Great Moderation in Europe: Impulses or Propagation?*

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Preliminary:
Comments welcome

Abstract

Stock and Watson (2002) analyze the "great moderation" of U.S. They identify the break date around 1984, and conclude that the variance reduction is attributable to a smaller error variance, not to changes in the autoregressive coefficients. In this paper, we find a similar "great moderation" in European economic time series. We identify the break dates for main European countries around 1983. We also show that although both France and U.K were experiencing a similar volatility reduction in 1980s, however, the cause for this variance break are completely different. In France, most of the reductions in the variance of inflation and GDP growth are attributable to changes in the variance matrix of the structural shocks (the "impulses"), while in U.K, most of the reductions are attributable to changes in the structural VAR lag coefficients ("propagation").

Keywords: Great Moderation; Variance Reduction; Changes in Mean; Changes in Variance; Impulse; Propagation

1 Introduction

A lot of attention has been paid to the U.S "great moderation". "Great moderation" is generally characterized as "predictable policy, low inflation, and modest business cycles", and manifests itself in the form of broad decline in volatility across the economy.

Generally there are three explanations for this dramatic change:

- **Structural Change**: Changes in economic institutions, technology, business practices, or other structural features of the economy have improved the ability of the economy to absorb

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shocks. For example, McConnell and Perez-Quiros (2000) argue that improved management of business inventories, made possible by advances in computation and communication, has reduced the amplitude of fluctuations in inventory stocks, which in earlier decades played an important role in cyclical fluctuations. The increased depth and sophistication of financial markets, deregulation in many industries, the shift away from manufacturing toward services, and increased openness to trade and international capital flows are other examples of structural changes that may have increased macroeconomic flexibility and stability.

- **Improved Performance of Macroeconomic Policies**: Economists generally agree that monetary policy has played a large part in stabilizing inflation, and that output volatility has declined in parallel with inflation volatility, both in the United States and abroad, suggests that monetary policy may have helped moderate the variability of output as well. There are a number of studies examining the extent to which this change in monetary policy caused the reduction of the variance of output growth and/or inflation; see Boivin and Giannoni (2002), Clarida, Gali and Gertler (2000), Cogley and Sargent (2001), Gali, Lopez-Salido, Valles (2002), Primiceri (2003), and Sims and Zha (2006). This is a challenging task: to evaluate the effect of a change in the monetary policy rule, it is necessary to specify a model of the economy that is arguably invariant to the policy shift, that is, to specify a plausible structural model for the economy. The general strategy in this literature has been to combine some structural reasoning with VARs that permit the model to fit the dynamics in the data, but within this general framework the details of the approach differ widely.
- **Smaller Shocks**: The shocks hitting the economy became smaller and more infrequent. In other words, the reduction in macroeconomic volatility we have lately enjoyed is largely the result of good luck, not an intrinsically more stable economy or better policies. Several prominent studies using distinct empirical approaches have provided support for the good-luck hypothesis. (Ahmed, Levin, and Wilson, 2002; Stock and Watson, 2002)

Stock and Watson (2002) are among the first to analyze the "great moderation" of U.S. They identify the break date around 1984, and conclude that the variance reduction is attributable to a smaller error variance, not to changes in the autoregressive coefficients. In this paper, we apply a similar method to European economic time series.We identify the break dates for main European countries around 1983. We also perform the counterfactual policy evaluation calculations using a three-variable structural VAR with real GDP growth (Δy), CPI inflation rate (π), and the overnight interbank rate (i). Moreover, we show that although both France and U.K were experiencing a similar volatility reduction in 1980s, however, the cause for this variance break are completely different. In France, most of the reductions in the variance of inflation and GDP growth are attributable to changes in the variance matrix of the structural shocks, while in U.K, most of the reductions are attributable to changes in the structural VAR lag coefficients..

The rest of the paper is organized as follows. Section 2 documents the widespread reduction in volatility in the 1990s across European countries. In Section 3 we consider whether this decline is associated with a single distinct break and, if so, when the break occurred. We conduct the reduced form counterfactual VAR method in Section 4, analyzing the quantitative importance of changes in VAR forecast errors ("Changes in mean") versus changes in VAR coefficients ("Changes in variance"). We orthogolize the VAR innovations and conduct further analysis in Section 5. Section 6 concludes. In Section 7, we briefly discuss potential steps required.

2 Reductions in volatility across European countries

This section documents the volatility reduction in real GDP growth rate and inflation rate across European countries. We will focus on the two main economies: France and U.K. Other economies' performances are similar.

This reduction in volatility is evident in the plot of inflation and economic growth in Figure 1 to 2. Table 1 reports the sample standard deviation of real GDP growth rate and inflation rate by decade (2011-2013Q1 is included in the 2000s). Each decade's standard deviation is presented relative to the full-sample standard deviation, so a value less than one indicates a period of relatively low volatility. The GDP growth rate series in all countries were less volatile since the 1980s than over the full sample. The volatility of inflation rate series has been decreasing in U.K since the 1980s, and in France since the 1990s.

[Figure 1 about here.]

[Figure 2 about here.]

[Table 1 about here.]

The moderation in volatility is widespread and appears in both nominal and real series. For real GDP growth rate, volatility seems to have fallen distinctly around 1980. For inflation rate, volatility seems to have fallen around mid-1980s, but to draw this conclusion with confidence we need to apply some statistical tests to distinguish distinct breaks, a task taken up in the next section.

3 Dating the Great Moderation

The evidence in Section 2 points towards a widespread decline in volatility across European countries. In this section, we search for breaks in the variance using Inclan and Tiao (1994). We leave the problem to the next section whether this decline is associated with changes in VAR forecast errors ("Changes in mean") or changes in VAR coefficients ("Changes in variance").

Results for the variance break test are summarized in Table 2. The break dates are significant under 5% significance level.

[Table 2 about here.]

The test identifies 1967Q4 and 1968Q3 as two break dates for France real GDP growth. This is consistent with Figure 1. We can see a big dive and then a rebound in 1968. We believe this volatility increase is caused by May 1968 events in France, and it is just a huge temporary shock, rather than structural changes of the economy, considering the fact that the economy recovers very quickly, and the economic performance are very similar within five years before and after 1968.

Aside from the two break points (1968 and 2008), we are able to conclude the common break dates for the two series (Δy_t and π_t) across European countries from Table 2: 1979Q4 for Δy_t and 1983Q2 for π_t[1]. This estimated break date for Europe is consistent with estimated break dates for U.S reported by McConnell Perez-Quintos (2000), Kim, Nelson and Piger (2001), and Stock and Watson (2002).

4 Changes in Mean v.s Changes in Variance

The changes in the variance evident in Table 2 could arise from changes in the autoregressive coefficients (that is, changes in the conditional mean of the process, given its past values), changes in the innovation variance (that is, changes in the conditional variance), or both. Research on U.S Great Moderation has generally concluded that the changes in variance are associated with changes in conditional variances. This conclusion was reached by Blanchard and Simon (2001) for GDP and by Sensier and van Dijk (2001) using autoregressive models, and by Ahmed, Levin and Wilson (2002) using spectral methods. Kim and Nelson (1999) suggest that both the conditional mean and conditional variance of GDP changed, although Pagan (2000) argues that the changes in the conditional mean function are quantitatively minor. Cogley and Sargent (2002) focus on the inflation process and conclude that although most of the reduction in volatility is associated with reductions in the innovation variance, some seems to be associated with changes in the conditional mean. When it comes to European Great Moderation, we wonder whether this conclusion still hold. Specifically, in the context of reduced form VARs, is the observed reduction in volatility associated with a change in the magnitude of the VAR forecast errors, in the lag dynamics modeled by the VAR, or both?

Because the results of Section 3 point to dictinct break points 1979Q4 for Δy_t and 1983Q2 for π_t, in

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[1] We pick the medium date as the estimated break date.

this section we apply the counterfactual VAR method for break point T=1983Q2[2]. We use reduced-form VARs estimated over 1960 – T and T – 2013Q1 to estimate how much of the reduction in the variance of GDP is due to changes in the VAR coefficients and how much is due to changes in the innovation covariance matrix. Each VAR has the form,

$$X_t = \Phi_i(L)X_{t-1} + u_t \tag{1}$$

$$var(u_t) = \Sigma_i \tag{2}$$

where X_t is a vector time series and the subscript $i = 1, 2$ denotes the first and second subsample (the intercept is omitted in (1) for notational convenience but is included in the estimation). Let B_{ij} be the matrix of coefficients of the jth lag in the matrix lag polynomial $G_i(L) = [I - \Phi_i(L)L]^{-1}$. With this notation, the variance of the kth series in X_t in the ith period is,

$$var(X_{kt}) = \left(\sum_{j=0}^{\infty} G_{ij}\Sigma_i G'_{ij}\right)_{kk} = \sigma_k(\Phi_i, \Sigma_i)^2 \tag{3}$$

By evaluating the expression in (3) for different Φ and Σ, it is possible to compute the counterfactual variance of X_{kt} that would have arisen had either Φ or Σ taken on different values. For example $\sigma_k(\Phi_1, \Sigma_1)$ is the standard deviation of X_{kt} in period 1, and $\sigma_k(\Phi_2, \Sigma_1)$ is the standard deviation of X_{kt} that would have occurred had the lag dynamics been those of the second period and the error covariance matrix been that of the first period. Although these expressions are based on the population parameters, the various counterfactuals can be estimated by replacing the population parameters with sample estimators.

The results are summarized in Table 3 for France and Table 4 for U.K, which presents results for a VAR(3) model consisting of inflation rate, real GDP growth, and the overnight interbank rate. The first two columns provide the sample standard deviations of the various series, and the final four columns provide the VAR-based estimates of the standard deviations for the four possible permutations of estimated lag coefficients and covariance matrices. The columns labeled $\sigma(\hat{\Phi}_1, \hat{\Sigma}_1)$ and $\sigma(\hat{\Phi}_2, \hat{\Sigma}_2)$ respectively contain the VAR-based estimate of the first- and second-period sample standard deviations, which (as they should be) are quite close to the respective sample standard deviations. The columns labeled $\sigma(\hat{\Phi}_1, \hat{\Sigma}_2)$ and $\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$ contain the counterfactual estimates.

[Table 3 about here.]

[Table 4 about here.]

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[2] We choose T=1983Q2 rather than T=1979Q4 for convenience, because most countries' overnight rate data are not available in 1970s.

4.1 Changes in Variance: France

First consider the results for France. The counterfactual combination of secondperiod dynamics and first-period shocks (that is, $\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$) produces an estimated standard deviation of 0.83 for inflation, and 1.63 for GDP growth, essentially the same as the first period standard deviation. In contrast, the first-period dynamics and second-period shocks produce an estimated standard deviation of 0.59 for inflation, and 0.62 for GDP growth, essentially the same as the second period standard deviation. According to these estimates, had the shocks of the first period (1960-1983Q1) occurred in the second period (1983Q2-2013Q1), the second period would have been almost as volatile as the first period. Similarly, had the shocks of the second period occurred in the first period, the first period would have been almost as quiescent as the second period. In short, the changes in the covariance matrix of the unforecastable components of the VARs – changes in variance – account for virtually all of the reduction in the observed volatility of price and output.

The estimates in Table 3 suggest that most, if not all, of the reductions in the variance of inflation and GDP growth are attributable to changes in the covariance matrix of the reduced-form VAR innovations, not to changes in the VAR lag coefficients. These changes in reduced-form VAR innovations could arise either from reductions in the variance of certain structural shocks or from changes in how those shocks impact the economy, notably through the coefficient matrix that combines the structural shocks into reduced form innovations. To sort out these possibilities, however, we need to move beyond reduced-form data description and consider structural economic models, a task taken up in Section 5.

4.2 Changes in Mean: U.K

Next consider the results for U.K. The counterfactual combination of secondperiod dynamics and first-period shocks (that is, $\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$) produces an estimated standard deviation of 0.99 for inflation, and 0.80 for GDP growth, essentially the same as the second period standard deviation. In contrast, the first-period dynamics and second-period shocks produce an estimated standard deviation of 1.83 for inflation, and 1.56 for GDP growth, essentially the same as the first period standard deviation. According to these estimates, had the VAR coefficients of the first period (1960-1983Q1) occurred in the second period (1983Q2-2013Q1), the second period would have been almost as volatile as the first period, had the VAR coefficients of the second period occurred in the first period, the first period would have been almost as quiescent as the second period. In short, the changes in the autoregressive coefficients of the VARs – changes in mean – account for virtually all of the reduction in the observed volatility of price and output.

The estimates in Table 4 suggest that most, if not all, of the reductions in the variance of inflation and GDP growth are attributable to changes in the VAR lag coefficients, not to changes in the covariance matrix of the reduced-form VAR innovations.

4.3 Comparision: France versus U.K

Both France and U.K were experiencing a similar volatility reduction in 1980s, however, the cause for this variance break are completely different. We showed that in France, most of the reductions in the variance of inflation and GDP growth are attributable to changes in the covariance matrix of the reduced-form VAR innovations, while in U.K, most of the reductions are attributable to changes in the VAR lag coefficients.

5 Impulse versus Propagation

In this section, we orthogonalize the VAR innovations. That is, decompose the reduced-form VAR innovations into certain structural shocks and structural VAR coefficients. We consider three types of shocks: price shocks, productivity shocks and money shocks. This could help us better determine whether the observed reduction in volatility is attributable to a change in the variances of structural shocks (the "impulses"), to the lag dynamics modeled by the structural VAR system ("propagation"), or both. Each structural VAR has the form,

$$X_t = B_i X_t + \Psi_i(L) X_{t-1} + \nu_t \tag{4}$$

$$var(\nu_t) = D_i \tag{5}$$

where X_t and the subscript i are the same as in equations (1) and (2), D_i is a diagonal matrix, $\Phi_i(L) = (I - B_i)^{-1}\Psi_i(L)$, $u_t = (I - B_i)^{-1}\nu_t$ and $\Sigma_i = (I - B_i)^{-1} D_i (I - B_i')^{-1}$.

To identify this structural VAR, we assume that the diagonal elements of B_i are zero and B_i is lower-triangular, i.e., $(I - B)^{-1}$ is lower-triangular and the diagonal elements are all one. That is, private agents cannot make price or production decisions based on current realizatiom of monetary policy.

As in equation (3), we denote the variance of the kth series in X_t in the ith period is,

$$var(X_{kt}) = \sigma_k(B_i, \Psi_i, D_i) \tag{6}$$

Here, we decompose the covariance matrix Σ_i of the reduced form VAR innovation in equation (3) into the structural shocks variance matrix D_i and structural VAR coefficients B_i. Similarly to Section 4, we can estimate the counterfactual VARs, and check out whether the observed reduction in volatility is attributable to a change in the variances of structural shocks (the "impulses") D_i, to the lag dynamics modeled by the structural VAR system ("propagation")B_i and Ψ_i, or both.

The results are summarized in Table 5 for France and Table 6 for U.K, which presents results for a VAR(3) model consisting of inflation rate, real GDP growth, and the overnight interbank rate. The first two columns provide the sample standard deviations of the various series, and the final four columns provide the VAR-based estimates of the standard deviations for the four possible permutations of estimated lag coefficients and covariance matrices. The columns labeled $\sigma(\hat{B}_1, \hat{\Psi}_1, \hat{D}_1)$ and $\sigma(\hat{B}_2, \hat{\Psi}_2, \hat{D}_2)$ respectively contain the VAR-based estimate of the first- and second-period sample standard deviations, which (as they should be) are quite close to the respective sample standard deviations. The columns labeled $\sigma(\hat{B}_1, \hat{\Psi}_1, \hat{D}_2)$ and $\sigma(\hat{B}_2, \hat{\Psi}_2, \hat{D}_1)$ contain the counterfactual estimates. Note that Table 5 and Table 6 are different from Table 3 and Table 4 only in the the last two columns.

[Table 5 about here.]

[Table 6 about here.]

We can see that counterfactual estimates $\sigma(\hat{B}_1, \hat{\Psi}_1, \hat{D}_2)$ and $\sigma(\hat{B}_2, \hat{\Psi}_2, \hat{D}_1)$ in Table 5 and 6 are very close to $\sigma(\hat{\Phi}_1, \hat{\Sigma}_2)$ and $\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$ in Table 3 and 4, so we can further conclude:

1. For both France and U.K, B_1 and B_2 are very close. Most, if not all, of the reductions in the variance of inflation and GDP growth are attributable to changes in the structural VAR lag coefficients Ψ_i, or the variance matrix of the structural shocks D_i, not to changes in B_i.
2. Both France and U.K were experiencing a similar volatility reduction in 1980s, however, the cause for this variance break are completely different. In France, most of the reductions in the variance of inflation and GDP growth are attributable to changes in the variance matrix of the structural shocks D_i, while in U.K, most of the reductions are attributable to changes in the structural VAR lag coefficients Ψ_i.

6 Conclusion

Generally, there are three explanations for the “great moderation” – structural change, improved performance of macroeconomic performances, and smaller shocks. In this paper, however, we does not follow this category exactly. We divide the potential elements into two categories: smaller shocks (i.e., smaller variance of the structural shocks) and others (as captured by the structural VAR lag coefficients). Similar to Stock and Watson (2002), We find a “great moderation” in European economic time series. We identify the break dates for main European countries around 1983. Most importantly, we show that although both France and U.K were experiencing a similar volatility reduction in 1980s, however, the cause for this variance break are completely different. In France, most of the reductions in the variance of inflation and GDP growth are attributable to changes in the variance matrix of the structural shocks, i.e., France simply have had good luck; while in U.K, most of the reductions are attributable to changes in the structural VAR lag coefficients, i.e., U.K have experienced an economic structural change.

7 Potential Steps Required

The comparison of Table 3 v.s Table 4 and Table 5 v.s Table 6 are simply conducted by naked eyes. Although we believe it is enough obvious and straightforward to draw the conclusion, maybe it is better to draw the conclusion by conducting an econometric test.

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List of Figures

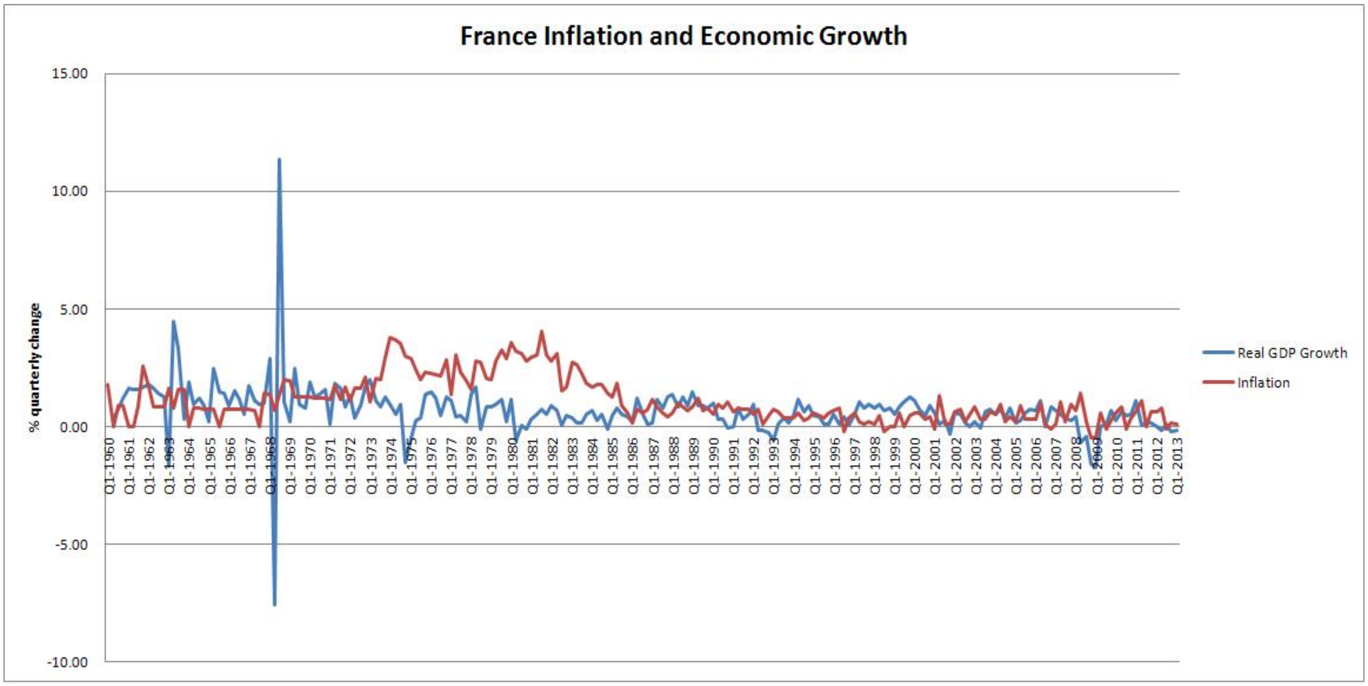

Figure 1: France Inflation and Economic Growth

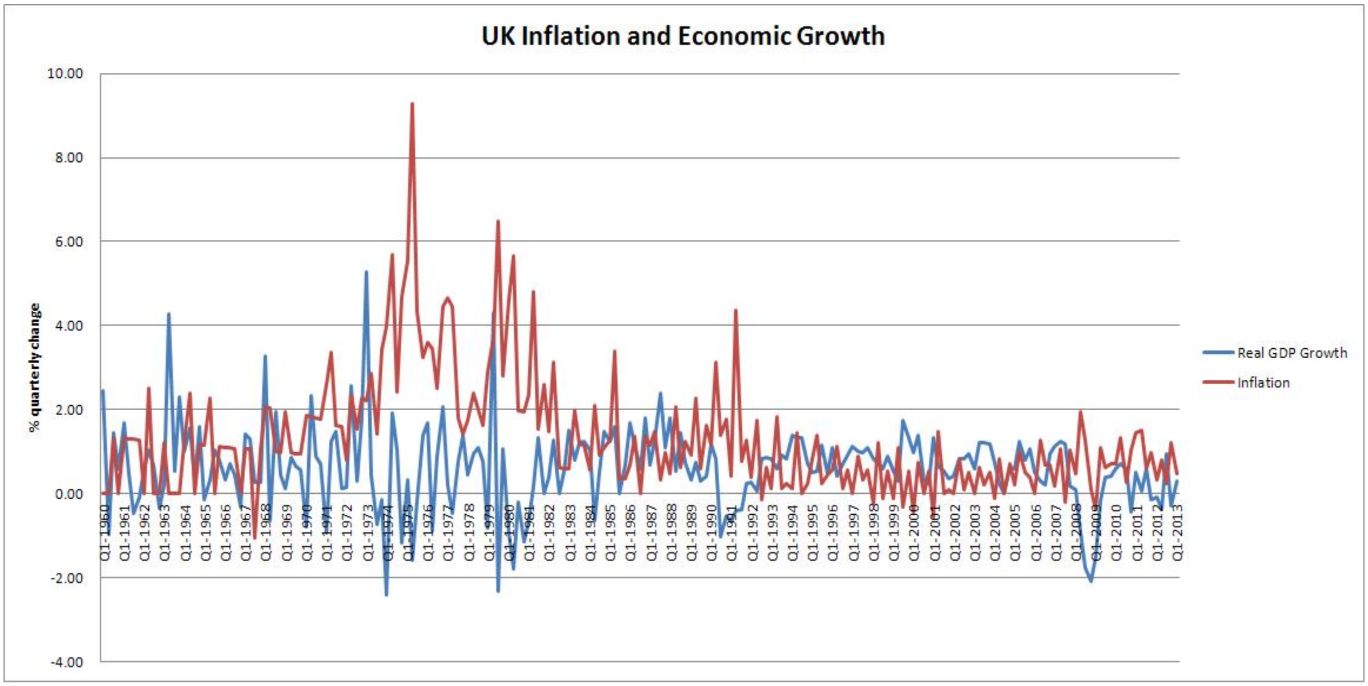

Figure 2: UK Inflation and Economic Growth

List of Tables

Table 1: Standard Deviations, by Decade, of Real GDP Growth Rate and Inflation Rate

Series	Standard Deviation 1960-2013Q1	Standard Deviation, relative to 1960-2013Q1				
		1960-1969	1970-1979	1980-1989	1990-1999	2000-2013Q1
GDP: France	1.182	1.99	0.58	0.38	0.36	0.46
GDP: U.K	0.991	1.03	1.52	0.88	0.59	0.74
inflation: France	0.955	0.62	0.79	1.09	0.31	0.43
inflation: U.K	1.403	0.57	1.18	0.89	0.65	0.39

Table 2: Variance Break Test

Series	break date
GDP: France	1967Q4 1968Q3 1979Q3
GDP: U.K	1980Q2
inflation: France	1973Q1 1983Q3 1991Q4
inflation: U.K	1973Q3 1982Q2

Table 3: France: Implied Standard Deviations from Subsample Reduced Form VARs

France Variable	Sample standard deviation		Standard deviation of the variables implied by the VAR			
	1960-1983Q1	1983Q2-2013Q1	$\sigma(\hat{\Phi}_1, \hat{\Sigma}_1)$	$\sigma(\hat{\Phi}_2, \hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_1, \hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$
Inflation	1.00	0.51	0.92	0.45	0.59	0.83
GDP growth	1.64	0.51	1.67	0.50	0.62	1.63
Overnight rate	3.72	3.58	3.56	3.24	1.97	9.15

Table 4: U.K: Implied Standard Deviations from Subsample Reduced Form VARs

U.K Variable	Sample standard deviation		Standard deviation of the variables implied by the VAR			
	1978-1983Q1	1983Q2-2013Q1	$\sigma(\hat{\Phi}_1, \hat{\Sigma}_1)$	$\sigma(\hat{\Phi}_2, \hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_1, \hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$
Inflation	1.57	0.76	1.84	0.71	1.83	0.99
GDP growth	1.36	0.70	1.53	0.70	1.56	0.80
Overnight rate	2.89	3.88	2.74	4.37	2.31	3.83

Table 5: France: Implied Standard Deviations from Subsample Structural Form VARs

France Variable	Sample standard deviation		Standard deviation of the variables implied by the VAR			
	1960-1983Q1	1983Q2-2013Q1	$\sigma(\hat{B}_1, \hat{\Psi}_1, \hat{D}_1)$	$\sigma(\hat{B}_2, \hat{\Psi}_2, \hat{D}_2)$	$\sigma(\hat{B}_1, \hat{\Psi}_1, \hat{D}_2)$	$\sigma(\hat{B}_2, \hat{\Psi}_2, \hat{D}_1)$
Inflation	1.00	0.51	0.92	0.45	0.60	0.84
GDP growth	1.64	0.51	1.67	0.50	0.63	1.62
Overnight rate	3.72	3.58	3.56	3.24	2.06	9.41

Table 6: U.K: Implied Standard Deviations from Subsample Structural Form VARs

U.K Variable	Sample standard deviation		Standard deviation of the variables implied by the VAR			
	1978-1983Q1	1983Q2-2013Q1	$\sigma(\hat{B}_1, \hat{\Psi}_1, \hat{D}_1)$	$\sigma(\hat{B}_2, \hat{\Psi}_2, \hat{D}_2)$	$\sigma(\hat{B}_1, \hat{\Psi}_1, \hat{D}_2)$	$\sigma(\hat{B}_2, \hat{\Psi}_2, \hat{D}_1)$
Inflation	1.57	0.76	1.84	0.71	1.92	0.95
GDP growth	1.36	0.70	1.53	0.70	1.66	0.84
Overnight rate	2.89	3.88	2.74	4.37	2.70	3.58