



EUROPEAN CENTRAL BANK

EUROSYSTEM

WORKING PAPER SERIES

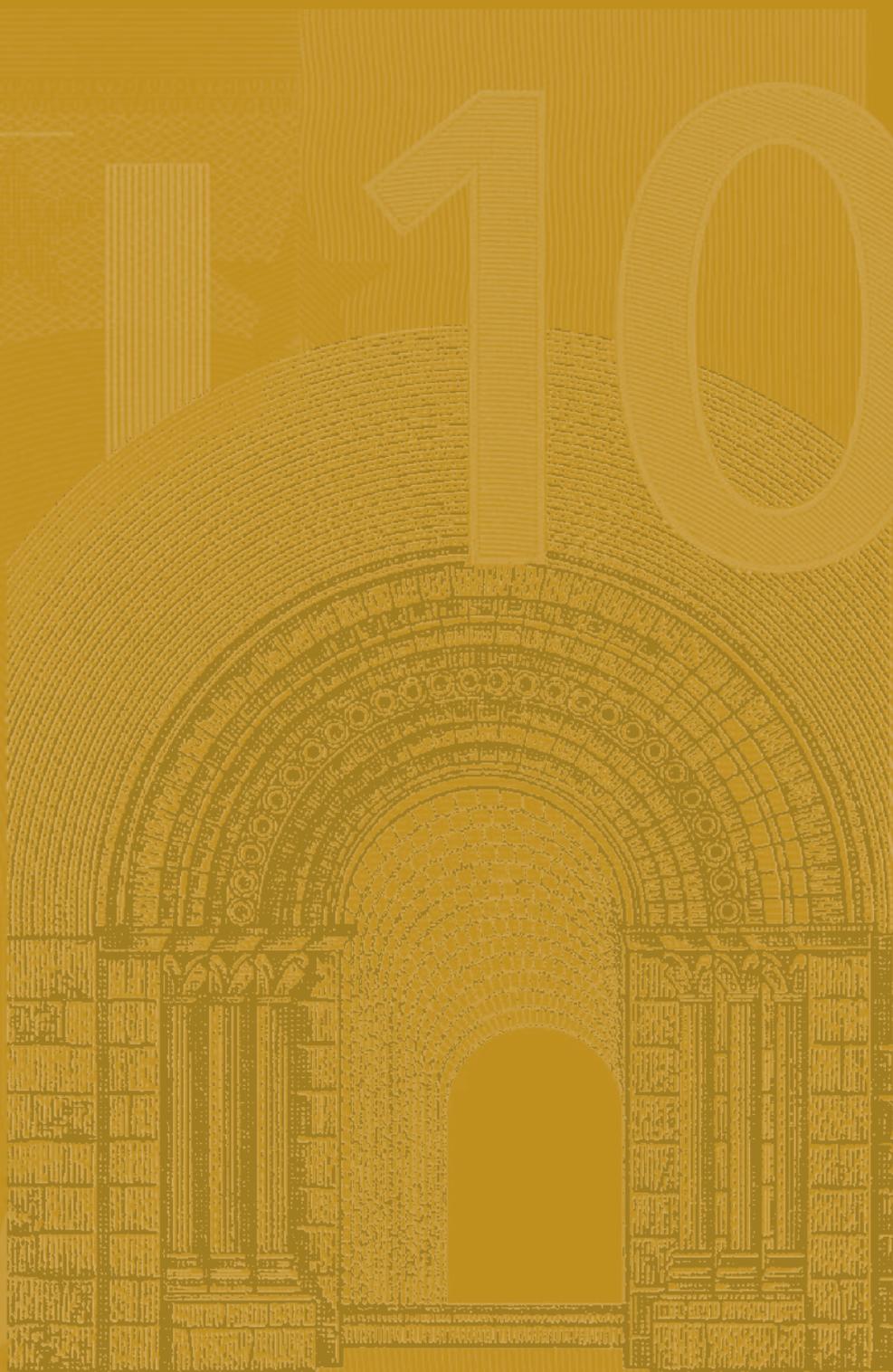
NO 865 / FEBRUARY 2008

ECB EZB EKT EKP

**EXPLAINING THE
GREAT MODERATION**

IT IS NOT THE SHOCKS

by Domenico Giannone, Michele Lenza
and Lucrezia Reichlin





EUROPEAN CENTRAL BANK

EUROSYSTEM



WORKING PAPER SERIES

NO 865 / FEBRUARY 2008

EXPLAINING THE GREAT MODERATION

IT IS NOT THE SHOCKS¹

Domenico Giannone²,
Michele Lenza³
and Lucrezia Reichlin⁴



In 2008 all ECB publications feature a motif taken from the €10 banknote.

This paper can be downloaded without charge from <http://www.ecb.europa.eu> or from the Social Science Research Network electronic library at http://ssrn.com/abstract_id=1090279.

¹ Paper prepared for the 22th Annual Congress of the European Economic Association, August 2007, Budapest. The opinions in this paper are those of the authors and do not necessarily reflect the views of the European Central Bank.

² European Central Bank and CEPR, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany; e-mail: domenico.giannone@ecb.europa.eu

³ European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany; e-mail: michele.lenza@ecb.europa.eu

⁴ European Central Bank and CEPR, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany; e-mail: lucrezia.reichlin@ecb.europa.eu



© European Central Bank, 2008

Address

Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address

Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone

+49 69 1344 0

Website

<http://www.ecb.europa.eu>

Fax

+49 69 1344 6000

All rights reserved.

Any reproduction, publication and reprint in the form of a different publication, whether printed or produced electronically, in whole or in part, is permitted only with the explicit written authorisation of the ECB or the author(s).

The views expressed in this paper do not necessarily reflect those of the European Central Bank.

The statement of purpose for the ECB Working Paper Series is available from the ECB website, <http://www.ecb.europa.eu/pub/scientific/wps/date/html/index.en.html>

ISSN 1561-0810 (print)

ISSN 1725-2806 (online)

CONTENTS

Abstract	4
Non-technical summary	5
1 Introduction	6
2 Some facts for the United States	7
3 Shocks or propagation? The role of information	8
4 Large models: the great moderation revisited	11
5 Summary, conclusions, and implications of the results	14
References	14
European Central Bank Working Paper Series	17

Abstract

This paper shows that the explanation of the decline in the volatility of GDP growth since the mid-eighties is not the decline in the volatility of exogenous shocks but rather a change in their propagation mechanism.

JEL Classification: E32, E37, C32, C53

Keywords: Shocks, Information, Great Moderation.

Non-technical summary

In the last twenty years the volatility of output growth and inflation in all OECD economies has declined. This phenomenon is known as “the Great Moderation”. Is the volatility decline to be attributed to exogenous causes, that is the decline in the volatility of shocks (“good luck” hypothesis) or to a change in the propagation mechanism of the shocks (change in the structure – “good policy” hypothesis)? Concerning inflation, the literature tends to attribute the decline in volatility to a credible monetary policy that, since the early eighties has stabilized inflationary expectations via commitment to a nominal anchor (see e.g. Stock and Watson 2002, 2003; Ahmed, Levin and Wilson 2004; Cogley and Sargent 2005). Concerning output, the literature is more divided but, overall, the consensus is towards the “good luck” hypothesis. Different views on inflation and output are often supported by the observation that while the dynamic properties of inflation have changed over time, those of GDP growth have not.

This paper revisits the results on the causes of the Great Moderation on output and inflation volatility and shows that the typical macroeconomic models, looking only at a handful of variables, overstate the role of good luck. Instead, changes in the economic structure are given more and more prominence as we look at larger models.

Hence, we conclude that the finding that “good luck” explains the Great Moderation is based on models which are excessively naive, either univariate or small dimensional, which do not reflect accurately the information processed by both markets and central bankers when producing their forecasts. Since the analysis is contaminated by omitted variables problems, the estimation of the shocks is not consistent and this tends to over-estimate their variance in the pre- Great Moderation sample. More generally, we argue that, since models are typically miss-specified, shocks stand for features that either are exogenous to the model we are considering or that we don’t understand. The more detailed is the model, the more limited is the role of the shocks relative to the internal propagation mechanism.

Our results suggest that it might be possible to construct a structural model in which the Great Moderation is explained by a change in the structure and not by a change in the residuals. However, given our results, such model must be larger than the medium scale standard DSGE model with six or seven variables.

1 Introduction

One of the most interesting facts of the last twenty years is that the volatility of output growth and inflation in all OECD economies has declined, a phenomenon that has been labeled as the Great Moderation. The literature has tried to establish whether the volatility decline should be attributed to exogenous causes that is, the decline in the volatility of shocks (the “good luck” hypothesis), or to a change in the propagation mechanism of the shocks (change in the structure – “good policy” hypothesis).

Regarding inflation, studies with few exceptions have concluded that the decline in volatility is due to credible monetary policy which has since the early eighties stabilized inflationary expectations via commitment to a nominal anchor (see e.g. Stock and Watson 2002, 2003; Ahmed, Levin and Wilson 2004; Cogley and Sargent 2005). Regarding output, on the other hand, the consensus supports the “good luck” hypothesis (a summary review of the empirical findings is provided in Section 2).

One explanation of why different conclusions have been reached for output and inflation is that the evolution of the dynamic properties of these two variables differs. For inflation, the evidence points to an increase in persistence and therefore to a change not only in variance but also in the autocorrelation structure (see e.g. Stock and Watson 2007). For gross domestic product (GDP), it has been shown that the spectral density of output growth before and during the Great Moderation period differs only by a proportional factor (Ahmed, Levin and Wilson 2004) and that the coefficient of the univariate autoregressive model for GDP growth is time invariant (Stock and Watson 2002). Both pieces of evidence suggest no change in the autocorrelation function of the process. However, there is another stylized fact concerning output and inflation that suggests that the “good luck” explanation for GDP might not be the right one. In the Great Moderation sample, the ability to predict output and inflation beyond what can be predicted on the basis of a simple random walk model (relative predictability) has decreased. The evidence on inflation is well known: Atkinson and Ohanian (2001) and, more recently, Stock and Watson (2007) have shown that the ratio between the mean squared error of any (simple or complex) forecast and the variance of the process has increased in the last twenty years. Recent evidence (D’Agostino, Giannone and Surico 2006; De Mol, Giannone and Reichlin 2006) points to the same phenomenon for GDP. Ever since the mid-eighties and in contrast with the seventies both the professional forecasters and the Federal Reserve Board (Greenbook forecasts) have been unable to outperform the forecast obtained by a naive model in which tomorrow is predicted to be the same as today.

How can we reconcile the good luck view with the evidence of invariant dynamic properties of GDP and diminished relative predictability? This paper makes the point that, if the autocorrelation function of the univariate process has not changed, then diminished relative predictability can be explained only by the cross-covariances between GDP and other variables used by the Greenbooks and the professional forecasters in computing their forecast. Relative predictability depends on the model and, therefore, on the information we condition our forecast on. But if multivariate information matters, then any estimate of the role of the shocks for explaining the Great Moderation must take it into account. If not, we incur an omitted variable problem with the con-

sequence of not obtaining a consistent estimate of the structural shocks. It is therefore important to evaluate whether conclusions about good luck versus good policy – change in structure are altered when we use information sets of different size. In this paper we pursue this evaluation through vector autoregressive (VAR) analysis. We consider VARs of different size from a minimum of four to a maximum of nineteen variables, both nominal and real. To overcome problems of overfitting in the larger models, we will use Bayesian shrinkage as suggested in Banbura, Giannone and Reichlin (2007).

2 Some facts for the United States

Let us consider quarterly data for GDP and GDP deflator in the samples 1959–1983 (pre–Great Moderation) and 1984–2007 (Great Moderation).¹ In the United States, the standard deviation of yearly real GDP growth declined from 2.7 in the first sample to 1.28 in the second, the standard deviation of yearly GDP deflator inflation declined from 2.7 to 0.75. The mean remained roughly unchanged for GDP growth while nearly halving for inflation.² Similar numbers are obtained for other OECD countries, but here we focus on the United States.

Can these facts be attributed to exogenous causes (the shocks) or rather to changes in the propagation mechanism? Table 1 summarizes results obtained by the empirical literature using a variety of statistical techniques.

Table 1 Shocks or propagation? Summary of the findings on GDP

Authors	Results
McConnell and Perez-Quiros (2000)	Propagation: Inventories
Kahn, McConnell and Perez-Quiros(2002)	Propagation: Inventories
Stock and Watson (2002)	Shocks 90%
Stock and Watson (2003)	Shocks 80-120%
Primiceri (2005)	Shocks
Boivin and Giannoni (2006)	Shocks 50-75%
Dynan, Elmedorf and Sichel (2006)	Propagation: Financial innovation
Justiniano and Primiceri (2006)	Shocks: Investment wedge
Sims and Zha (2006)	Shocks
Arias, Hansen, and Ohanian (2007)	Shocks: Total Factor Productivity
Canova, Gambetti and Pappa (2006)	Propagation and shocks
Castelnuovo (2007)	Shocks
Gali and Gambetti (2007)	Propagation and shocks
Mojon (2007)	Shocks: Monetary policy shocks
Smets and Wouters (2007)	Shocks

Clearly, the majority view is that the explanation on the decline in GDP growth volatility is in the decline in shock volatility.³

¹More precisely, our pre–Great Moderation sample ranges from the first quarter of 1959 to the fourth quarter of 1983 and the Great Moderation sample from the first quarter of 1984 to the first quarter of 2007.

²The average annual growth rates were 3.33 and 3.03 for GDP in the two periods while GDP deflator inflation declined from 4.77 to 2.48.

³In presence of model miss-specification, changes in structure might show up as changes in the size of exogenous shocks. Structural explanations for the Great Moderation, however, might still be uncovered by looking at the nature of the shocks in the spirit of Chari, Kehoe and McGrattan (2007). For example, Justiniano and Primiceri (2006) find that the Great Moderation is entirely explained by investment-specific shocks, but they can not exclude the possibility that this finding reflects changes in unmodeled financial frictions.

Let us now turn to predictability. In Table 2 we report findings in D’Agostino, Giannone and Surico (2006) on the relative performance of institutional forecasters: the Federal Reserve (Greenbooks) and the Survey of Professional Forecasters (SPF). The upper panel in Table 2 refers to inflation and the lower panel to GDP. Each of the two panels are divided in two sections: on the left we report pre–Great Moderation results and on the right we report results of the Great Moderation.⁴ In each section, we report statistics on the forecast based on the random walk model⁵ (Naive), Greenbook forecasts (GB), and the Survey of Professional Forecasters (SPF) for the four forecasting horizons (h) from one to four quarters ahead. In particular, the “Naive” column reports the mean squared forecast error (MSFE) of the random walk forecasts, while the GB and SPF columns report, respectively, the *ratio* of the MSFE of the Greenbook and Survey of Professional Forecasters to the corresponding MSFE of the random walk.

Table 2 Greenbook (GB) and Survey of Professional Forecasters (SPF): Relative Mean Squared Forecast Errors

<i>Inflation</i>				<i>Post-85</i>			
<i>Pre-85</i>				<i>Post-85</i>			
h	Naive	GB	SPF	h	Naive	GB	SPF
1	0.54	0.30***	0.27***	1	0.08	0.58**	0.82
2	1.72	0.21**	0.24**	2	0.17	0.93	1.15
3	3.51	0.21**	0.25*	3	0.28	0.97	1.39
4	5.69	0.23*	0.32*	4	0.39	1.18	1.82

<i>GDP</i>				<i>Post-85</i>			
<i>Pre-85</i>				<i>Post-85</i>			
h	Naive	GB	SPF	h	Naive	GB	SPF
1	25.82	0.37**	0.45**	1	3.77	0.73	0.77
2	19.01	0.44**	0.41**	2	2.51	0.77	0.70
3	15.39	0.40***	0.45***	3	2.15	0.85	0.73
4	13.18	0.42***	0.46***	4	2.03	0.89	0.74

Note: Asterisks denote rejection of the null hypothesis of equal predictive accuracy between each model and the random walk at 1% (***), 5% (**), and 10% (*) significance levels.

Table 2 shows that inflation and GDP forecasts achieved MSFEs significantly lower than the naive forecasts in the pre-1985 period. However, this picture changed dramatically after 1985, when the MSFE of the Greenbooks and the Survey of Professional Forecasters no longer differ statistically from those of a naive forecast. From these results, one can conclude that relative predictability has strongly declined in the Great Moderation sample.

3 Shocks or Propagation? The role of information

Let us denote real GDP growth as Δy_t and assume that it can be represented by

$$\Delta y_t = \mu + \Psi(L)u_t,$$

where μ is the unconditional mean and u_t an i.i.d. scalar shock with variance σ_u^2 . Denote the variance of Δy_t by σ_y^2 .

⁴Notice that D’Agostino, Giannone and Surico (2006) splits the sample in 1985.

⁵In each period the random walk for the price variable predicts that the annual growth rate of inflation h periods ahead is the same as the last observed in sample, while the random walk for GDP predicts that the annual GDP growth rate h periods ahead will be equal to the average GDP growth observed up to the period in which the forecast is made.

We are interested in understanding changes in the ratio σ_u^2/σ_y^2 . The variance of the structural shock u_t is estimated as the forecast error of an econometric model; therefore, the empirical ratio is related to the measure of relative predictability defined as⁶

$$P = 1 - \frac{\text{Var}(\text{forecast error})}{\sigma_y^2}.$$

If GDP is driven by one shock only and if the forecast error is a good estimate of the structural shock u_t , then declining predictability should indicate an increase in the ratio between the variance of shocks and the variance of the process. This increase would contradict most of the empirical evidence supporting the good luck hypothesis.

Therefore, if that evidence is accurate, then one or more of the following facts are also true: (i) the institutional forecasters provide a poor forecast; (ii) there are two or more shocks driving GDP and their relative importance has changed, with shocks that entail less predictable dynamics becoming more sizable; (iii) the models used in the literature omit relevant information for estimating the structural shocks.

Possibility (i) is unlikely because institutional forecasters are quite accurate (see e.g. Sims 2002). Possibility (ii) is also unlikely because, if the relative importance of the shocks had changed, we would have observed a significant change in the shape of the spectral density. The evidence does not support such change (on this point see Ahmed, Levin and Wilson 2004).

Possibility (iii) requires some discussion. We first denote the spectral density of Δy_t as $S_y(\theta)$ with $\theta \in (-\pi, \pi)$. Let us now see what this implies for predictability on the basis of a univariate model.

The variance of the forecast error associated with a univariate model can be derived from the spectral density as

$$\sigma_e^2 = \exp\left(\frac{1}{2\pi} \int_{-\pi}^{+\pi} \ln(S_y(\theta)) d\theta\right),$$

and a measure of relative predictability associated to that model can be obtained by dividing σ_e^2 by the variance of Δy_t , which is the integral of the spectral density:

$$\tilde{P} = 1 - \frac{\exp\left(\frac{1}{2\pi} \int_{-\pi}^{+\pi} \ln(S_y(\theta)) d\theta\right)}{\frac{1}{2\pi} \int_{-\pi}^{+\pi} S_y(\theta) d\theta}.$$

If, as the evidence suggests, the spectral density has changed by only a proportional factor, then clearly relative predictability based on the univariate model cannot have changed. Since predictability by institutional forecasters has declined, this suggests that the univariate model is misspecified.

Let us now consider the following example, which mimics the evidence on diminished volatility of the series, diminished predictability, and no change in the autocorrelation function:

⁶In Table 2 we reported, among other things, the ratios between the MSFE of the Greenbook and Survey of Professional Forecasters GDP forecasts with respect to the MSFE of the random walk. Such ratios can be considered as measures of $\text{Var}(\text{forecast error})/\sigma_y^2$.

$$\begin{aligned}\Delta y_t^{pre84} &= (1 + 2L)u_t^{pre84}, \\ \Delta y_t^{post84} &= (1 + 0.5L)u_t^{post84},\end{aligned}$$

with $\text{Var}(u_t^{post84}) = \text{Var}(u_t^{pre84})$.

Observe in this example that although the autocorrelation function has not changed, the change in volatility in the second period is explained by a change in propagation while the variance of the shocks has remained the same. Predictability defined in terms of the structural shock declines in the post-1984 sample.

Key here is that the process in the pre-1984 sample is not invertible and that $u_t^{pre84} = \sum_{j=1}^{\infty} [(-1/2)^j \Delta y_{t+j}^{pre84}]$. If the econometrician wrongly assumes that the shock is an innovation with respect to GDP growth and estimates it through a simple univariate model, then he will end up estimating:

$$\Delta y_t^{pre84} = (1 + 0.5L)e_t^{pre84},$$

where $e_t^{pre84} = \frac{1+2L}{1+0.5L}u_t^{pre84}$. The estimated shock e_t^{pre84} has a larger variance than the structural shock u_t^{pre84} ($\text{Var}(e_t^{pre84}) = 4\text{Var}(u_t^{pre84})$), and this will lead the econometrician to over-estimate the importance of the shocks relative to the propagation in the pre-1984 sample and to conclude that predictability has not changed.

The important point here is that a regression of GDP on its past leads to an omitted variables problem. Because the shock u_t is non-fundamental with respect to Δy_t , it can be recovered only by using either future observations on Δy_t or other variables. As discussed by Forni et al. (2007), the shock can be recovered as the forecast error of a larger model, including those variables that may help forecasting GDP growth.

This point remains true for more general cases of models with more than one shock. An interesting illustration was when the monetary authorities shifted from a passive interest rate policy (pre-1979 period) to implementing an active one (see, e.g. Clarida, Gali and Gertler 2000). In mainstream neo-Keynesian models, a passive policy is shown to be destabilizing, which implies an indeterminate equilibrium. In this case, as pointed out by Castelnuovo and Surico (2006) and Canova and Gambetti (2007), the standard log-linearized three-variables neo-Keynesian model for the output gap, inflation, and the nominal rate cannot be approximated by a VAR on those three variables. In the indeterminate regime, expectations variables must be included in order to estimate the shocks consistently. This is another example of an omitted variables problem. In this case, the estimated shocks are a mix of structural shocks, forecast errors, and their lags and this mix has a larger variance than that of the structural shocks. Moreover, the model will not perform well in predicting. The implication is that it would be misleading to explain the Great Moderation via any counterfactual exercise based on a three-variables VAR. Again, this is an example where the shocks are non fundamental for a three-variables system.

The lesson of this discussion is very simple. In a time-series model, the split between shocks and propagation depends on the conditioning information set. Shocks estimated on the basis of small models may not be good estimates of structural shocks. This suggests that the explanation of results that attribute the Great Moderation to the

good luck hypothesis is that the models used to estimate the shocks did not include enough information and were therefore misspecified. Therefore, when evaluating the role of shocks in the Great Moderation, we should study models of different size.

How do we know whether the size of the forecasting model is appropriate? Loosely speaking, we should consider the model size appropriate when it is sufficient to make forecasts that is, increasing the number of variables included in the model no longer improves the forecasting performance. Having established the size, we can then identify structural shocks as linear combinations of the innovations obtained from the estimated VAR. On this point, see Giannone and Reichlin (2006).

4 Large models: The great moderation revisited

In this section we perform counterfactual exercises to assess the role of shocks versus propagation in explaining the declined volatility. This approach has been extensively used in the literature (Stock and Watson 2002, 2003; Ahmed, Levin and Wilson 2004; Primiceri 2005; Justiniano and Primiceri 2006; Smets and Wouters 2007). Our exercise is based on four model specifications: a small VAR with GDP, GDP deflator, federal funds rate, and commodity prices (as in Stock and Watson 2003); two larger systems of six and seven variables, used, respectively, by Sims and Zha (2006) in their VAR specification and by Smets and Wouters (2007) for estimating a dynamic stochastic general equilibrium (DSGE) model of the U.S. economy; and, finally, a VAR with nineteen variables, including all the variables typically used in macro models. We do not consider larger VARs as done in Banbura, Giannone and Reichlin (2007), since the empirical results of that paper suggest that a VAR with about twenty macroeconomic variables, which closely correspond to those used in this paper, is enough to capture the structural shocks since adding extra variables does not significantly change the results.

Table 3 lists the variables considered in the four models.

Table 3. VAR specifications

Large VAR	Small VAR	Sims - Zha	Smets - Wouters
GDP	x	x	x
GDP deflator	x	x	x
Federal Funds rate	x	x	x
Commodity prices	x		
Consumer prices			
Consumption			x
Investment		x	x
Change in inventories			
Producer price index			
Interest rate 1 year			
Interest rate 5 years			
Interest rate 10 years			
Hours worked			x
Hourly compensation			x
Capacity utilization			
Stock Prices			
M2		x	
Total Reserves			
Unemployment rate		x	

Data are quarterly, ranging from the first quarter of 1959 to the first quarter of 2007.⁷ The small model is estimated by ordinary least squares (OLS). For larger models

⁷The models are estimated with data in log-levels except for interest rates, capacity utilization, unemployment rates, and changes in inventories, for which we do not take logarithms.



we face an issue of overfitting, which we address by using Bayesian shrinkage (see Banbura, Giannone and Reichlin 2007; De Mol, Giannone and Reichlin 2006). In practice we use a Litterman (random walk) prior whose tightness is set so that the in-sample fit of the interest rate equation in the large VAR models is fixed at the level achieved by the simple four-variables monetary VAR. This choice is grounded on the evidence that U.S. short-term interest rates are well described by linear functions of inflation and real activity (Taylor rules).

The VARs are estimated separately in the two subsamples:

$$\Delta X_t = A_{pre84}(L)\Delta X_{t-1} + e_{pre84,t} \quad e_{pre84,t} \sim \text{WN}(0, \Sigma^{pre84}),$$

$$\Delta X_t = A_{post84}(L)\Delta X_{t-1} + e_{post84,t} \quad e_{post84,t} \sim \text{WN}(0, \Sigma^{post84}).$$

First counterfactual exercise: How much of the Great Moderation can be explained by a change in the propagation?

In this exercise we simulate shocks assuming that their covariance matrix has remained unchanged at the level of the pre-84 sample estimates ($\hat{\Sigma}_{pre84}$) and feed them through the propagation mechanism estimated for the post-1984 sample ($\hat{A}_{post84}(L)$). Precisely, we consider the following counterfactual processes:

$$\Delta X_t^* = \hat{A}_{post84}(L)\Delta X_{t-1}^* + e_{pre84,t}^*, \quad e_{pre84,t}^* \sim \text{WN}(0, \hat{\Sigma}_{pre84}).$$

If the counterfactual GDP standard deviation is the same as the actual standard deviation observed in the post-1984 sample, then this should indicate that the change of propagation mechanisms fully explains the Great Moderation. The change in shocks plays a role if, instead, the counterfactual decline in volatility is smaller than observed.

Second counterfactual exercise: How much of the Great Moderation can be explained by a change in the shocks?

In this exercise we assume that the propagation mechanisms has remained unchanged at the level of the pre-1984 estimates ($\hat{A}_{pre84}(L)$) and feed them with shocks simulated using the covariance matrix estimated in the post-1984 sample ($\hat{\Sigma}_{post84}$). That is:

$$\Delta X_t^{**} = \hat{A}_{pre84}(L)\Delta X_{t-1}^{**} + e_{post84,t}^{**}, \quad e_{post84,t}^{**} \sim \text{WN}(0, \hat{\Sigma}_{post84}).$$

If the counterfactual GDP standard deviation is the same as the actual standard deviation observed in the post-1984 sample, then this should indicate that a change in shocks fully explains the Great Moderation. The change in propagation mechanisms plays a role if, instead, the counterfactual decline in volatility is smaller than observed.

Since the two exercises might not provide symmetric answers to the question of what caused the Great Moderation, we report results in separate tables. Table 4a refers to the first and Table 4b to the second counterfactual exercise.

Table 4a First counterfactual exercise: Changes in propagation only

Coefficients	Shocks	Std. Deviation	
		GDP growth	Inflation
<i>Observed</i>			
Pre 84	Pre 84	2.68	2.66
Post 84	Post 84	1.28	0.75
<i>Small</i>			
Post 84	Pre 84	2.33	1.34
<i>Sims and Zha</i>			
Post 84	Pre 84	1.75	0.92
<i>Smets and Wouters</i>			
Post 84	Pre 84	1.90	0.93
<i>Large</i>			
Post 84	Pre 84	1.30	0.69

Table 4a shows that, in the small model, the change in propagation explains none of the decline in the standard deviation of GDP and half of the decline in the standard deviation of inflation (good luck for GDP and both good luck and good policy for inflation), while in the large model the change in propagation explains all the decline in standard deviation both for GDP and inflation (good policy in both cases).

Table 4b Second counterfactual exercise: Changes in shock only

Coefficients	Shocks	Std. Deviation	
		GDP growth	Inflation
<i>Observed</i>			
Pre 84	Pre 84	2.68	2.66
Post 84	Post 84	1.28	0.75
<i>Small</i>			
Pre 84	Post 84	1.21	2.23
<i>Sims and Zha</i>			
Pre 84	Post 84	1.42	2.28
<i>Smets and Wouters</i>			
Pre 84	Post 84	1.54	2.41
<i>Large</i>			
Pre 84	Post 84	1.90	2.42

As for the second counterfactual exercise, in the small model the change in shocks volatility explains all the decline in GDP standard deviation and a fifth of the decline in inflation (good luck for GDP and mostly good policy for inflation). In the large model, the decline in shocks volatility explains about a half of the decline in GDP standard deviation but almost none of the decline in inflation volatility (good policy for inflation and both good luck and good policy for GDP).

Summing up, both exercises give qualitatively similar results. The degree to which shocks or propagation explain the Great Moderation depends on the size of the model. Smaller models tend to favor changes in exogenous shocks as an explanation for the great moderation, understating the role of changes in the structure of the economy.

5 Summary, conclusions, and implications of the results

The paper has considered VAR models of different size and estimated them over the pre-Great Moderation and the Great Moderation samples to evaluate the role of shocks in explaining the observed decline in output volatility. We have found that results based on counterfactual exercises change with the dimension of the model. The large model attributes the Great Moderation to a change in propagation rather than a change in shocks volatility.

We make the point that the larger model is the one to be trusted because, when variables that Granger-cause GDP are not included in the estimated model, the shock we estimate does not correspond to the structural shock. In general, if the decline in output growth volatility is attributed to a decline in the variance of the shocks then, since the dynamic properties of output growth do not show any significant change, this should imply that predictability remained the same since the eighties. This implication is counterfactual, as indicated by the evidence based on forecasts produced by the Fed and professional forecasters.

We conclude that the finding that “good luck” explains the Great Moderation is based on models that are excessively naive either univariate or small dimensional and that do not accurately reflect the information processed both by markets and central banks when producing their forecasts. Because such analysis is contaminated by omitted variables problems, the estimation of the shocks is not consistent and this leads to over-estimating their variance in the first period.

Our analysis suggests that what the literature on the Great Moderation attributes to “luck” might better be attributed to “ignorance”. We focus on the omitted variables problem, but the point is more general. Models are generally miss-specified. In structural models, shocks represent features that either are exogenous to the model or that we don’t understand. The more detailed is the model, the smaller are the shocks and the more limited is their role relative to the internal propagation mechanism. Our results suggest that it might be possible to construct a structural model in which the Great Moderation is explained by a change in the structure and not by a change in the residuals. However, our results indicate that such a model would have to be larger than the medium-scale standard DSGE model with six or seven variables.

References

- Ahmed, Shaghil, Andrew Levin, and Beth Anne Wilson (2004). Recent U.S. Macroeconomic Stability: Good Policies, Good Practices, or Good Luck? *The Review of Economics and Statistics*, 86(3), 824–832.

- Arias, Andres, Gary D. Hansen, and Lee E. Ohanian (2007). Why have business cycle fluctuations become less volatile? NBER Working Papers 12079, National Bureau of Economic Research, Inc.
- Atkenson, Andrew and Lee H. Ohanian (2001). Are Phillips Curve Useful for Forecasting Inflation? *Federal Reserve Bank of Minneapolis, Quarterly Review*, 25(1), 2–11.
- Banbura, Marta, Domenico Giannone, and Lucrezia Reichlin (2007). Bayesian VARs with Large Panels. CEPR Discussion Papers 6326, C.E.P.R. Discussion Papers.
- Boivin, Jean and Marc P. Giannoni (2006). Has Monetary Policy Become More Effective? *The Review of Economics and Statistics*, 88(3), 445–462.
- Canova, Fabio and Luca Gambetti (2007). Do inflations expectations matter? The Great Moderation revisited. Unpublished manuscript.
- Canova, Fabio, Luca Gambetti, and Evi Pappa (2007). The structural dynamics of output growth and inflation: some international evidence. *The Economic Journal*, 117, C167–C191.
- Castelnuovo, Efrem (2007). Assessing different drivers of the great moderation in the US. unpublished manuscript, University of Padova.
- Castelnuovo, Efrem and Paolo Surico (2006). The price puzzle: fact or artifact? Working Paper 288, Bank of England.
- Chari, Varadarajan, Patrick J. Kehoe, and Ellen R. McGrattan (2007). Business Cycle Accounting. *Econometrica*, 75(3), 781–836.
- Clarida, Richard, Jordi Gali, and Mark Gertler (2000). Monetary Policy Rules And Macroeconomic Stability: Evidence And Some Theory. *The Quarterly Journal of Economics*, 115(1), 147–180.
- Cogley, Timothy and Thomas J. Sargent (2005). Drift and Volatilities: monetary policies and outcomes in the post WWII US. *Review of Economic Dynamics*, 8, 262–302.
- D’Agostino, Antonello, Domenico Giannone, and Paolo Surico (2006). (Un)Predictability and macroeconomic stability. Working Paper Series 605, European Central Bank.
- De Mol, Christine, Domenico Giannone, and Lucrezia Reichlin (2006). Forecasting Using a Large Number of Predictors: Is Bayesian Regression a Valid Alternative to Principal Components? CEPR Discussion Papers 5829, C.E.P.R. Discussion Papers.
- Dynan, Karen E., Douglas W. Elmendorf, and Daniel E. Sichel (2006). Can financial innovation help to explain the reduced volatility of economic activity? *Journal of Monetary Economics*, 53, 123–150.
- Forni, Mario, Domenico Giannone, Marco Lippi, and Lucrezia Reichlin (2007). Opening the Black Box: Structural Factor Models with large cross-sections. Working Paper 712, European Central Bank.
- Gali, Jordi and Luca Gambetti (2007). On the sources of the great moderation. unpublished manuscript.

- Giannone, Domenico and Lucrezia Reichlin (2006). Does information help recovering structural shocks from past observations? *Journal of the European Economic Association*, 4(2-3), 455–465.
- Justiniano, Alejandro and Giorgio E. Primiceri (2006). The time varying volatility of macroeconomic fluctuations. NBER Working Papers 12022, National Bureau of Economic Research, Inc.
- Kahn, James A., Margaret McConnell, and Gabriel Perez-Quiros (2002). On the causes of the increased stability of the US economy. Economic policy review, Federal Reserve Bank of New York.
- McConnell, Margaret and Gabriel Perez-Quiros (2000). Output fluctuations in the United States: what has changed since the early 1980's? *American Economic Review*, 90(5), 1464–1476.
- Mojon, Benoit (2007). Monetary policy, output composition and the great moderation. unpublished manuscript.
- Primiceri, Giorgio (2005). Time varying structural vector autoregressions and monetary policy. *Review of Economic Studies*, 72, 821–852.
- Sims, Christofer A. (2002). The role of models and probabilities in the monetary policy process. *Brookings papers on economic activity*, 1–40.
- Sims, Christopher A. and Tao Zha (2006). Were There Regime Switches in U.S. Monetary Policy? *American Economic Review*, 96(1), 54–81.
- Smets, Frank and Rafael Wouters (2007). Shocks and frictions in US business cycles: a Bayesian DSGE approach. *American Economic Review*, 97(3), 586–606.
- Stock, James H. and Mark W. Watson (2002). Has the Business Cycle Changed and Why? In M. Gertler and K. Rogoff (Eds.), *NBER Macroeconomics Annual 2002*. MIT Press.
- Stock, James H. and Mark W. Watson (2003). Has the Business Cycle changed? Evidence and explanations. Paper prepared for the Federal Reserve of Kansas city simposium "Monetary policy and uncertainty", Jackson Hole, August 2003.
- Stock, James H. and Mark W. Watson (2007). Why Has U.S. Inflation Become Harder to Forecast? *Journal of Money, Credit and Banking*, 39, 3–33.

European Central Bank Working Paper Series

For a complete list of Working Papers published by the ECB, please visit the ECB's website (<http://www.ecb.europa.eu>).

- 827 “How is real convergence driving nominal convergence in the new EU Member States?” by S. M. Lein-Rupprecht, M. A. León-Ledesma, and C. Nerlich, November 2007.
- 828 “Potential output growth in several industrialised countries: a comparison” by C. Cahn and A. Saint-Guilhem, November 2007.
- 829 “Modelling inflation in China: a regional perspective” by A. Mehrotra, T. Peltonen and A. Santos Rivera, November 2007.
- 830 “The term structure of euro area break-even inflation rates: the impact of seasonality” by J. Ejsing, J. A. García and T. Werner, November 2007.
- 831 “Hierarchical Markov normal mixture models with applications to financial asset returns” by J. Geweke and G. Amisano, November 2007.
- 832 “The yield curve and macroeconomic dynamics” by P. Hördahl, O. Tristani and D. Vestin, November 2007.
- 833 “Explaining and forecasting euro area exports: which competitiveness indicator performs best?” by M. Ca’ Zorzi and B. Schnatz, November 2007.
- 834 “International frictions and optimal monetary policy cooperation: analytical solutions” by M. Darracq Pariès, November 2007.
- 835 “US shocks and global exchange rate configurations” by M. Fratzscher, November 2007.
- 836 “Reporting biases and survey results: evidence from European professional forecasters” by J. A. García and A. Manzanares, December 2007.
- 837 “Monetary policy and core inflation” by M. Lenza, December 2007.
- 838 “Securitisation and the bank lending channel” by Y. Altunbas, L. Gambacorta and D. Marqués, December 2007.
- 839 “Are there oil currencies? The real exchange rate of oil exporting countries” by M. M. Habib and M. Manolova Kalamova, December 2007.
- 840 “Downward wage rigidity for different workers and firms: an evaluation for Belgium using the IWFP procedure” by P. Du Caju, C. Fuss and L. Wintr, December 2007.
- 841 “Should we take inside money seriously?” by L. Stracca, December 2007.
- 842 “Saving behaviour and global imbalances: the role of emerging market economies” by G. Ferrucci and C. Miralles, December 2007.
- 843 “Fiscal forecasting: lessons from the literature and challenges” by T. Leal, J. J. Pérez, M. Tujula and J.-P. Vidal, December 2007.
- 844 “Business cycle synchronization and insurance mechanisms in the EU” by A. Afonso and D. Furceri, December 2007.
- 845 “Run-prone banking and asset markets” by M. Hoerova, December 2007.

- 846 “Information combination and forecast (st)ability. Evidence from vintages of time-series data” by C. Altavilla and M. Ciccarelli, December 2007.
- 847 “Deeper, wider and more competitive? Monetary integration, Eastern enlargement and competitiveness in the European Union” by G. Ottaviano, D. Taglioni and F. di Mauro, December 2007.
- 848 “Economic growth and budgetary components: a panel assessment for the EU” by A. Afonso and J. González Alegre, January 2008.
- 849 “Government size, composition, volatility and economic growth” by A. Afonso and D. Furceri, January 2008.
- 850 “Statistical tests and estimators of the rank of a matrix and their applications in econometric modelling” by G. Camba-Méndez and G. Kapetanios, January 2008.
- 851 “Investigating inflation persistence across monetary regimes” by L. Benati, January 2008.
- 852 “Determinants of economic growth: will data tell?” by A. Ciccone and M. Jarocinski, January 2008.
- 853 “The cyclical behavior of equilibrium unemployment and vacancies revisited” by M. Hagedorn and I. Manovskii, January 2008.
- 854 “How do firms adjust their wage bill in Belgium? A decomposition along the intensive and extensive margins” by C. Fuss, January 2008.
- 855 “Assessing the factors behind oil price changes” by S. Déés, A. Gasteuil, R. K. Kaufmann and M. Mann, January 2008.
- 856 “Markups in the euro area and the US over the period 1981-2004: a comparison of 50 sectors” by R. Christopoulou and P. Vermeulen, January 2008.
- 857 “Housing and equity wealth effects of Italian households” by C. Grant and T. Peltonen, January 2008.
- 858 “International transmission and monetary policy cooperation” by G. Coenen, G. Lombardo, F. Smets and R. Straub, January 2008.
- 859 “Assessing the compensation for volatility risk implicit in interest rate derivatives” by F. Fornari, January 2008.
- 860 “Oil shocks and endogenous markups: results from an estimated euro area DSGE model” by M. Sánchez, January 2008.
- 861 “Income distribution determinants and public spending efficiency” by A. Afonso, L. Schuknecht and V. Tanzi, January 2008.
- 862 “Stock market volatility and learning” by K. Adam, A. Marcet and J. P. Nicolini, February 2008.
- 863 “Population ageing and public pension reforms in a small open economy” by C. Nickel, P. Rother and A. Theophilopoulou, February 2008.
- 864 “Macroeconomic rates of return of public and private investment: crowding-in and crowding-out effects” by A. Afonso and M. St. Aubyn, February 2008.
- 865 “Explaining the Great Moderation: it is not the shocks” by D. Giannone, M. Lenza and L. Reichlin, February 2008.

ISSN 1561-0810



9 771561 081005