to good policy. In particular,

(1) a shift from indeterminacy to determinacy can reproduce the main qualitative features of the Great Moderation. In particular, the shift is associated with decreases in both the total prediction variance of the system, and in the variances of each individual series.

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[39]Identification is achieved by imposing, on the estimated reduced-form VAR, the sign restrictions implied by the theoretical model on impact. (Since, under indeterminacy, we consider the so-called 'continuity' solution—see Lubik and Schorfheide (2003) and Lubik and Schorfheide (2004)—the signs on impact are identical under the two regimes.)

(2) The counterfactual experiment of switching the estimated interest rate rules in the structural VARs across regimes points towards the incorrect conclusion that changes in the systematic component of monetary policy did not play a significant role in causing changes of the DGP.

6   Conclusions

So, was it good luck? Based on our results—which, it is worth pointing out, are broadly in line with the evidence for the U.S. produced by Stock and Watson (2002), Primiceri (2005), Sims and Zha (2006), Canova and Gambetti (2005), Gambetti, Pappa, and Canova (2006), and Benati and Mumtaz (2007)—it looks like it was indeed. To recapitulate, results from counterfactual simulations show that (1) the Great Inflation was due, to a dominant extent, to large demand non-policy shocks, and to a lesser extent—especially in 1973 and 1979—to supply shocks; (2) imposing the 1970s' monetary rule over the entire sample period would have made almost no difference in terms of inflation and output growth outcomes; and (3) alternatively, mechanically 'bringing the Monetary Policy Committee back in time' would only have had a limited impact on the Great Inflation episode.

We have however discussed a possible, inportant *caveat* to this interpretation of our results, based on the notion that, in the bad old days of the boom-and-bust, the U.K. economy was under indeterminacy. If that's the case, the preliminary results from related work in progress of ours suggest a possible way of reconciling the evidence produced in the present paper with the narrative evidence coming from the work of Ed Nelson and his co-authors.

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A   The Data

Quarterly seasonally adjusted series for both real GDP (ABMI) and the GDP deflator (YBGB) are from the *Office for National Statistics*. A quarterly seasonally unadjusted series for the short-term government bond yield (series' code: 11261A..ZF...) is from the *International Monetary Fund*'s International Financial Statistics. A quarterly seasonally adjusted M4 series is from the *Bank of England* database (series'acronym is LPQAUYN).

B   Details of the Markov-Chain Monte Carlo Procedure

We estimate (1)-(9) *via* Bayesian methods. The next two subsections describe our choices for the priors, and the Markov-Chain Monte Carlo algorithm we use to simulate the posterior distribution of the hyperparameters and the states conditional on the data, while the third section discusses how we check for convergence of the Markov chain to the ergodic distribution.

B.1   Priors

For the sake of simplicity, the prior distributions for the initial values of the states—θ_0, α_0, and h_0—which we postulate all to be normal, are assumed to be independent both from one another, and from the distribution of the hyperparameters. In order to calibrate the prior distributions for θ_0, α_0 and h_0 we estimate a time-invariant version of (1) based on the first 8 years of data, from 1959:3 to 1966:4, and we set

$$\theta_0 \sim N\left[\hat{\theta}_{OLS}, 4 \cdot \hat{V}(\hat{\theta}_{OLS})\right] \tag{B1}$$

As for α_0 and h_0 we proceed as follows. Let $\hat{\Sigma}_{OLS}$ be the estimated covariance matrix of ϵ_t from the time-invariant VAR, and let C be the lower-triangular Choleski factor of $\hat{\Sigma}_{OLS}$—i.e., $CC' = \hat{\Sigma}_{OLS}$. We set

$$\ln h_0 \sim N(\ln \mu_0, 10 \times I_4) \tag{B2}$$

where μ_0 is a vector collecting the logarithms of the squared elements on the diagonal of C. We then divide each column of C by the corresponding element on the diagonal—let's call the matrix we thus obtain $\tilde{C}$—and we set

$$\alpha_0 \sim N[\tilde{\alpha}_0, \tilde{V}(\tilde{\alpha}_0)] \tag{B3}$$

where $\tilde{\alpha}_0$—which, for future reference, we define as $\tilde{\alpha}_0 \equiv [\tilde{\alpha}_{0,11}, \tilde{\alpha}_{0,21}, ..., \tilde{\alpha}_{0,61}]'$—is a vector collecting all the non-zero and non-one elements of $\tilde{C}^{-1}$ (i.e, the elements below

the diagonal), and its covariance matrix, $\tilde{V}(\tilde{\alpha}_0)$, is postulated to be diagonal, with each individual (j,j) element equal to 10 times the absolute value of the corresponding j-th element of $\tilde{\alpha}_0$. Such a choice for the covariance matrix of α_0 is clearly arbitrary, but is motivated by our goal to scale the variance of each individual element of α_0 in such a way as to take into account of the element's magnitude.

Turning to the hyperparameters, we postulate independence between the parameters corresponding to the three matrices Q, S, and Z—an assumption we adopt uniquely for reasons of convenience—and we make the following, standard assumptions. The matrix Q is postulated to follow an inverted Wishart distribution,

$$Q \sim IW\left(\bar{Q}^{-1}, T_0\right) \tag{B4}$$

with prior degrees of freedom T_0 and scale matrix $T_0\bar{Q}$. In order to minimize the impact of the prior, thus maximizing the influence of sample information, we set T_0 equal to the minimum value allowed, the length of θ_t plus one. As for $\bar{Q}$, we calibrate it as $\bar{Q} = \gamma \times \hat{\Sigma}_{OLS}$, setting $\gamma = 3.5 \times 10^{-4}$, the same value used by Cogley and Sargent (2005).

The three blocks of S are assumed to follow inverted Wishart distributions, with prior degrees of freedom set, again, equal to the minimum allowed, respectively, 2, 3 and 4:

$$S_1 \sim IW\left(\bar{S}_1^{-1}, 2\right) \tag{B5}$$

$$S_2 \sim IW\left(\bar{S}_2^{-1}, 3\right) \tag{B6}$$

$$S_3 \sim IW\left(\bar{S}_3^{-1}, 4\right) \tag{B7}$$

As for $\bar{S}_1$, $\bar{S}_2$ and $\bar{S}_3$, we calibrate them based on $\tilde{\alpha}_0$ in (B3) as $\bar{S}_1 = 10^{-3} \times |\tilde{\alpha}_{0,11}|$, $\bar{S}_2 = 10^{-3} \times \mathrm{diag}([|\tilde{\alpha}_{0,21}|, |\tilde{\alpha}_{0,31}|]')$ and $\bar{S}_3 = 10^{-3} \times \mathrm{diag}([|\tilde{\alpha}_{0,41}|, |\tilde{\alpha}_{0,51}|, |\tilde{\alpha}_{0,61}|]')$. Such a calibration is consistent with the one we adopted for Q, as it is equivalent to setting $\bar{S}_1$, $\bar{S}_2$ and $\bar{S}_3$ equal to 10^{-4} times the relevant diagonal block of $\tilde{V}(\tilde{\alpha}_0)$ in (B3). Finally, as for the variances of the stochastic volatility innovations, we follow Cogley and Sargent (2002, 2005) and we postulate an inverse-Gamma distribution for the elements of Z,

$$\sigma_i^2 \sim IG\left(\frac{10^{-4}}{2}, \frac{1}{2}\right) \tag{B8}$$

B.2   Simulating the posterior distribution

We simulate the posterior distribution of the hyperparameters and the states conditional on the data *via* the following MCMC algorithm, combining elements of Primiceri (2005) and Cogley and Sargent (2002, 2005). In what follows, x^t denotes the entire history of the vector x up to time t—i.e. $x^t \equiv [x'_1, x'_2, \quad , x'_t]'$—while T is the sample length.

(a) Drawing the elements of θ_t Conditional on Y^T, α^T, and H^T, the observation equation (1) is linear, with Gaussian innovations and a known covariance matrix.

Following Carter and Kohn (2004), the density $p(\theta^T|Y^T, \alpha^T, H^T, V)$ can be factored as

$$p(\theta^T|Y^T, \alpha^T, H^T, V) = p(\theta_T|Y^T, \alpha^T, H^T, V) \prod_{t=1}^{T-1} p(\theta_t|\theta_{t+1}, Y^T, \alpha^T, H^T, V) \quad \text{(B9)}$$

Conditional on α^T, H^T, and V, the standard Kalman filter recursions nail down the first element on the right hand side of (??), $p(\theta_T|Y^T, \alpha^T, H^T, V) = N(\theta_T, P_T)$, with P_T being the precision matrix of θ_T produced by the Kalman filter. The remaining elements in the factorization can then be computed via the backward recursion algorithm found, e.g., in Kim and Nelson (2000), or Cogley and Sargent (2005, appendix B.2.1). Given the conditional normality of θ_t, we have

$$\theta_{t|t+1} = \theta_{t|t} + P_{t|t}P_{t+1|t}^{-1}\left(\theta_{t+1} - \theta_t\right) \quad \text{(B10)}$$

$$P_{t|t+1} = P_{t|t} - P_{t|t}P_{t+1|t}^{-1}P_{t|t} \quad \text{(B11)}$$

which provides, for each t from T-1 to 1, the remaining elements in (1), $p(\theta_t|\theta_{t+1}, Y^T, \alpha^T, H^T, V) = N(\theta_{t|t+1}, P_{t|t+1})$. Specifically, the backward recursion starts with a draw from $N(\theta_T, P_T)$, call it $\tilde{\theta}_T$ Conditional on $\tilde{\theta}_T$, (B10)-(B11) give us $\theta_{T-1|T}$ and $P_{T-1|T}$, thus allowing us to draw $\tilde{\theta}_{T-1}$ from $N(\theta_{T-1|T}, P_{T-1|T})$, and so on until t=1.

(b) *Drawing the elements of* α_t Conditional on Y^T, θ^T, and H^T, following Primiceri (2005), we draw the elements of α_t as follows. Equation (1) can be rewritten as $A_t\tilde{Y}_t \equiv A_t(Y_t\text{-}X_t'\theta_t)=A_t\epsilon_t \equiv u_t$, with $\text{Var}(u_t)=H_t$, namely

$$\tilde{Y}_{2,t} = -\alpha_{21,t}\tilde{Y}_{1,t} + u_{2,t} \quad \text{(B12)}$$

$$\tilde{Y}_{3,t} = -\alpha_{31,t}\tilde{Y}_{1,t} - \alpha_{32,t}\tilde{Y}_{2,t} + u_{3,t} \quad \text{(B13)}$$

$$\tilde{Y}_{4,t} = -\alpha_{41,t}\tilde{Y}_{1,t} - \alpha_{42,t}\tilde{Y}_{2,t} - \alpha_{43,t}\tilde{Y}_{3,t} + u_{4,t} \quad \text{(B14)}$$

—plus the identity $\tilde{Y}_{1,t} = u_{1,t}$—where $[\tilde{Y}_{1,t}, \tilde{Y}_{2,t}, \tilde{Y}_{3,t}, \tilde{Y}_{4,t}]' \equiv \tilde{Y}_t$. Based on the observation equations (B12)-(B14), and the transition equation (7), the elements of α_t can then be drawn by applying the same algorithm we described in the previous paragraph separately to (B12), (B13) and (B14). The assumption that S has the block-diagonal structure (9) is in this respect crucial, although, as stressed by Primiceri (2005, Appendix D), it could in principle be relaxed.

(c) *Drawing the elements of* H_t Conditional on Y^T, θ^T, and α^T, the orthogonalised innovations $u_t \equiv A_t(Y_t\text{-}X_t'\theta_t)$, with $\text{Var}(u_t)=H_t$, are observable. Following Cogley and Sargent (2002), we then sample the $h_{i,t}$'s by applying the univariate algorithm of Jacquier, Polson, and Rossi (2004) element by element.[40]

(d) *Drawing the hyperparameters* Finally, conditional on Y^T, θ^T, H^T, and α^T, the innovations to θ_t, α_t, the $h_{i,t}$'s are observable, which allows us to draw the

---

[40]For details, see Cogley and Sargent (2005, Appendix B.2.5).

hyperparameters—the elements of Q, S_1, S_2 S_3, and the σ_i^2—from their respective distributions.

Summing up, the MCMC algorithm simulates the posterior distribution of the states and the hyperparameters, conditional on the data, by iterating on (a)-(d). In what follows we use a burn-in period of 50,000 iterations to converge to the ergodic distribution, and after that we run 10,000 more iterations sampling every 10th draw in order to reduce the autocorrelation across draws.[41]

B.3 Assessing the convergence of the Markov chain to the ergodic distribution

Following Primiceri (2005), we assess the convergence of the Markov chain by inspecting the autocorrelation properties of the ergodic distribution's draws. Specifically, in what follows we consider the draws' inefficiency factors (henceforth, IFs), defined as the inverse of the relative numerical efficiency measure of Geweke (1992),

$$RNE = (2\pi)^{-1} \frac{1}{S(0)} \int_{-\pi}^{\pi} S(\omega)d\omega \tag{B15}$$

where $S(\omega)$ is the spectral density of the sequence of draws from the Gibbs sampler for the quantity of interest at the frequency ω. We estimate the spectral densities by smoothing the periodograms in the frequency domain by means of a Bartlett spectral window. Following Berkowitz and Diebold (1998), we select the bandwidth parameter automatically *via* the procedure introduced by Beltrao and Bloomfield (1987).

Figure 10 shows the draws' IFs for the models' hyperparameters—i.e., the free elements of the matrices Q, Z, and S—and for the states, i.e. the time-varying coefficients of the VAR (the θ_t), the volatilities (the $h_{i,t}$'s), and the non-zero elements of the matrix A_t. As the figure clearly shows, the autocorrelation of the draws is uniformly very low, being in the vast majority of cases around or below 3—as stressed by Primiceri (2005, Appendix B), values of the IFs below or around twenty are generally regarded as satisfactory.

C Computing Generalised Impulse-Response Functions

This appendix describes the Monte Carlo integration procedure we use in section __ to compute generalised IRFs to a monetary policy shock. In order to reduce the computational burden, we only perform the exercise every four quarters starting in 1968Q1. For every quarter t out of four, we perform the following procedure 1,000 times.

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[41]In this we follow Cogley and Sargent (2005). As stressed by Cogley and Sargent (2005), however, this has the drawback of 'increasing the variance of ensemble averages from the simulation'.

Randomly draw the current state of the economy at time t from the Gibbs sampler's output. Given the current state of the economy, repeat the following procedure 100 times. Draw four independent $N(0, 1)$ variates—the four structural shocks—and based on the relationship $\epsilon_t = A_{0,t} e_t$, with $e_t \equiv [e_t^R, e_t^D, e_t^S, e_t^{MD}]'$, where e_t^R, e_t^D, e_t^S, and e_t^{MD} are the monetary policy, demand non-policy, supply, and money demand structural shocks, respectively, compute the reduced-form shocks ϵ_t at time t. Simulate both the VAR's time-varying parameters, the θ_t, and the covariance matrix of its reduced-form innovations, Ω_t, 20 quarters into the future. Based on the simulated Ω_t, randomly draw reduced-form shocks from $t+1$ to $t+20$. Based on the simulated θ_t, and on the sequence of reduced-form shocks from t to $t+20$, compute simulated paths for the three endogenous variables. Call these simulated paths as $\hat{X}_{t,t+20}^{j}$, $j = 1, .., 100$. Repeat the same procedure 100 times based on exactly the same simulated paths for the VAR's time-varying parameters, the θ_t; the same reduced-form shocks at times $t+1$ to $t+20$; and the same structural shocks e_t^D, e_t^S, and e_t^{MD} at time t, but setting e_t^R to one. Call these simulated paths as $\tilde{X}_{t,t+20}^{j}$. For each of the 100 iterations define $irf_{t,t+20}^{j} \equiv \hat{X}_{t,t+20}^{j} - \tilde{X}_{t,t+20}^{j}$. Finally, compute each of the 1,000 generalised IRFs as the mean of the distribution of the $irf_{t,t+20}^{j}$'s.

Table 1 Measuring changes in predictability: time-varying multivariate R^2's in selected quarters (median and 16th and 84th percentiles)		
	Short rate	*Inflation*
1972:2	0.937 [0.892; 0.966]	0.418 [0.233; 0.648]
1982:2	0.931 [0.892; 0.958]	0.358 [0.202; 0.575]
1992:2	0.925 [0.884; 0.959]	0.361 [0.192; 0.580]
2002:2	0.953 [0.918; 0.976]	0.351 [0.191; 0.551]
	Output growth	*M4 growth*
1972:2	0.127 [0.065; 0.227]	0.677 [0.524; 0.798]
1982:2	0.196 [0.096; 0.365]	0.535 [0.385; 0.701
1992:2	0.529 [0.308; 0.753]	0.509 [0.346; 0.677]
2002:2	0.521 [0.308; 0.743]	0.409 [0.249; 0.604]

Table 2 The width of the 'fan charts': standard deviations (in basis points) of k-step-ahead projections					
	Short rate			*Inflation*		
	$k=1$	$k=4$	$k=8$	$k=1$	$k=4$	$k=8$
1972:2	24	54	75	179	219	257
1982:2	26	62	86	131	159	189
1992:2	15	36	48	75	92	113
2002:2	10	24	37	51	61	74
	Output growth			*M4 growth*		
	$k=1$	$k=4$	$k=8$	$k=1$	$k=4$	$k=8$
1972:2	194	222	257	169	274	327
1982:2	110	134	159	118	184	224
1992:2	52	74	98	100	142	181
2002:2	35	46	67	99	13	165

The raw results from the stochastic simulations have been smoothed *via* the Christiano and Fitzgerald (2003) band-pass filter as described in section 3.3.
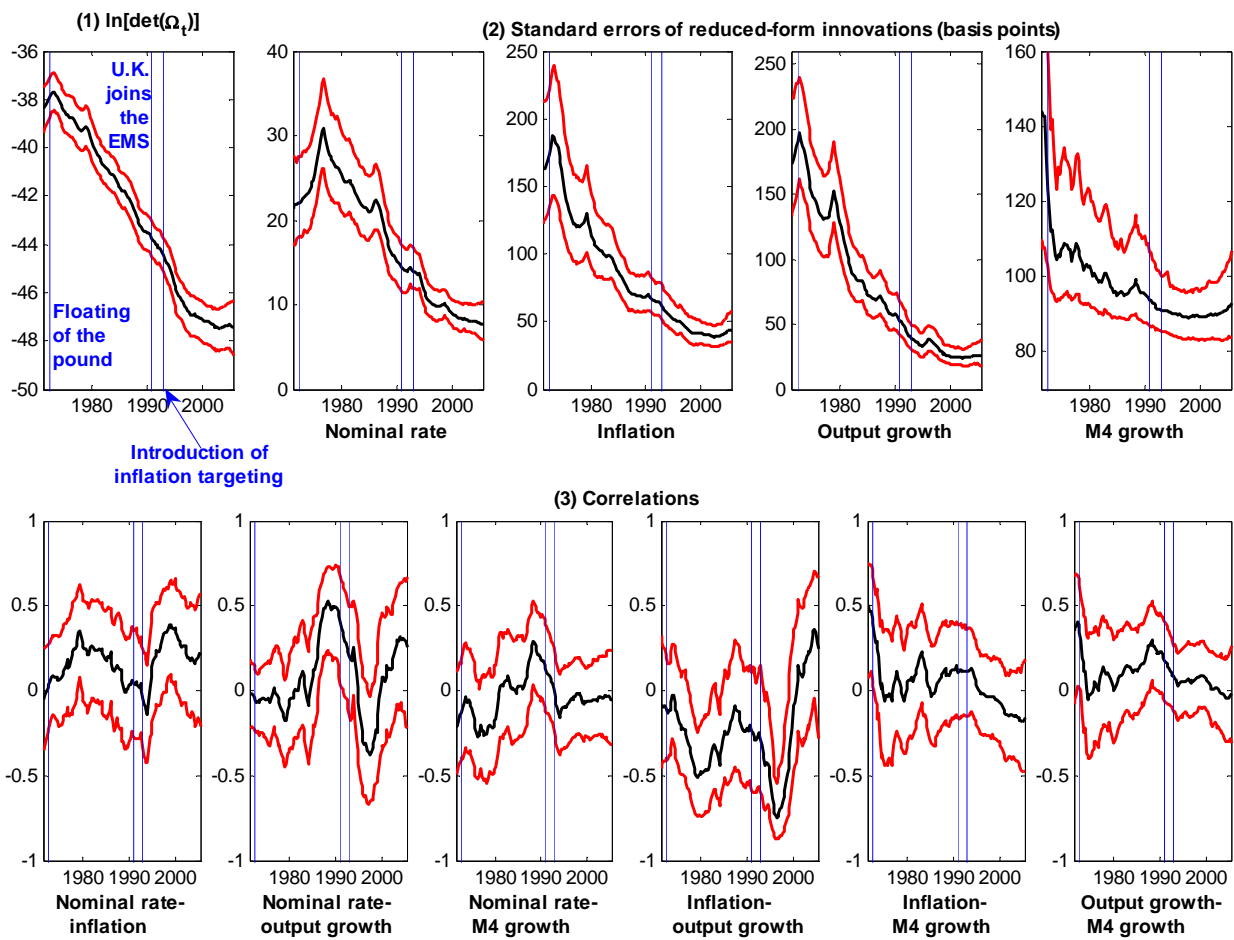
(1) ln[det(Ω_t)]

(2) Standard errors of reduced-form innovations (basis points)

Nominal rate

Inflation

Output growth

M4 growth

(3) Correlations

Nominal rate-
inflation

Nominal rate-
output growth

Nominal rate-
M4 growth

Inflation-
output growth

Inflation-
M4 growth

Output growth-
M4 growth

Figure 1: The evolution of Ω_t: $\ln|\Omega_t|$, standard errors of reduced-form innovations (in basis points), correlations, and 16th and 84th percentiles
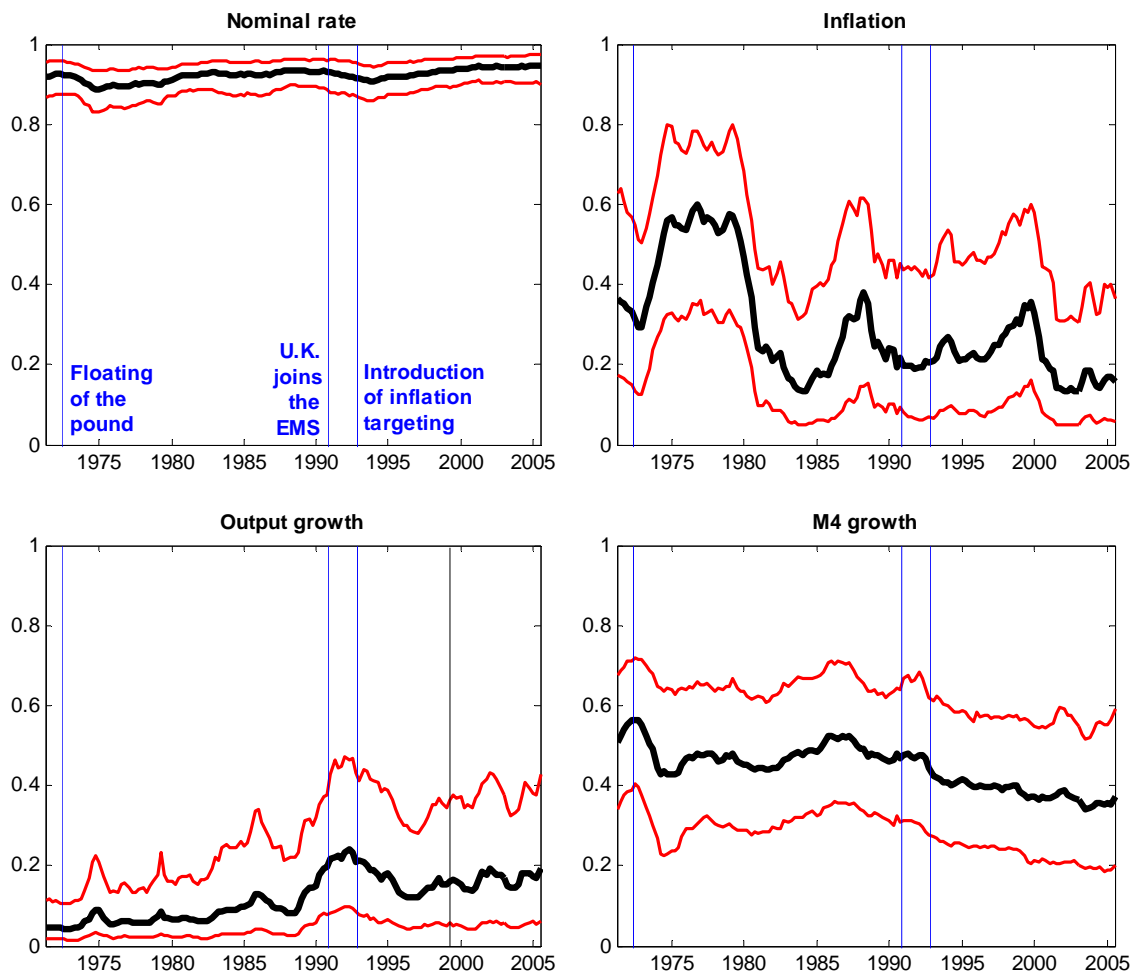
Figure 2: Measuring predictability: median R^2, and 16th and 84th percentiles
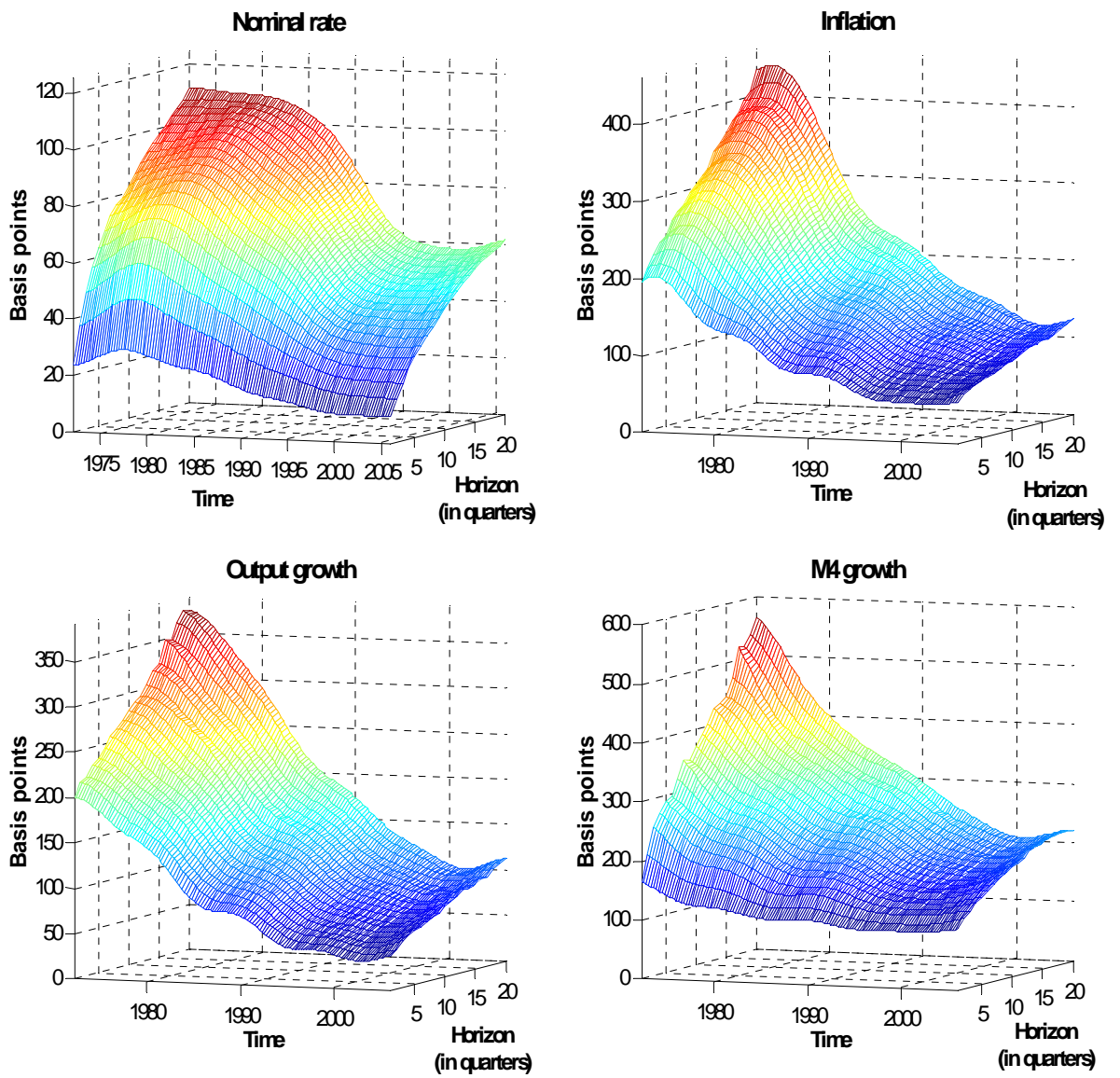
Figure 3: The width and shape of the 'fan charts': standard deviations (in basis points) of k-step ahead projections

Long-run coefficient on:
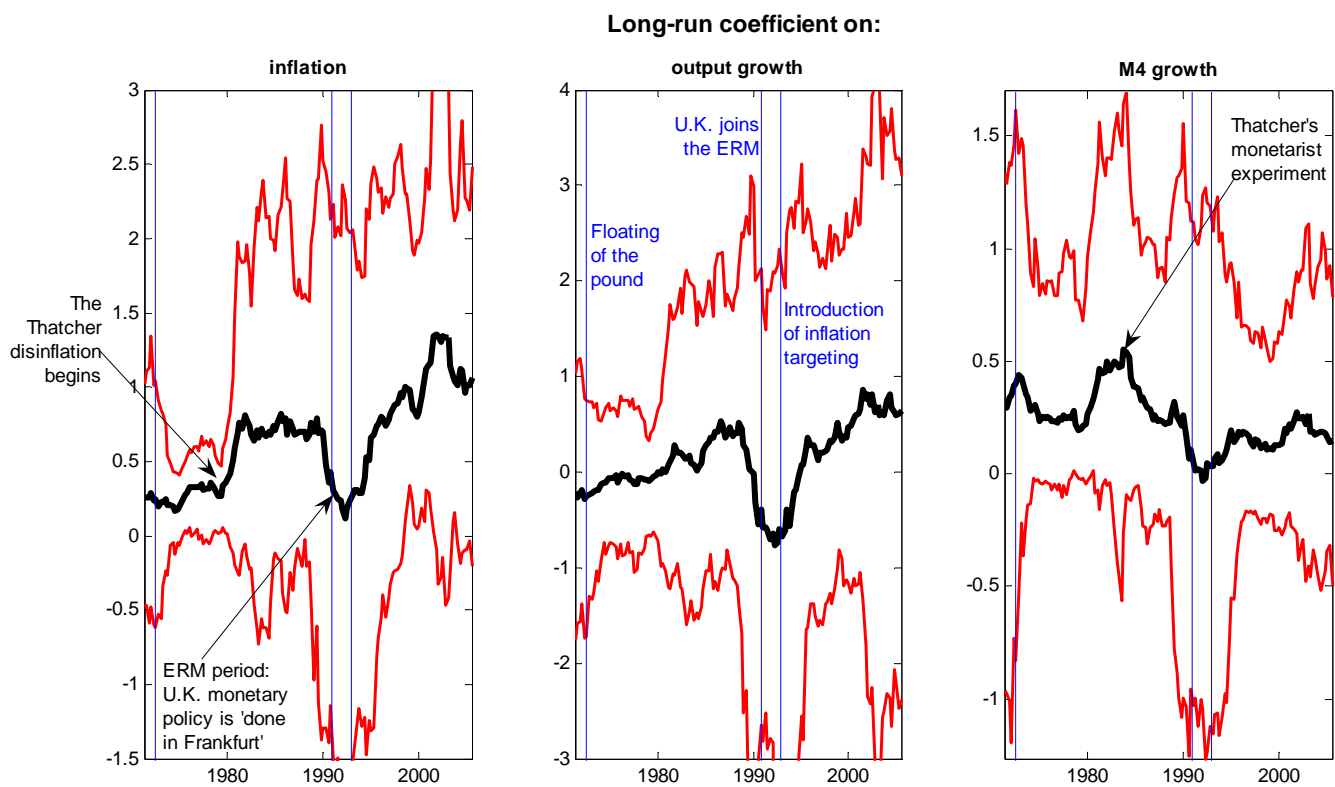
Figure 4: The evolution of the monetary policy stance: time-varying long-run coefficients on inflation, output growth, and M4 growth in the structural monetary policy rule (medians and 16th and 84th percentiles)
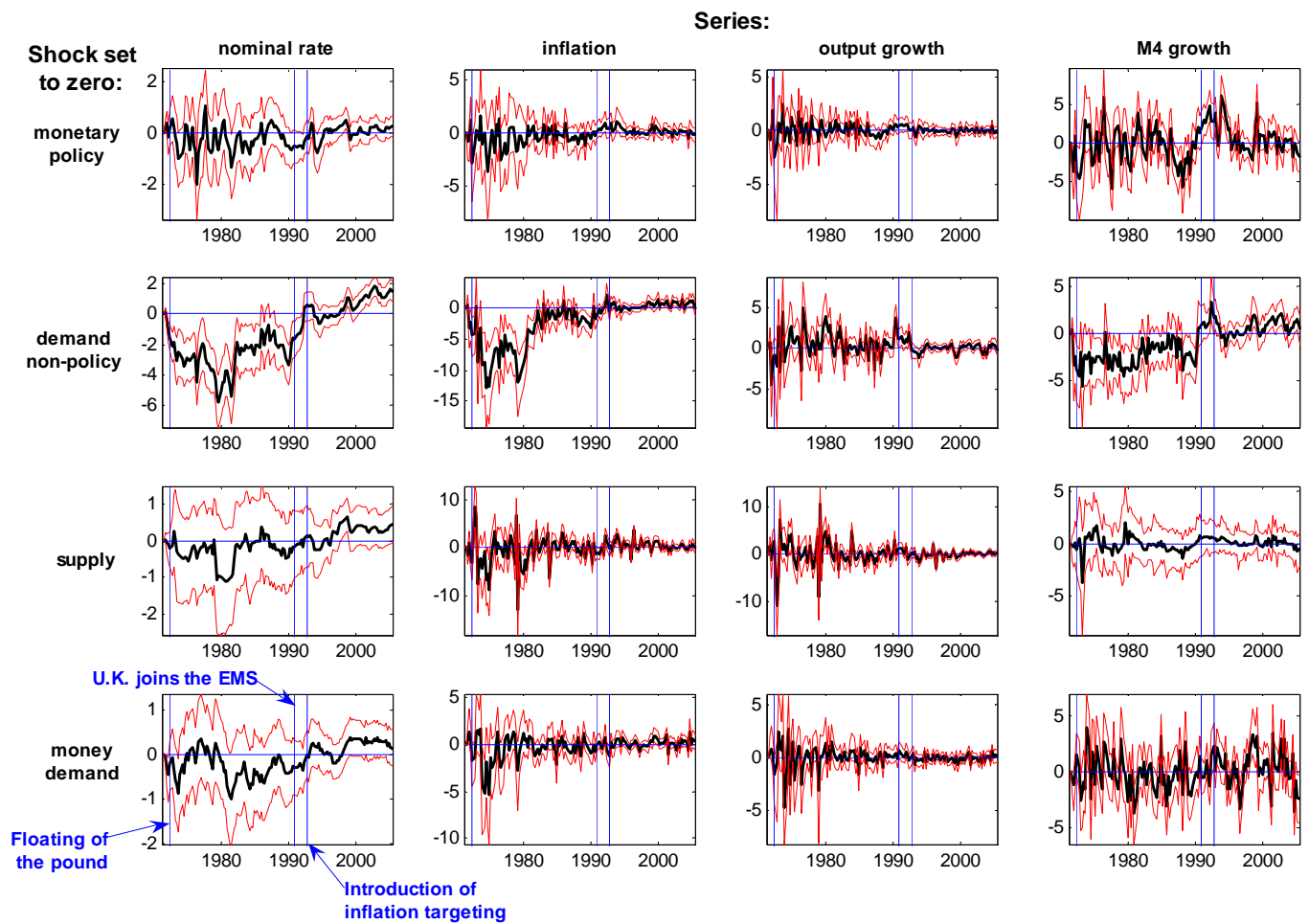
Figure 5: Setting to zero one shock at a time: counterfactual minus actual, medians of the distributions and 16th and 84th percentiles
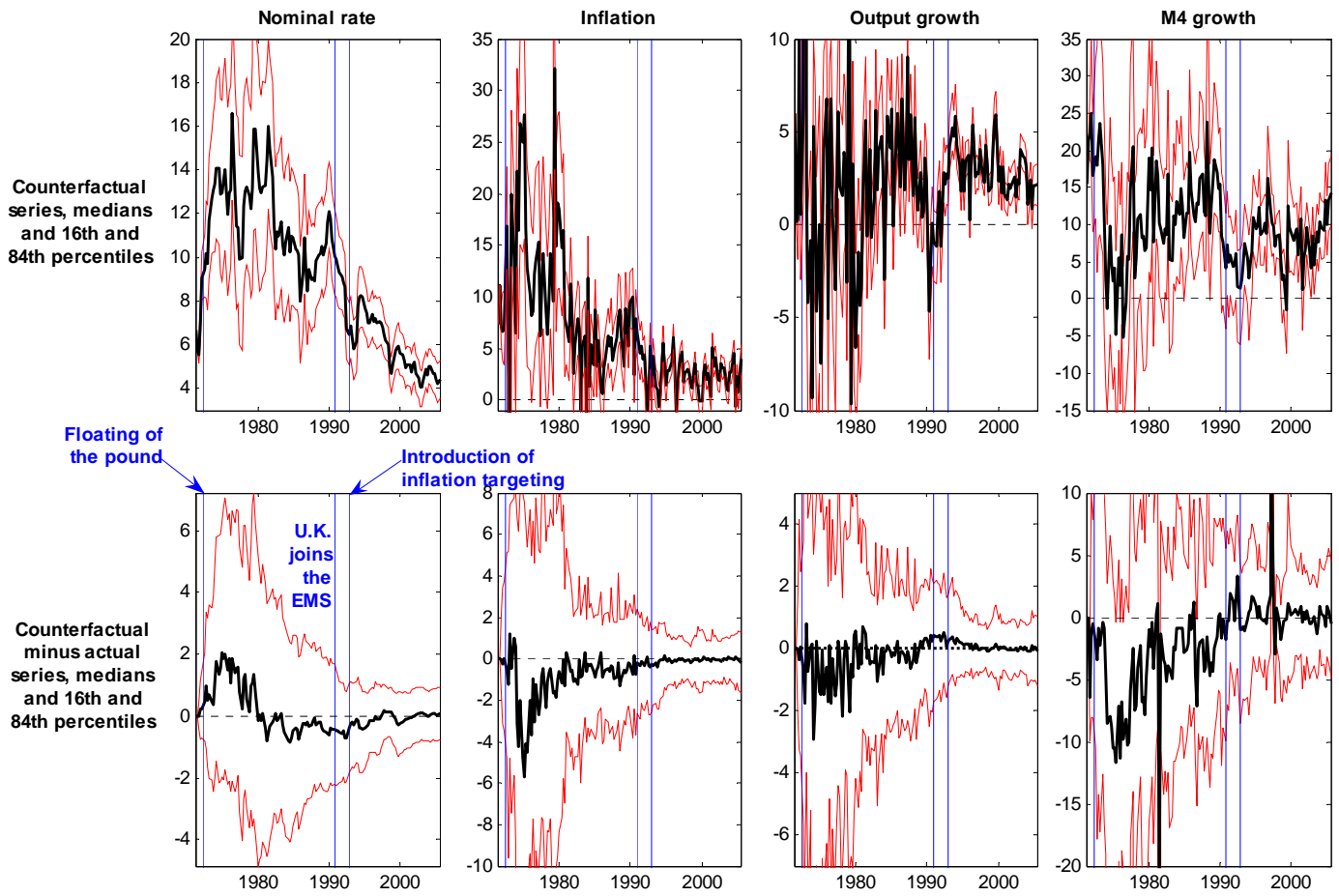
Figure 6: Bringing the *Monetary Policy Committee* back in time
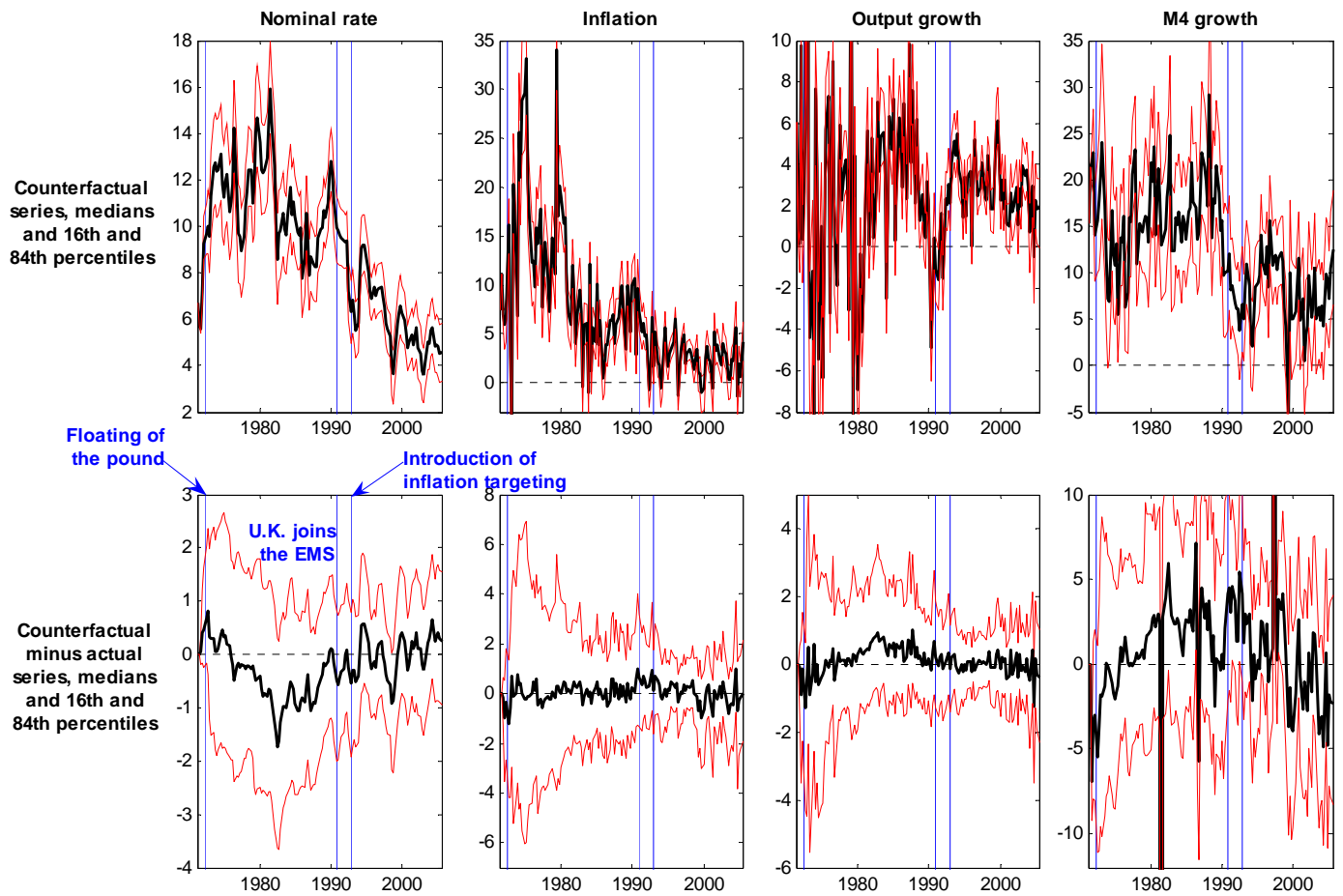
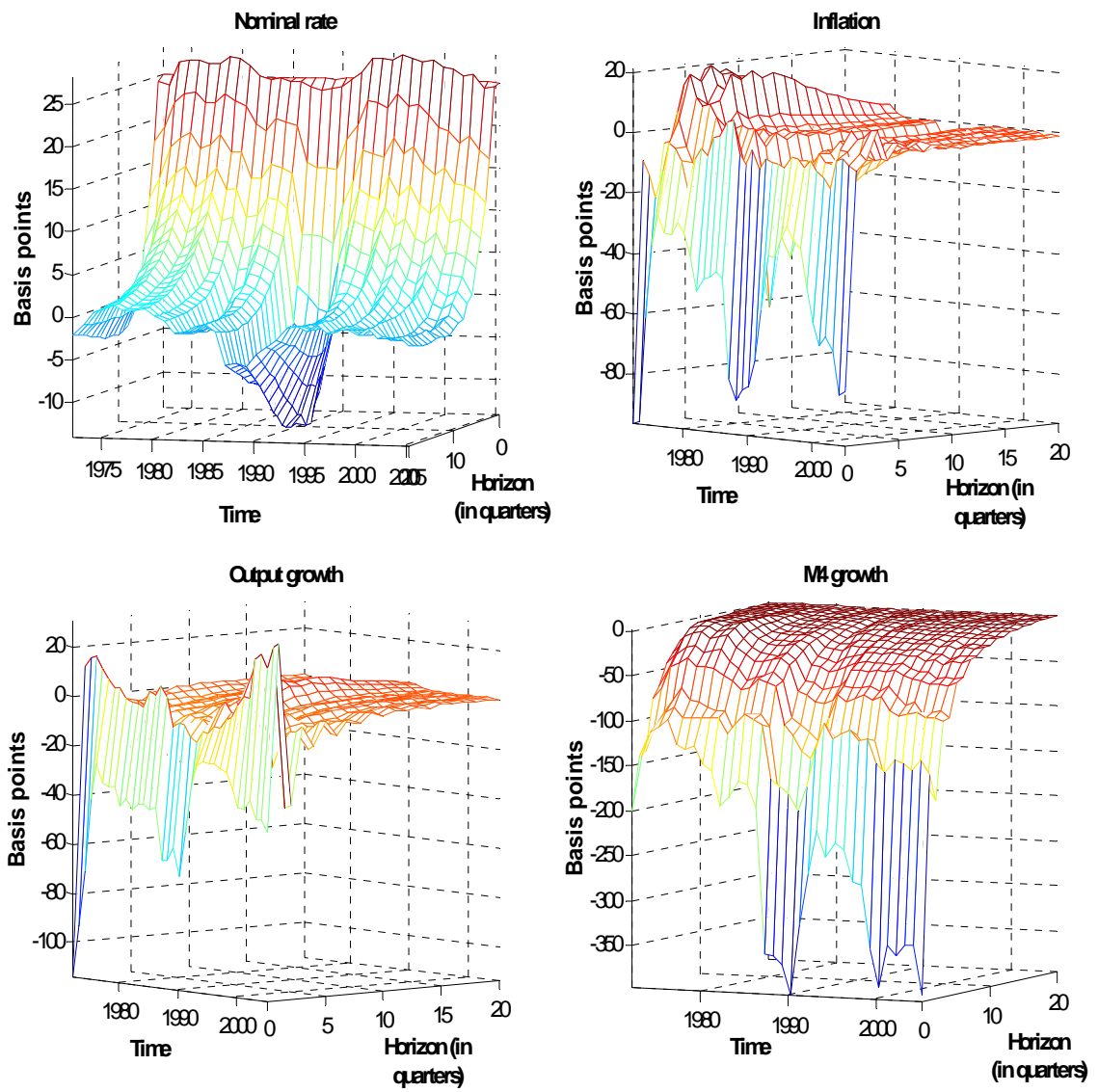Figure 7: Imposing the 1970's monetary rule over the entire sample period

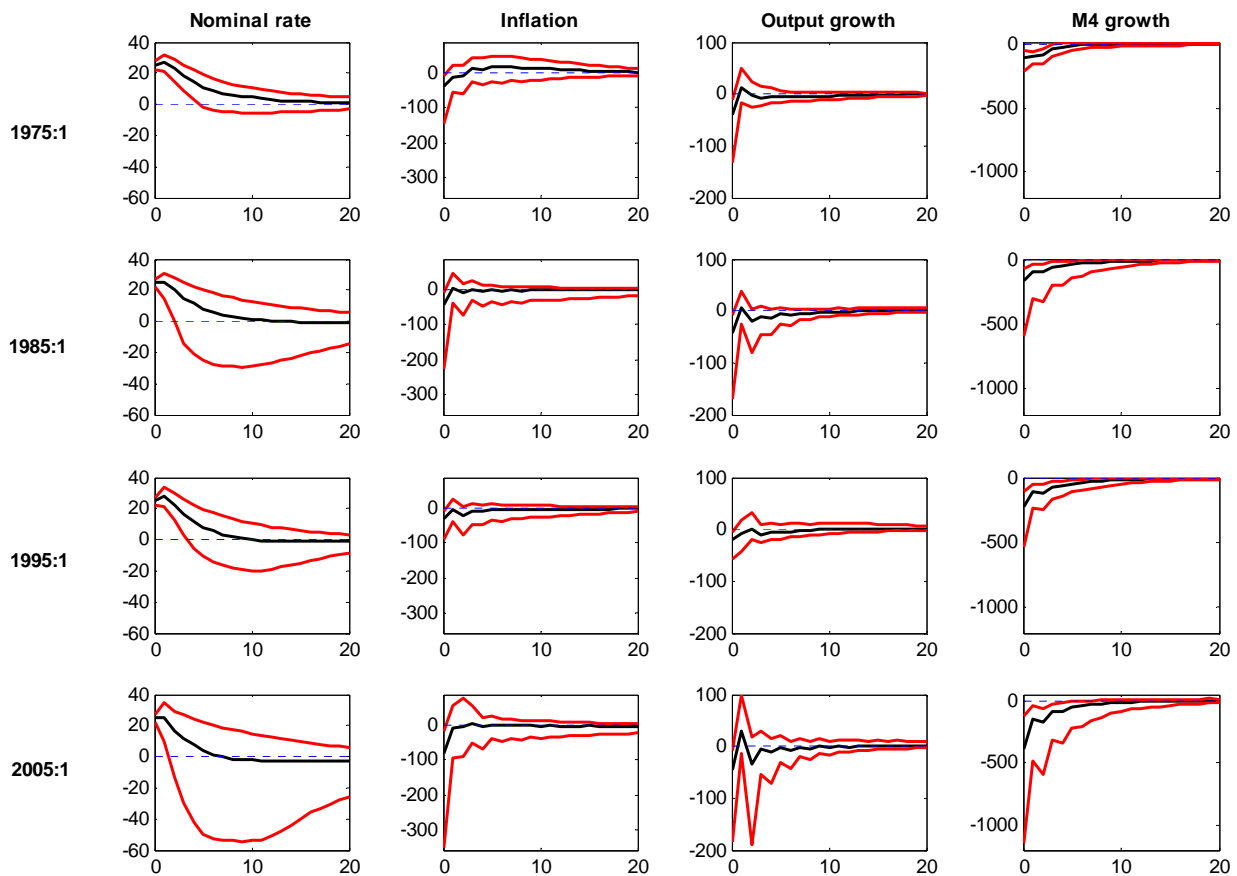Figure 8: Time-varying median impulse-response functions to a monetary policy shock (basis points)

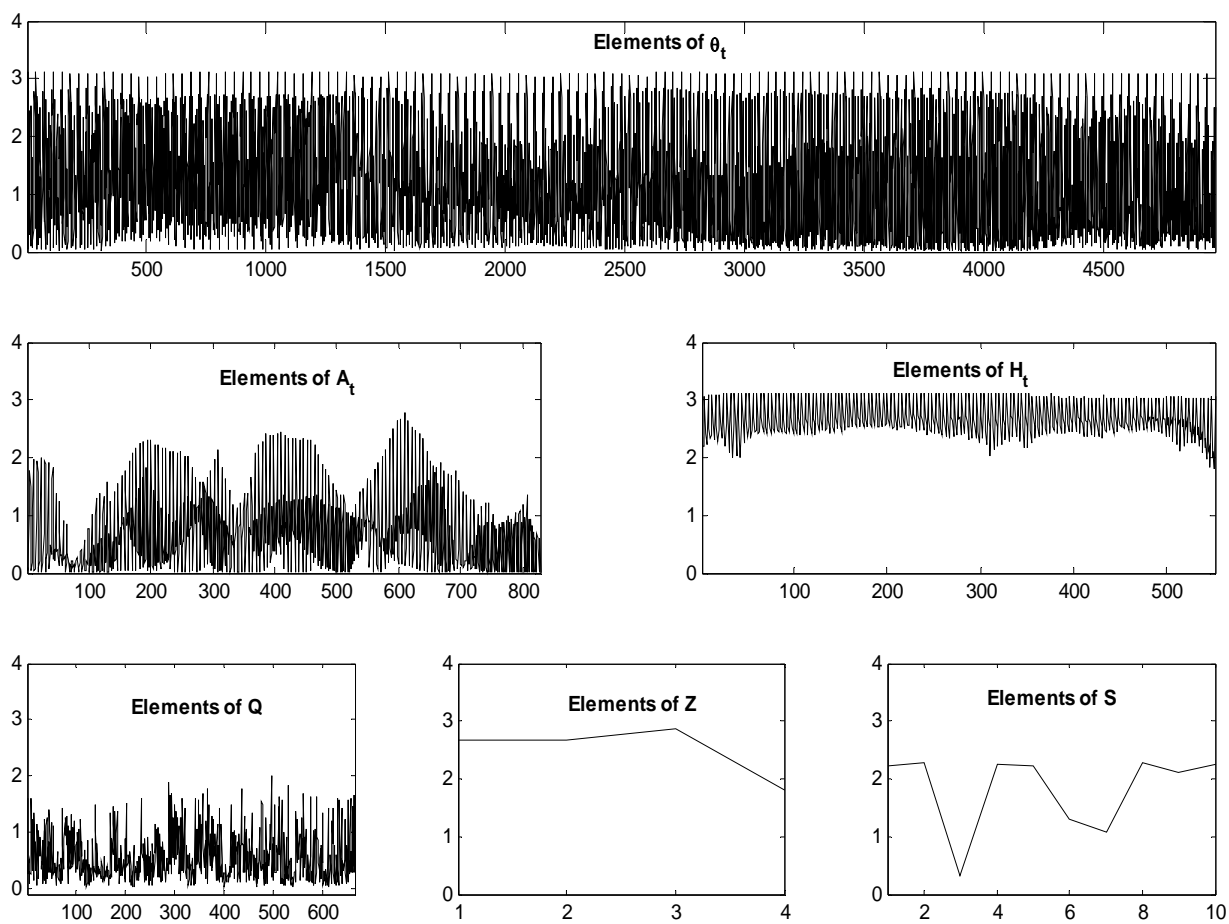Figure 9: Median impulse-response functions to a monetary policy shock in selected quarters (in basis points)

Figure 10: Checking for the convergence of the Markov chain: inefficiency factors for the draws from the ergodic distribution for the hyperparameters and the states

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