

The Great Moderation and the ‘Bernanke Conjecture’*

Luca Benati
Bank of England

Paolo Surico
Bank of England
University of Bari

Abstract

Was the Great Moderation in the United States due to good policy or good luck? Taking, as data generation process, a New Keynesian sticky-price model in which the *only* source of change is the move from a passive to an active monetary rule, we show how standard econometric methods, both reduced-form and structural, often misinterpret good policy for good luck. Specifically, we show how such a move is perfectly compatible with:

(a) little change in the estimated impulse-response functions to a monetary policy shock, as in Stock and Watson (2002), Primiceri (2005), Canova and Gambetti (2005), and Gambetti, Pappa, and Canova (2006).

(b) Significant changes in the estimated volatilities of both reduced-form and structural shocks—as in (e.g.) Ahmed, Levin, and Wilson (2004) and Stock and Watson (2002)—even in the absence, by construction, of any change in the volatilities of structural innovations.

(c) Little change in the integrated normalised spectra of inflation and GDP growth at the business-cycle frequencies, as in Ahmed, Levin, and Wilson (2004).

In line with Bernanke’s (2004) conjecture, the explanation is that conventional econometric methods are *intrinsically* incapable of capturing the role played by the systematic component of monetary policy in (de)stabilising inflation expectations, and are therefore *inevitably* bound to confuse shifts in expected inflation with true structural innovations, thus giving the illusion of good luck even when good policy is, by construction, the authentic explanation.

Keywords: Great Inflation, indeterminacy, structural break tests; frequency domain, VARs.

*Acknowledgements: We wish to thank Thomas Lubik and Giorgio Primiceri for helpful discussions. Usual disclaimers apply. The views expressed in this paper are those of the authors, and do not necessarily reflect those of the Bank of England or the Monetary Policy Committee. Address for correspondence: Bank of England, Threadneedle Street, London, EC2R 8AH. Email: Luca.Benati@bankofengland.co.uk and paolo.surico@bankofengland.co.uk.

1 Introduction

Post-WWII U.S. economic history is usually divided into two distinct sub-periods. The former period, extending up to the end of the Volcker disinflation, is characterised by a large extent of macroeconomic turbulence, with highly volatile output growth, and highly volatile and highly persistent inflation. The latter period, from the end of the Volcker disinflation up to the present day, is characterised instead by significantly smaller volatilities for both inflation and output growth¹ and, possibly, by a lower extent of inflation persistence.² These dramatic changes in the reduced-form properties of the U.S. economy over the last several decades characterise a phenomenon known as the ‘Great Moderation’.

A vast literature has investigated the source(s) of the Great Moderation in an attempt to disentangle the relative contributions of two main candidates: good policy and good luck. The importance of this debate stems from the policy lessons that can be drawn from alternative interpretations of historical experience. If the Great Moderation has simply been the result of a more benign macroeconomic environment, in the form of smaller non-policy shocks, then nothing, at least in principle, can prevent the macroeconomic turbulence of the 1970s to reappear. If, by contrast, the remarkable stability of recent years is the result of a superior monetary policy, the outlook for the future looks decisively more benign.

Based on (time-varying) structural VAR methods, the good luck hypothesis has been advocated by a number of authors including Stock and Watson (2002), Primiceri (2005), Canova and Gambetti (2005), Hanson (2005), Gambetti, Pappa, and Canova (2006) and Sims and Zha (2006) for the U.S., and Benati and Mumtaz (2005) for the U.K.. By contrast, Lubik and Schorfheide (2004), based on an estimated sticky-price model for the U.S., identify, in line with Clarida, Gali, and Gertler (2000), shifts in the systematic component of monetary policy as the main reason underlying the dramatic stabilisation of the most recent period. How can we reconcile these two sets of results? Isn’t it the case that *methodological* differences between the two approaches may be at the root of the dramatically different results they produce?

In a recent speech on the ‘Great Moderation’ in the U.S., Bernanke (2004) conjectures that this is indeed the case, as standard econometric methods fail to capture the impact of the *systematic* component of monetary policy in stabilising private sector’s expectations, and therefore inevitably confuse good policy with plain good luck. Bernanke discusses several reasons why an econometrician, by applying standard techniques, might mistakenly attribute the impact of a more stabilising monetary rule to an exogenous reduction in the volatility of non-policy shocks. In particular,

¹See e.g. Kim and Nelson (1999), McConnell and Perez-Quiros (2000), Kim, Nelson, and Piger (2004), and Stock and Watson (2002).

²This is currently one of the most hotly debated issues in empirical macroeconomics—see eg Kim, Nelson, and Piger (2004), Cogley and Sargent (2002) and Cogley and Sargent (2005), on the one hand, and Stock (2002) for an opposite point of view.

he emphasizes how

[...] changes in monetary policy could conceivably affect the size and frequency of shocks hitting the economy, *at least as an econometrician would measure those shocks*. [...] [*C*]hanges in inflation expectations, which are ultimately the product of the monetary policy regime, can be confused with truly exogenous shocks in conventional econometric analyses. [...] Increases in inflation expectations have the flavour of adverse aggregate supply shocks in that they tend to increase the volatility of both inflation and output, in a combination that depends on how strongly the monetary policymakers act to offset these changes in expectations. (emphasis added)

It is important to stress, however, that Bernanke's is, at the moment, just a conjecture, as it had not been supported, so far, by any piece of research.

In this paper, taking as data generation process a New Keynesian sticky-price model in which the *only* source of change is the move from a passive to an active monetary rule³—i.e, from indeterminacy to determinacy—we show how standard econometric methods, both reduced-form and structural, often tend to misinterpret good policy for good luck. Specifically, we show how a move from a passive to an active monetary rule is perfectly compatible with:

(a) little change in the estimated impulse-response functions to a monetary policy shock, as in Stock and Watson (2002), Primiceri (2005), Canova and Gambetti (2005), and Gambetti, Pappa, and Canova (2006).

(b) Significant changes in the estimated volatilities of both reduced-form and structural shocks—as in (e.g.) Ahmed, Levin, and Wilson (2004) and Stock and Watson (2002)—even in the absence, by construction, of any change in the volatilities of structural innovations.

(c) Little change in the integrated normalised spectra of inflation, output growth and the output gap at the business-cycle frequencies, as in Ahmed, Levin, and Wilson (2004).

In line with Bernanke's (2004) conjecture, the explanation is that conventional econometric methods, both reduced-form and structural, are *intrinsically* incapable of capturing the crucial role played by the systematic component of monetary policy in (de)stabilising inflation expectations, and are therefore *inevitably* bound to confuse shifts in expected inflation—which, as stressed by Bernanke, are *ultimately* the product of the underlying monetary regime—with true structural innovations, thus giving the illusion of good luck even when good policy is, by construction, the authentic explanation.

³Given that in the present context we are ignoring the role of fiscal policy, the relationship between the monetary policy stance and equilibrium (in)determinacy is one-to-one, with a passive (active) rule being associated with an indeterminate (determinate) equilibrium. As it is well known, in more complex settings this is not the case—see e.g. Leeper (1991).

The paper is organized as follows. Section 2 briefly describes the standard New Keynesian model we use in the paper. Section 3, in the spirit of Ahmed, Levin, and Wilson (2004), presents results based on reduced-form methods. In section 4 we estimate structural VARs based on the simulated data, identifying the structural shocks *via* the sign restrictions implied by the New Keynesian model. In section 5 we discuss and interpret the results. Section 6 concludes.

2 The Model

In what follows we use the standard New Keynesian workhorse model of Clarida, Gali, and Gertler (1999), conditional on the Bayesian estimates for the U.S. economy of Lubik and Schorfheide (2004). In spite of its ‘bare bones’ structure, there are several reasons for preferring this model to the more sophisticated ones of, e.g., Smets and Wouters (2003), Christiano, Eichenbaum, and Evans (2004), or Altig, Christiano, Eichenbaum, and Linde (2006). First, its simplicity allows us to clearly highlight the conceptual issues involved in the present exercise, without the unnecessary complications coming from having to deal with much more complex structures. Second, such a simplicity makes it possible to obtain a purely analytical solution under both determinacy and indeterminacy.⁴ This is especially important for the case of indeterminacy, as it eliminates the need to resort to the approximated numerical solution described in Lubik and Schorfheide (2004).⁵ Third—and crucially—currently this is one of the very few DSGE models estimated without imposing the restriction that the parameters lay uniquely within the determinacy region,⁶ and as a result, it is the only one for which estimates under *both* determinacy *and* indeterminacy are available.⁷

The model is given by

$$x_t = x_{t+1|t} - \tau(R_t - \pi_{t+1|t}) + g_t \quad (1)$$

$$\pi_t = \beta\pi_{t+1|t} + \kappa(x_t - z_t) \quad (2)$$

⁴See Lubik and Schorfheide (2003) and the technical appendix to Lubik and Schorfheide (2004), available at Frank Schorfheide’s web page.

⁵For the reasons discussed, e.g., in Lubik and Schorfheide (2003)—essentially, a greater plausibility on strictly logical grounds—under indeterminacy we consider the case of continuity, in which the impulse-response functions of the model are prevented from changing discontinuously at the boundary between the determinacy and the indeterminacy regions.

⁶See also the work of Davig and Leeper—e.g., Davig, Leeper, and Chung (2005), Davig and Leeper (2005a), and Davig and Leeper (2005b)—which however is, for our own purposes, unnecessarily complex.

⁷A subtle but important issue is that, as stressed by Lubik and Schorfheide (2004), imposing, in estimation, the restriction that the parameters uniquely lay within the determinacy region has the potential to induce serious biases in the parameters’ estimates if, in fact, the data have been generated (at least in part) under indeterminacy. Given the evidence produced by Clarida, Gali, and Gertler (1999) and Lubik and Schorfheide (2004), pointing towards a passive monetary rule before October 1979, this implies that estimates like those of Smets and Wouters (2003), Christiano, Eichenbaum, and Evans (2004), or Altig, Christiano, Eichenbaum, and Linde (2006) might be seriously biased.

$$R_t = \rho_R R_{t-1} + (1 - \rho_R)[\phi_\pi \pi_t + \phi_x(x_t - z_t)] + \epsilon_{R,t} \quad (3)$$

$$g_t = \rho_g g_{t-1} + \epsilon_{g,t} \quad \text{and} \quad z_t = \rho_z z_{t-1} + \epsilon_{z,t} \quad (4)$$

where the notation is obvious, with x_t , π_t , R_t , g_t , and z_t being the output gap, inflation, the interest rate, a demand disturbance, and potential output, all expressed as log-deviations from a non-stochastic steady-state.

Based on Lubik and Schorfheide's (2004) Bayesian estimates, we calibrate the key parameters as follows. For both periods—1960:1-1979:2 and 1982:4-1997:4, respectively⁸—we set $\beta=0.99$, $\kappa=0.77$, $\tau=1.45^{-1}$, $\rho_g=0.68$, $\rho_z=0.82$, $\rho_{gz}=0.14$, $\sigma_R=0.23$, $\sigma_g=0.27$, $\sigma_z=1.13$. We then set the coefficients of the monetary policy rule to $\phi_\pi=0.77$, $\phi_x=0.17$, and $\rho_R=0.60$ for the former period, and to $\phi_\pi=2.19$, $\phi_x=0.30$, and $\rho_R=0.84$ for the latter one. Together with the other structural parameters, the two sets of coefficients for the monetary policy rule imply indeterminacy in the former period, and determinacy in the latter one. Finally, in order to make our results more transparent, we set the standard deviation of the sunspot shock—which only becomes relevant under indeterminacy—to zero.⁹

In the controlled experiment we are designing, everything is therefore *uniquely* driven, by construction, by changes in the *systematic* component of the monetary rule (it important to stress that the standard deviation of the monetary policy shocks, too, is kept constant across periods)—specifically, in the jargon of the literature on the Great Moderation, by ‘bad policy’ before October 1979, and by ‘good policy’ after 1982. The question we then ask is: ‘Are standard econometric methods capable of recovering the truth we ourselves constructed?’ As we will see in the next two sections, results from stochastic simulations of the New Keynesian model conditional on Lubik and Schorfheide's (2004) estimates provide indeed support for Bernanke's conjecture, with the evidence from estimated impulse-response functions to an identified monetary policy shock being especially startling.

Each of the results that follow is based on 10,000 simulations of the model under both determinacy and indeterminacy. The only exception is represented by the tests for structural breaks at unknown points in the sample in both the VAR's innovation variances, and the coefficients of the VAR's equations, which being based on bootstrapped critical values are quite remarkably computationally intensive. In this case—and only in this case—results are based on just 500 simulations. In order to be exactly consistent with Lubik and Schorfheide (2004), each simulation is 78 periods (i.e., quarters) long under indeterminacy, and 61 periods long under determinacy.¹⁰ We present results for three variables, inflation, the output gap, and output growth. Inflation and the output gap come just straight out of the model's simulations. As for output growth, we ‘reconstruct’ it in the following way. The output gap measure

⁸These were the original sub-sample periods in Lubik and Schorfheide (2004).

⁹In fact, setting it equal to Lubik and Schorfheide's estimate, 0.2, makes virtually no difference to the final results. This alternative set of results is available from the authors upon request.

¹⁰In order to reduce as much as possible dependence from the initial conditions, we run a ‘re-simulation’ 100 periods long, which we then discard.

Lubik and Schorfheide (2004) use to estimate their model is HP-filtered log GDP, with HP-filtering being performed over the period 1955:1-1998:4. So we take log GDP¹¹ for the period 1955:1-1998:4, we HP-filter it, we store the two trends for the sub-periods 1960:1-1979:2 and 1982:4-1997:4, and at each simulation we add the (log) trends to the simulated output gaps for the two periods, thus getting two simulated log GDP series. Finally, we first-difference both series, thus getting two simulated output growth series under determinacy and indeterminacy.

Let's start from the reduced-form evidence.

3 Reduced-Form Evidence: Back to Ahmed, Levin, and Wilson (2004)

In a well known contribution, Ahmed, Levin, and Wilson (2004) use both vector autoregressions and frequency-domain techniques to investigate the evolution of the reduced-form properties of the U.S. economy over the post-WWII era. Consistent with the finding of both Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) of a break in the volatility of U.S. GDP/GNP growth in the first quarter of 1984, they break the overall sample period into two disjoint sub-periods, 1960:1-1979:4 and 1984:1-2000:1, and compare their reduced-form properties along a number of dimensions. As for inflation they identify, post-1984, both a sharp decline in its overall variance, and breaks in the coefficients of the corresponding equation of the VAR. While the former change is compatible with the good luck hypothesis, the latter, as they stress, is not. As for output growth,

‘[...] reduced innovation variance accounts for the bulk of the decline in output volatility. For aggregate GDP, [they] cannot reject the hypothesis that the post-1984 shift in the spectrum is proportional across all frequencies. Estimating VARs across the two periods provides some evidence of structural breaks in the coefficients, and more support than [...] frequency-domain results for the importance of changes in the structure of the economy; however, a majority of the decline in output variance still appears to be due to a reduction in innovation variance.’

They interpret their evidence for GDP growth as broadly supportive of the ‘good luck’ hypothesis, but they are careful in pointing out how their results

[...] are consistent with a rather different view of improved monetary policy, in which—as argued by Clarida et al. (2000)—aggressive

¹¹The GDP measure we use is GDPC1 (‘Real Gross Domestic Product, 1 Decimal, Quarterly, Billions of Chained 2000 Dollars, Seasonally Adjusted Annual Rate’) from the *U.S. Department of Commerce: Bureau of Economic Analysis*.

policy works to reduce aggregate volatility by eliminating "sunspot" equilibria. More specifically, if improved monetary policy during the Volcker-Greenspan era has worked predominately through ensuring a unique rational expectations equilibrium, innovation variances could be reduced, as shifts in expectations unrelated to macroeconomic fundamentals—possibly at work in previous periods—would now be prevented from influencing the economy.

In spite of Ahmed, Levin, and Wilson’s care in recognising the possibility of a monetary policy-based explanation for their findings, their contribution is routinely classified in the literature as belonging to the good luck camp. In this paragraph we therefore show how most of Ahmed, Levin, and Wilson’s results are indeed compatible with a view of U.S. post-WWII economic history in which the key source of change has been a shift from a passive to an active monetary rule.

Table 1 reports the integrated normalised spectra of inflation, output growth, and the output gap¹² within three frequency bands, $[0, \pi/16]$, $[\pi/16, \pi/3]$, and $[\pi/3, \pi]$ —corresponding, with quarterly data, to fluctuations with a periodicity beyond 8 years, between six quarters and eight years, and below six quarters, respectively—based on both actual data, and 10,000 simulations of the model under determinacy and indeterminacy. We estimate the spectral densities by smoothing the series’ periodograms in the frequency domain by means of a Bartlett spectral window. We select the spectral bandwidth automatically via the procedure proposed by Beltrao and Bloomfield (1987). For the simulated data we report the medians of the distributions and the 90% lower and upper percentiles. For the actual data, we compute 90% confidence intervals *via* the spectral bootstrapping procedure introduced by Franke and Hardle (1992).¹³

As the Table shows, consistent with Ahmed, Levin, and Wilson’s (2004) results for output growth, for neither of the three variables we identify, in the actual data, significant changes across sub-periods in the amount of integrated normalised spectral power at the business-cycle frequencies. As stressed by Ahmed, Levin, and Wilson (2004, page 824), ‘improved monetary policy would be expected to shift the spectrum primarily at business-cycle frequencies’, and, consistently with this position, they interpret such lack of variation as broadly supportive of the good luck hypothesis. In spite of its intuitive appeal, results from stochastic simulations clearly show such a conclusion to be unwarranted, as *exactly* the same outcome is obtained within a framework in which everything is *uniquely* driven by a shift in the monetary rule, from active to passive. Results from stochastic simulations for the low and the high

¹²Consistent with Lubik and Schorfheide (2004), we approximate the output gap with HP-filtered log GDP.

¹³Specifically, we use the second of the procedures they propose, in which bootstrapping is implemented by sampling, with replacement, from the empirical distribution of the spectral residuals $\epsilon_j^* = 2I(\omega_j)/\hat{f}(\omega_j)$, with $I(\omega_j)$ and $\hat{f}(\omega_j)$ being the (unsmoothed) periodogram and the smoothed, consistent estimator of the spectral density respectively, and ω_j being the j -th Fourier frequency.

frequencies, on the other hand, do not conform with the picture we see in the data. While simulations give rise, for either of the three series, to a reallocation of a significant amount of normalised spectral power from the low to the high frequencies—thus reflecting the well-known higher serial correlation properties of the economy under indeterminacy¹⁴—in the data we see some slight reallocation in this sense for inflation, very little change for the output gap, and a shift in the opposite direction for output growth. Although a movement of the workhorse New Keynesian model from indeterminacy to determinacy cannot replicate all of the features of the data, such a ‘failure’ should however be put into perspective, as the main goal of the present exercise is not to provide a full and complete characterisation of what we see in the data, but rather to demonstrate, by example, how changes—or lack of—in the amount of integrated normalised spectral power at the business-cycle frequencies are, in general, *entirely uninformative* for the issue at hand.

Let’s now turn to time-domain methods. In line, once again, with the analysis of Ahmed, Levin, and Wilson (2004), we estimate, based on both actual and simulated data, and for either of the two sub-periods, reduced-form VARs for inflation, output growth, and the interest rate.¹⁵ As for the simulated data, since the authentic lag order of the VAR representation of the New Keynesian model is one, we just estimate a VAR(1) model. As for the actual data, given the well-known lack of reliability of traditional lag order selection criteria¹⁶, we consider four possible lag orders, from one to four. We then perform two types of break tests based on the Andrews and Ploberger (1994) *exp*-Wald test statistic, in both cases bootstrapping the critical values as in Diebold and Chen (1996).¹⁷ First, we test for breaks in the reduced-form innovation variance of each equation. Second, we test for a joint break in all of the coefficients for each equation of the VAR.

Starting from the simulated data, in going from indeterminacy to determinacy we reject the null of no breaks in the innovation variance 99.8% of the times for inflation, 46.6% of the times for output growth, and 100.0% of the times for the interest rate. As for the tests for breaks in the coefficients, the fractions of rejections are 99.4%, 6.1%, and 99.8% respectively. It is important to stress that while the breaks in the coefficients of the VAR are indeed there—due to the changes in the VAR representation of the model associated with the move from indeterminacy to determinacy—the

¹⁴See in particular Lubik and Schorfheide (2004).

¹⁵On the other hand, we do not estimate VARs based on the output gap. The reason is that, in order to be fully consistent with Lubik and Schorfheide (2004), we should use (as we have previously done) HP-filtered log output as the output gap proxy. As it is well-known, unfortunately, HP-filtering (as all linear filtering methods) introduces an infinite moving-average representation in the data, so that, from a strictly technical point of view, no model can be fitted to filtered data.

¹⁶See, e.g., Kilian and Ivanov (2005).

¹⁷As we previously mentioned, given the computational intensity of this exercise, we only consider 500 simulations of the New Keynesian model. For each of them, bootstrapped *p*-values are computed based on 500 bootstrap replications. As for the actual data, on the other hand, bootstrapped *p*-values are computed based on 1,000 replications.

estimated breaks in the reduced-form innovation variance are taking place even in the absence, by construction, of *any* change in the volatilities of the structural innovations, and are instead *entirely* attributable to the shift in the monetary rule. The reduction in the volatilities of reduced-form VARs' residuals have been often interpreted in the literature as *prima facie* evidence in favor of the good luck hypothesis. As in the case of the integrated normalised spectrum at the business-cycle frequencies, however, the present example clearly shows, once again, how seemingly sensible and intuitively appealing conclusions based on reduced-form methods may turn out to be *entirely* unwarranted, and how the use of reduced-form methods may give rise to highly misleading inference. As we will see in the next section, similar problems plague structural VAR methods too, to the point of casting serious doubts about the ability of econometric methods of capturing historical truth.

Results based on the actual data are reported in Table 2. Rejection of the null of no breaks in the innovation variance is very strong for both inflation and output growth, while for the interest rate it is strong only based on a VAR(1), and it becomes insignificant for higher lag orders. As we have just shown, while several researchers have interpreted the finding of breaks in the innovation variance of reduced-form VARs as *prima facie* evidence in favor of the good luck hypothesis, these results are *entirely uninformative* for the issue at hand, as they naturally arise under the Lubik-Schorfheide vision of the world. Rejection of the null of a joint break in all of the equation's coefficients, on the other hand, is strong only for inflation, while it is virtually non-existent for either output growth or the interest rate. The failure to detect breaks in the interest rate equation of the VAR is noteworthy, and it is especially troubling for the Lubik-Schorfheide vision of the world since, as we have just seen based on the simulated data, break tests based on bootstrapped critical values should be expected to identify breaks in the monetary rule if the breaks are indeed there.

Let's now turn to structural evidence.

4 Structural Evidence

Based on time-varying structural vector autoregressions, neither Primiceri (2005), Canova and Gambetti (2005), nor Gambetti, Pappa, and Canova (2006) identify any significant time-variation in the estimated impulse-response functions to an identified monetary policy shock. They interpret this result as strong evidence in favor of the good luck hypothesis, and against the notion that monetary policy may have played a crucial role in fostering the more stable macroeconomic environment of the most recent years. As we will now show, *such inference is entirely unwarranted*, as *exactly* the same results are generated by structural VAR methods applied to the simulated data from our experiment. Further, structural VAR methods will be shown to identify changes in the estimated volatilities of structural innovations even in the absence, by construction, of any change in the volatilities of the structural shocks.

Figure 1 shows the theoretical impulse-response functions of the Lubik and Schorfheide (2004) model under both determinacy (red line) and indeterminacy (black line). As we previously mentioned, under indeterminacy we consider the more logically plausible ‘continuity’ solution—see Lubik and Schorfheide (2003). As the figure shows, the impact of the three structural shocks on the three variables at zero has the same sign under either determinacy or indeterminacy.¹⁸ In what follows we will therefore identify the three structural shocks by imposing the following sign restrictions either only on impact—as in Faust (1998)—or both on impact and on the subsequent four quarters.¹⁹ Specifically, we postulate that

- a positive monetary policy shock has a positive impact on the interest rate, and a negative impact on inflation and the output gap (output growth);
- a positive demand non-policy shock has a positive impact on all variables; and
- a positive supply shock has a positive impact on the output gap (output growth), and a negative impact on inflation and the interest rate.

For each of the 10,000 simulations under either determinacy or indeterminacy, we compute the structural impact matrix, A_0 , *via* the procedure recently introduced by Rubio, Waggoner, and Zha (2005).²⁰ Specifically, let $\Omega = P \cdot D \cdot P'$ be the eigenvalue-eigenvector decomposition of the VAR’s estimated covariance matrix Ω , and let $\tilde{A}_0 \equiv P \cdot D^{\frac{1}{2}}$. 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 structural impact matrix as $A_0=\tilde{A}_0 \cdot Q'$. Following Rubio, Waggoner, and Zha (2005), for each of the 10,000 simulations we keep on drawing (i.e., computing rotations) until the sign restrictions are satisfied.

Although we plan, in future work, to also consider the alternative identification scheme of Sims and Zha (2006), which allows to only identify monetary policy shocks, but without exploiting the questionable recursive assumption of the Cholesky decomposition, we regard our choice of imposing the sign restrictions implied by the model as the most natural one. In particular, other identifying restrictions—e.g., Cholesky—suffer from the notable drawback of being false under both determinacy and indeterminacy, so that, in the end, it would not be clear at all what to make of the results obtained by imposing such restrictions.

Figures 2 and 3 show, in the top rows, the distributions of the estimated impulse-response functions (henceforth, IRFs) to a unitary monetary shock for the interest rate, inflation, and the output gap (output growth), based on 10,000 simulations

¹⁸This is a key reason to prefer the ‘continuity’ solution to the alternative ‘orthogonality’ one. As shown by Lubik and Schorfheide (2003), under orthogonality inflation *increases* on impact under indeterminacy in response to a monetary contraction (i.e., a positive monetary shock).

¹⁹[on impact and on the subsequent four quarters: still to be done]

²⁰See at <http://home.earthlink.net/~tzha02/ProgramCode/SRestrictRWZalg.m>.

of the model under both determinacy and indeterminacy, while the bottom rows plot the medians of the two distributions shown in the corresponding panels in the top row. Focussing on the medians of the distributions, a striking finding emerging from the two figures is the virtual invariance of estimated IRFs to changes in the systematic component of monetary policy so dramatic as to move the economy from the indeterminacy to the determinacy region. For inflation, in particular, the medians of the distributions are virtually identical based on either the VAR with the output gap or the one with output growth, in spite of the fact that the coefficient on inflation in the monetary rule goes from 0.77 during the pre-October 1979 period to 2.19 over the period following the end of the Volcker disinflation. As in the case of inflation, the medians of the distributions of the estimated IRFs for output growth are virtually indistinguishable across the two periods. Finally, both the interest rate and the output gap exhibit some mild extent of variation, but clearly not nearly as comparable to what one would expect, *ex-ante*, based on knowledge of the extent of the shifts in the monetary rule.

These results clearly show how

- the inference drawn by Primiceri (2005), Canova and Gambetti (2005), and Gambetti, Pappa, and Canova (2006) from analogous evidence based on U.S. data, against good policy, and in favour of good luck, *is entirely unwarranted*, as lack of time-variation in estimated IRFs to a monetary policy shock emerges naturally from the present experiment.
- In general, lack of time-variation in estimated IRFs to a monetary shock *is entirely uninformative* for the issue of investigating the role played by monetary policy in fostering the greater macroeconomic stability of recent years.

Table3 shows the estimated standard deviations of structural shocks based on structural VARs with either the output gap or output growth. A key finding emerging from the table is that, in spite of the complete lack of variation, by construction, in the volatilities of structural innovations, the *estimated* volatilities of structural non-policy shocks exhibit a quite substantial extent of variation, with the standard deviation of the demand non-policy shock increasing, and that of the supply shock decreasing, based on either VAR specification. The estimated volatility of the monetary policy shock, on the other hand, exhibits virtually no time-variation across the two sub-periods. Although the estimated pattern of variation in the volatilities of the non-policy shocks, with one increasing and the other decreasing, does not bear clear-cut implications for the plausibility of a monetary policy-based explanation of the Great Moderation, a key point to stress is how, once again, structural VAR methods give rise to highly misleading inference when applied to data generated at least in part under indeterminacy.

5 Conclusions

Taking, as data generation process, a New Keynesian sticky-price model in which the only source of change is the move from a passive to an active monetary rule—i.e, from indeterminacy to determinacy—in this paper we show how standard econometric methods, both reduced-form and structural, often misinterpret good policy for good luck. Specifically, we show how a move from a passive to an active monetary rule is perfectly compatible with:

(a) little change in the estimated impulse-response functions to a monetary policy shock, as in Stock and Watson (2002), Primiceri (2005), Canova and Gambetti (2005), and Gambetti, Pappa, and Canova (2006).

(b) Significant changes in the estimated volatilities of both reduced-form and structural shocks—as in (e.g.) Ahmed, Levin, and Wilson (2004) and Stock and Watson (2002)—even in the absence, by construction, of any change in the volatilities of structural innovations.

(c) Little change in the integrated normalised spectra of inflation, output growth and the output gap at the business-cycle frequencies, as in Ahmed, Levin, and Wilson (2004).

In line with Bernanke’s (2004) conjecture, the explanation is that conventional econometric methods, both reduced-form and structural, are *intrinsically* incapable of capturing the crucial role played by the systematic component of monetary policy in (de)stabilising inflation expectations, and are therefore *inevitably* bound to confuse shifts in expected inflation—which, as stressed by Bernanke, are *ultimately* the product of the underlying monetary regime—with true structural innovations, thus giving the illusion of good luck even when good policy is, by construction, the authentic explanation.

References

- AHMED, S., A. LEVIN, AND B. WILSON (2004): “Recent U.S. Macroeconomic Stability: Good Luck, Good Policies, or Good Practice?,” *Review of Economics and Statistics*, 86(3), 824–832.
- ALTIG, D., L. CHRISTIANO, M. EICHENBAUM, AND J. LINDE (2006): “Firm-Specific Capital, Nominal Rigidities, and the Business-Cycle,” Federal Reserve Bank of Cleveland, Northwestern University, and Sveriges Riksbank, mimeo.
- ANDREWS, D. K., AND W. PLOBERGER (1994): “Optimal Tests When a Nuisance Parameter is Present Only Under the Alternative,” *Econometrica*, 62(6), 1383–1414.
- BELTRAO, K. I., AND P. BLOOMFIELD (1987): “Determining the Bandwidth of a Kernel Spectrum Estimate,” *Journal of Time Series Analysis*, 8(1), 21–38.
- BENATI, L., AND H. MUMTAZ (2005): “The ‘Great Stability’ in the U.K.: Good Policy or Good Luck?,” Bank of England, mimeo.
- BERNANKE, B. S. (2004): “The Great Moderation,” Remarks at the meetings of the Eastern Economic Association, Washington, DC, February 20, 2004.
- CANOVA, F., AND L. GAMBETTI (2005): “Structural Changes in the U.S. Economy: Bad Luck or Bad Policy?,” Universitat Pompeu Fabra and IGER, mimeo.
- CHRISTIANO, L., M. EICHENBAUM, AND C. EVANS (2004): “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy,” *Journal of Political Economy*, forthcoming.
- CLARIDA, R., J. GALI, AND M. GERTLER (1999): “The Science of Monetary Policy: A New Keynesian Perspective,” *Journal of Economic Literature*, XXXVII, 1661–1707.
- (2000): “Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory,” *Quarterly Journal of Economics*, 115, 147–180.
- COGLEY, T., AND T. J. SARGENT (2002): “Evolving Post-WWII U.S. Inflation Dynamics,” in *B. Bernanke and K. Rogoff, eds. (2002), NBER Macroeconomics Annuals 2001*.
- (2005): “Drifts and Volatilities: Monetary Policies and Outcomes in the Post WWII U.S.,” *Review of Economic Dynamics*, 8(April), 262–302.
- DAVIG, T., AND E. M. LEEPER (2005a): “Fluctuating Macro Policies and the Fiscal Theory,” The College of William and Mary and Indiana University, mimeo.

- (2005b): “Generalizing the Taylor Principle,” The College of William and Mary and Indiana University, mimeo.
- DAVIG, T., E. M. LEEPER, AND H. CHUNG (2005): “Monetary and Fiscal Policy Switching,” The College of William and Mary and Indiana University, mimeo.
- DIEBOLD, F. X., AND C. CHEN (1996): “Testing Structural Stability with Endogenous Breakpoint: A Size Comparison of Analytic and Bootstrap Procedures,” *Journal of Econometrics*, 70(1), 221–241.
- FAUST, J. (1998): “The Robustness of Identified VAR Conclusions About Money,” *Carnegie-Rochester Conference Series on Public Policy*, 49, 207–244.
- FRANKE, J., AND W. HARDLE (1992): “On Bootstrapping Kernel Spectral Estimates,” *Annals of Statistics*, 20, 121–145.
- GAMBETTI, L., E. PAPPA, AND F. CANOVA (2006): “The Structural Dynamics of US Output and Inflation: What Explains the Changes?,” *Journal of Money, Credit, and Banking*, forthcoming.
- HANSON, M. (2005): “Varying Monetary Policy Regimes: A Vector Autoregressive Investigation,” Wesleyan University, mimeo.
- KILIAN, L., AND V. IVANOV (2005): “A Practitioner’s Guide to Lag Order Selection for VAR Impulse Response Analysis,” *Studies in Nonlinear Dynamics and Econometrics*, 9(1), Article 2.
- KIM, C. J., AND C. NELSON (1999): “Has the U.S. Economy Become More Stable? A Bayesian Approach Based on a Markov-Switching Model of the Business-Cycle,” *Review of Economics and Statistics*, 81, 608–616.
- KIM, C. J., C. NELSON, AND J. PIGER (2004): “The Less Volatile U.S. Economy: A Bayesian Investigation of Timing, Breadth, and Potential Explanations,” *Journal of Business and Economic Statistics*, 22(1), 80–93.
- LEEPEER, E. (1991): “Equilibria Under ‘Active’ and ‘Passive’ Monetary and Fiscal Policies,” *Journal of Monetary Economics*, 27, 129–147.
- LUBIK, T., AND F. SCHORFHEIDE (2003): “Computing Sunspot Equilibria in Linear Rational Expectations Models,” *Journal of Economic Dynamics and Control*, 28(2), 273–285.
- (2004): “Testing for Indeterminacy: An Application to U.S. Monetary Policy,” *American Economic Review*, 94(1), 190–217.

- MCCONNELL, M., AND G. PEREZ-QUIROS (2000): “Output Fluctuations in the United States: What Has Changed Since the Early 1980s?,” *American Economic Review*, 90, 1464–1476.
- PRIMICERI, G. E. (2005): “Time Varying Structural Vector Autoregressions and Monetary Policy,” Northwestern University, mimeo.
- RUBIO, J., D. WAGGONER, AND T. ZHA (2005): “Regime Changes in the Euro Area,” Federal Reserve Bank of Atlanta, mimeo.
- SIMS, C., AND T. ZHA (2006): “Were There Regime Switches in U.S. Monetary Policy?,” *American Economic Review*, forthcoming.
- SMETS, F., AND R. WOUTERS (2003): “Shocks and Frictions in U.S. Business Cycles: A Bayesian DSGE Approach,” European Central Bank and National Bank of Belgium, mimeo.
- STOCK, J. (2002): “Discussion,” in *B. Bernanke and K. Rogoff, eds. (2002), NBER Macroeconomics Annuals 2001*.
- STOCK, J., AND M. WATSON (2002): “Has the Business Cycle Changed and Why?,” in *M. Gertler and K. Rogoff, eds. (2003) NBER Macroeconomics Annuals 2002*.

Table 2 Testing for breaks in the VAR's equations: Wald test statistics and bootstrapped p-values				
Testing for breaks in the equation for:	Lag order:			
	<i>p</i> =1	<i>p</i> =2	<i>p</i> =3	<i>p</i> =4
	<i>Testing for breaks in the innovation variance:</i>			
inflation ^a	9.84 (4.0E-3)	7.29 (0.015)	8.88 (8.7E-3)	10.51 (0.004)
output growth	16.89 (3.0E-4)	18.75 (0.000)	19.81 (0.000)	19.17 (0.000)
interest rate ^b	15.67 (0.036)	14.05 (0.112)	12.12 (0.130)	9.53 (0.209)
	<i>Testing for joint breaks in the equation's coefficients:</i>			
inflation ^a	35.12 (0.000)	24.15 (0.001)	21.85 (0.016)	20.37 (0.084)
output growth	1.20 (0.886)	1.26 (0.982)	6.48 (0.700)	7.37 (0.817)
interest rate ^b	3.65 (0.372)	5.18 (0.521)	5.58 (0.802)	11.24 (0.522)
^a Based on GDP deflator inflation. ^b Federal funds rate.				

Table 3 Standard deviations of structural shocks, median estimates and 90% confidence intervals, based on sign restrictions			
	Monetary policy	Demand non-policy	Supply
	<i>Based on the structural VAR with output growth:</i>		
Pre-October 1979	0.110 [0.013; 0.205]	0.459 [0.053; 0.916]	0.551 [0.332; 0.736]
Post-Volcker stabilisation	0.118 [0.022; 0.187]	0.246 [0.029; 0.517]	0.694 [0.308; 0.981]
	<i>Based on the structural VAR with the output gap:</i>		
Pre-October 1979	0.114 [0.014; 0.209]	0.428 [0.048; 0.877]	0.516 [0.334; 0.667]
Post-Volcker stabilisation	0.121 [0.022; 0.191]	0.241 [0.026; 0.516]	0.676 [0.321; 0.939]

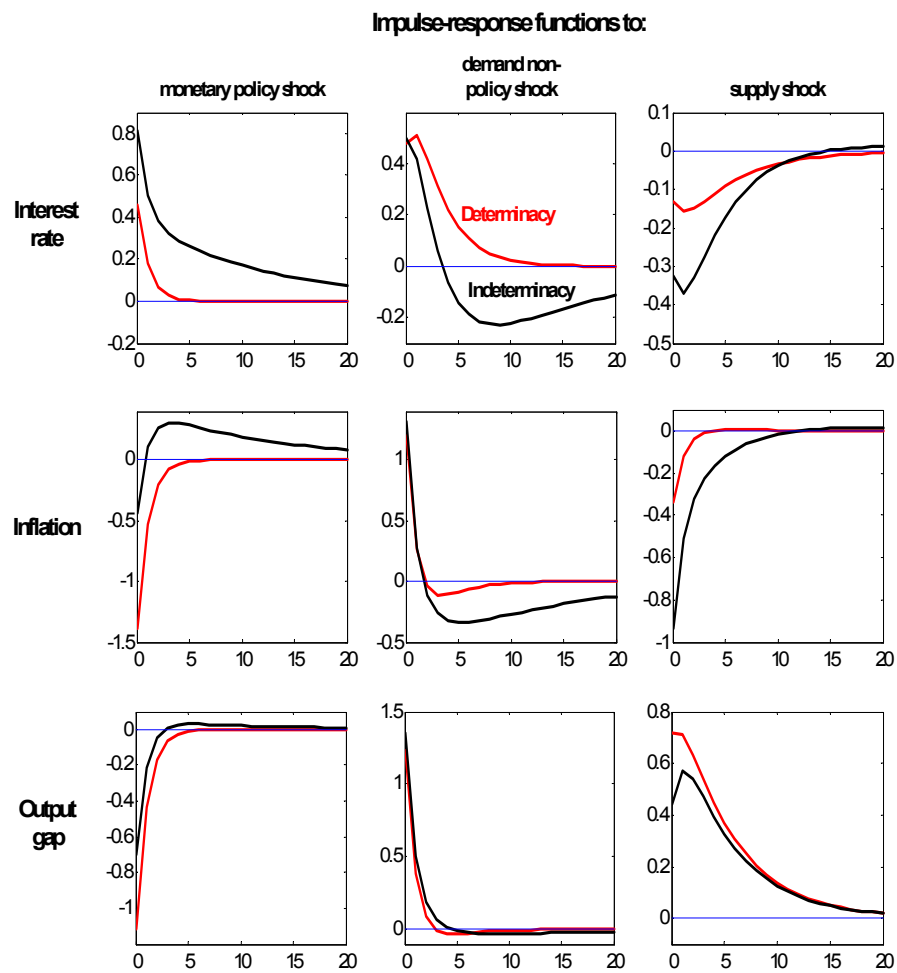


Figure 1: Impulse-response functions in the estimated New Keynesian model of Lubik and Schorfheide (2004)

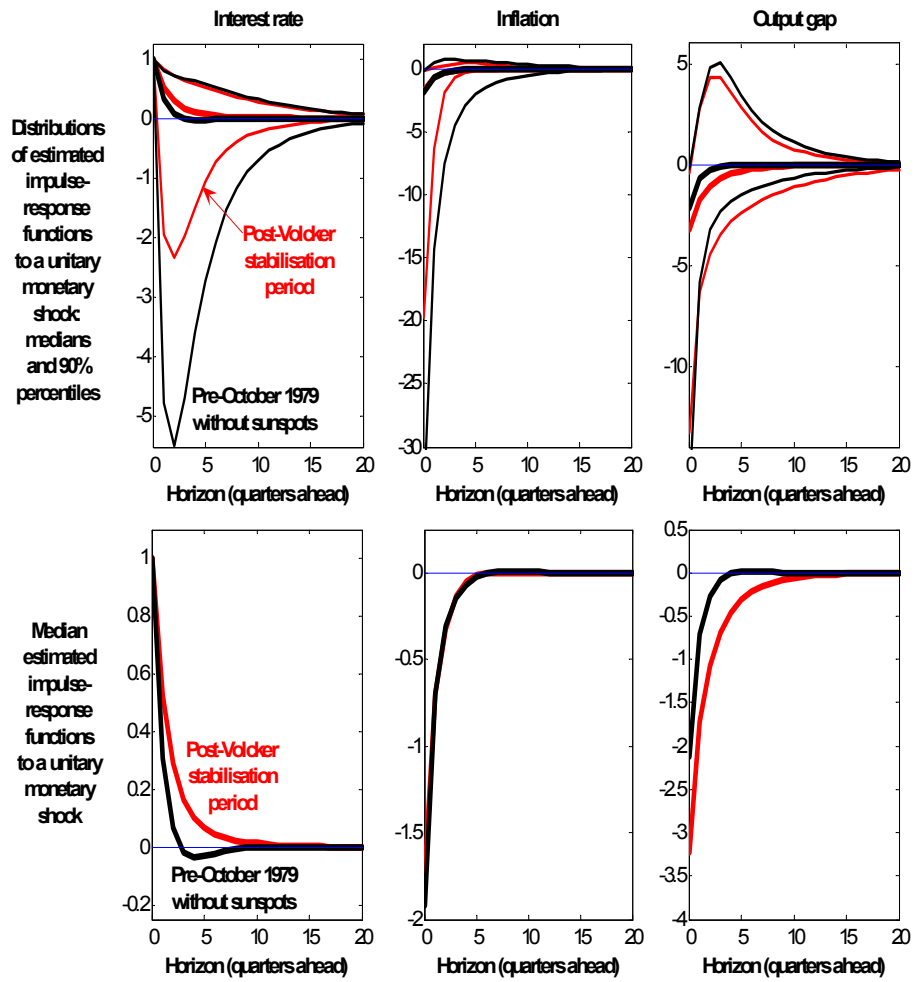


Figure 2: Estimated impulse-response functions to a unitary monetary shock based on sign restrictions (based on the output gap)

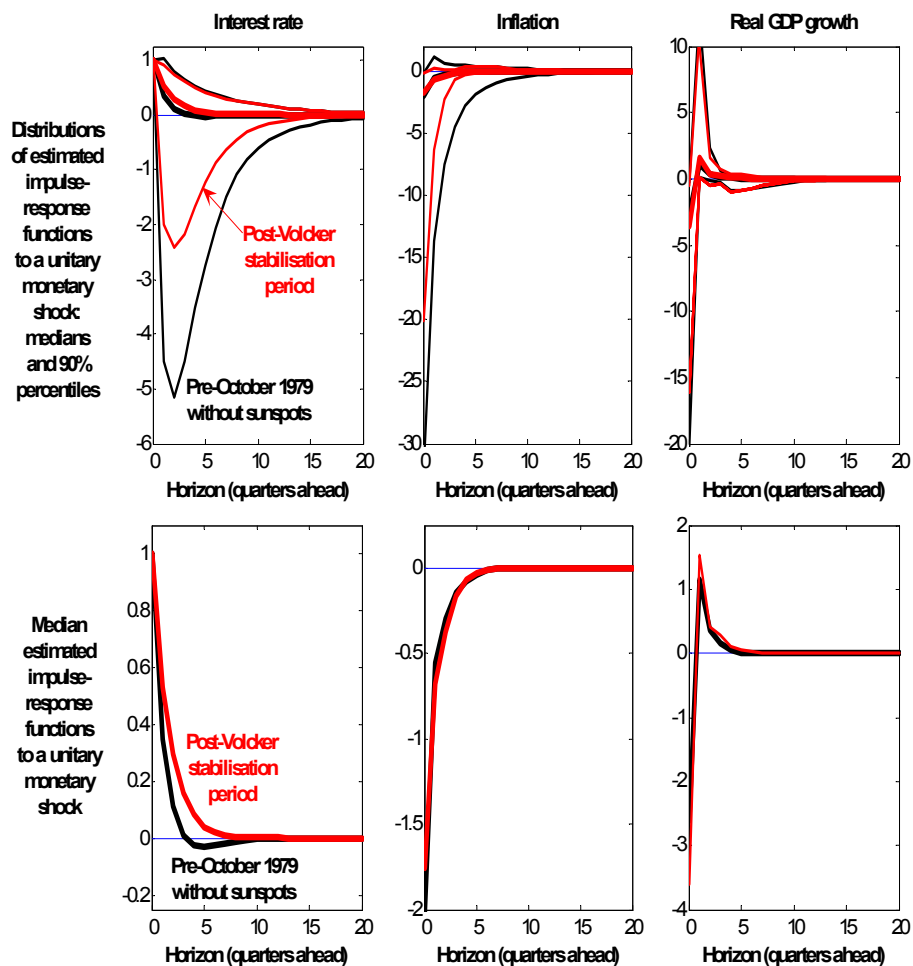


Figure 3: Estimated impulse-response functions to a unitary monetary shock based on sign restrictions (based on output growth)