What explains changes in postwar output volatility: shocks or propagation mechanisms?

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Abstract

In this paper, we attempt a simple approach to identifying changes and the causes of changes in G7 output volatility in the postwar period. The key question we are trying to answer is whether changes in output volatility are due to changes in economic structure, as reflected in the propagation mechanisms, or due to changes in the pattern of shocks. Our approach is based on recent tests for multiple unknown break dates. We first apply these tests to real output data for a range of country aggregates. We then apply the tests to real output series simulated under the assumption that either structure or shocks have changed. By comparing the results of these tests, we are thus able to attribute the change in output volatility to structure or shocks. Initially, we assume that structure and shocks are specific to sub-samples, i.e. structural change occurs in discrete time. We then allow for structural change to be continuous, and use time-varying estimates of structure and shocks. These estimates are derived from two VARs, which are estimated with a simple time-varying coefficients method based on weighted least squares.

Summary

Your summary here, please.

1 Introduction

Several recent papers have sought to identify and interpret the decline in output volatility in the US, see for example McConnell and Perez-Quiros (2000), Blanchard and Simon (2001), Stock and Watson (2002) and Ahmed, Levin and Wilson (2002).(1) The core evidence presented in these papers can be summarised as follows. First, the best characterisation of the decline is a shift in volatility occurring at the beginning of the 1980s. Second, the decline in volatility appears to be common to most of the components of GDP. And third, in terms of the underlying causes, the evidence seems to point towards a lower variance of the shocks (or ‘good luck‘), although some evidence has also been produced for ‘good policies’, in particular better monetary policy. The latter aspect is probably the most interesting, and the one where further evidence would be useful for policy makers and those studying business cycle developments. Moreover, to complement the analysis provided for individual countries, there is a need for evidence on the global business cycle.

In this paper, we therefore identify changes in output volatility for several country aggregates, and present a simple approach to determining the underlying causes of changes in output volatility in the G7, using a postwar sample extending from 1970 Q1 to 2002 Q4.(2) The key question we are trying to answer is whether changes in G7 output volatility are due to changes in economic structure, as reflected in the propagation mechanisms, or due to changes in the pattern of shocks. Our approach to this question has two steps. The first step consists in identifying the periods in which output volatility has changed. For this we use recently developed tests for unknown breaks, applied to the innovation variance of real output series modelled as AR(1) processes. The second step in our approach consists in obtaining estimates of propagation mechinisms and shocks for different periods (including those identified in step one), and using these estimates to simulate output series under the assumption that structure or shocks have not changed. We then assess the volatility of the simulated output series, using once more the tests employed in step one. In this way, we will be able to assess whether the simulated output series have the same break dates as the observed output series, and to judge whether the change in output volatility observed in the actual data is accounted for by changes in structure or shocks.

We obtain the estimates of structure and shocks from two simple four-variable VARs. The first

(1) Extensive work has also been conducted recently on the UK, see Benati (2003).
(2) Recent evidence on the G7 countries can be found in Osborne, Sensier and Van Dijk (2002).

VAR is an extended version of a VAR first proposed by Gerlach and Smets (1995), which includes the oil price as an additional variable. It is identified with zero restrictions, which impose zero effects on the effects of some shocks in the initial period or in the long run (or both). The other VAR uses the same variables, but is based on sign restrictions, as initially suggested by Canova and De Nicolo (2002), Canova and De Nicolo (2003), Faust (1998) and Uhlig (1999). The advantage of these restrictions is that they are more general, and more intuitive when economic theory offers qualitative rather than quantitative predictions on the effects of shocks. Both VARs have been used in Peersman (2003), although similar variables have been used before, e.g. in Stock and Watson (2002).

Despite the relatively small number of variables, estimating these VARs would normally require a large number of observations. This poses a potential problem, especially when the interest is, as here, in sub samples or individual periods. In order to obtain estimates, we therefore use a variant of the weighted least squares estimation used to estimate the time-varying effects of global shocks in Labhard (2003). The basic idea behind this approach is that propagatin mechanisms and shocks can be captured by applying weighted least squares. Concretely, this means that in order to obtain sub-sample estimates, we attach a large weight to observations belonging to the sub-sample and a small weight to other observations. In other words, we obtain sub-sample estimates by ensuring a good fit for the sub-sample without throwing away the other observations, as would be the case in a traditional sub-sample analysis.

Our results indicate that for most aggregates there is only one break in actual output data. This break is in 1982 Q3 for the industrialised world, reflecting the end of the Volcker episode in the United States, and in 1993 Q1 for most aggregates of the European countries, corresponding to the widening of the bands in the exchange rate mechanism (ERM). When we use 1982 Q3 as the break date (we dubb this the discrete-time view of changes in output volatility), we find little evidence that differences in either structure or shocks between these two periods have impact on the break date. But when we adopt a continuous-time view, with structures and shocks specific to individual time periods, the evidence becomes clearer and points to an important role of the shocks, especially the shocks occurring in the early 1970s. When we simulate output under the assumption that those shocks had persisted, we find that real output would have had two breaks rather than one.

The remainder of this paper is structured as follows. In Section 2, we identify changes in output volatility, using recent tests for unknown multiple structural breaks. In Section 3, we present our approach to assessing the role of shocks and propagation mechanisms in driving changes in output volatility. We then present our results. In Section 4, we present the results using the dates identified by the tests, in Section 5 we extend the analysis by allowing for structural change to occur continuously.

2 Identifying changes in output volatility

In order to identify changes in output volatility, we adopt the tests for multiple unknown structural breaks developed by Andrews (1993), Andrews and Ploberger (1994), Bai (1997b) and Bai (1997a). These tests have been applied recently in a comprehensive study of evolving economic performance in the UK by Benati (2003).[3] The tests are based on a univariate AR(1) process for real output, such that

$$y_t = \mu + \sum \rho_p y_{t-p} + \varepsilon_t \qquad \textbf{(1)}$$

where y_t is real output.[4] The test consists in moving through the sample, and computing for each observation the exponential Wald test statistic

$$\exp W = \ln\left((N_2 - N_1 - 1)^{-1} \sum_{t=N_1}^{N_2} \exp\left(\frac{1}{2} W(t)\right)\right) \qquad \textbf{(2)}$$

where W is the standard Wald statistic. An observation for which the value of the test statistic exceeds the corresponding critical value is identified as a structural break. The procedure is then applied to the resulting sub-samples to identify further breaks, and so forth until no further break is found, subject to a minimum distance between the break dates of 15% of the sample. As pointed out in Benati (2003), the sequential identification of break dates has the advantage of being computational more efficient and more robust than estimating all breaks simultaneously. The break tests can be applied jointly or individually to the innovation variance ε_t (which captures volatility), the mean μ and the autocorrelation coefficient $\sum \rho_p$. In the following we focus on the tests on the innovation variance, considering both the individual and joint tests. However, it is worth pointing out that the individual test is based on the assumption of no break in the other parameters of the output process specified in **(1)**, and has low power.

Our results are reported in Table A. Looking first at the results of the joint test, the table shows

(3) We are grateful to Luca Benati for assisting with the code for these tests.
(4) The complete specification also includes seasonal dummies.

Table A: Estimated break dates for real output

Aggregate	Break in variance Estimate	Interval	Joint break in variance, mean and AC Estimate	Interval
W	82Q4	[73Q3, 92Q1]	82Q3	[72Q4, 92Q2]
G7	82Q4	[73Q4, 91Q4]	82Q3	[73Q1, 92Q1]
N3	83Q3	[75Q3, 91Q3]	82Q3	[74Q4, 90Q2]
E3	93Q2	[85Q2, 01Q2]	83Q1	[76Q3, 89Q3]
	-	-	92Q3	[90Q1, 95Q1]
E4	93Q2	[86Q3, 00Q1]	83Q1	[73Q4, 92Q2]
	-	-	92Q3	[90Q1, 95Q1]
EA	93Q2	[84Q4, 01Q4]	93Q1	[84Q4, 01Q2]
EM	93Q2	[86Q1, 00Q3]	93Q1	[86Q2, 99Q4]
EU	93Q2	[86Q1, 00Q3]	93Q1	[86Q2, 99Q4]
SU	93Q4	[87Q4, 99Q4]	76Q4	[72Q3, 81Q1]
	-	-	93Q3	[89Q1, 98Q1]

Notes: The table shows break date estimates and confidence intervals, based on the methodology described in Andrews (1993), Andrews and Ploberger (1994), Bai (1997b) and Bai (1997a). The sample period is 1970 Q1-2002 Q4. The aggregates are: W - 17 industrialised countries; N3 - Canada, Japan, US; E3 - France, Germany, Italy; E4 - E3 and UK; EA - euro area; EM - EA including the UK; SU - small EU countries: EU less France, Germany, Italy and the UK.

that there is one break in most of the output series. For the industrialised countries and the G7, the break date is 1982 Q3, reflecting the end of the Volcker episode in the United States. The break date is 1993 Q1 for most of the European countries, corresponding to the widening of the bands in the ERM.(5) For some of the smaller European aggregates we estimate two breaks, with the second break estimated for 1983 Q1. This is another date of significance in the ERM, marking the transition to the no-alignement period in the ERM.

Table A also shows the results for the test focussing on breaks in the innovation variance of the output process. The advantage of this test is that it identifies breaks based solely on the volatility aspect. However, the drawback is that the test is computed under the assumption that there are no breaks in the other parameters of the output process, i.e. it is assumed that mean and autocorrelation remain unchanged. The results of this test therefore have to be considered with caution, given that these assumptions are probably not justified, but the results tend to support the results of the joint test. For the industrialised countries as a group, the evidence again points to the second half of 1983, while for the aggregates involving European countries, the evidence is stronger for 1993. In fact, in all cases in which the joint test identified two breaks, the test on the innovation variance does not capture the break in 1982 and identifies only the break in 1993.

(5) This episode is analysed in Labhard and Wyplosz (1996).

Overall, our results suggest that the best characterisation for the output process is indeed one of a shift in volatility that has taken place in the early part of the 1980s decade.

Table B: Estimated break dates for inflation

	Break in variance		Joint break in variance, mean and AC	
Aggregate	Estimate	Interval	Estimate	Interval
W	80Q2	[77Q4, 82Q4]	75Q2	[67Q3, 83Q1]
	-	-	82Q4	[81Q2, 84Q2]
	-	-	93Q3	[92Q3, 94Q3]
G7	75Q2	[70Q2, 80Q2]	75Q2	[69Q1, 81Q3]
	-	-	80Q1	[78Q4, 81Q2]
	-	-	91Q1	[88Q4, 93Q2]
N3	75Q3	[70Q1, 81Q1]	75Q2	[68Q1, 82Q3]
	-	-	81Q4	[80Q3, 83Q1]
	-	-	91Q1	[88Q2, 93Q4]
E3	-	-	82Q3	[79Q4, 85Q2]
E4	81Q3	[77Q4, 85Q2]	82Q3	[80Q1, 85Q1]
	-	-	96Q3	[96Q2, 96Q4]
EA	-	-	85Q2	[83Q3, 87Q1]
	-	-	96Q3	[95Q4, 97Q2]
EM	81Q1	[77Q3, 84Q3]	82Q1	[79Q1, 95Q1]
	-	-	96Q3	[96Q2, 96Q4]
EU	-	-	82Q1	[79Q1, 85Q1]
	-	-	96Q3	[96Q2, 96Q4]
SU	-	-	80Q2	[78Q1, 82Q3]
	-	-	91Q3	[89Q2, 93Q4]

Notes: see Table A.

In Table B, we show the corresponding break dates for inflation. It is interesting to observe that in the case of inflation, the joint test indicates the existence of multiple breaks. One break is estimated for 1975 Q2, just after the end of the first big oil price shock. However, this is identified only for the broad aggregates including all countries or the G7. Two other breaks are identified for these aggregates as well as the European countries. One is identified in the early 1980s, broadly coinciding with the break identified in the output series. The other is identified in the early 1990s, between 1991 for the G7 (reflecting mostly the non-European countries) and 1996 for the European aggregates (although for the smaller countries it is also 1991).

Also for inflation, we test as well for a break only in the innovation variance, subject to the assumption that the other parameters of the univariate represenation of inflation have remained constant. These results are quite interesting, in that in most instances only one break is found, coinciding with the first break identified by the joint test, and in the other cases no break is found.

This provides some evidence that the main changes in inflation performance may have been a move to a low-inflation environment (i.e. a change in the mean) and an increase in inflation persistence (i.e. a change in the AR coefficients), rather than a shift in volatility. Given the low power of the tests though, we do not wish to overinterpret these findings.

3 A simple method to assess shocks and propagation mechanisms

In order to assess the impact of shocks and propagation mechanisms, we use two VARs, which permit to identify four major types of shocks: monetary policy shocks, oil price shocks, technology shocks and real demand shocks. Both VARs are based on the same variables: real GDP, the consumer expenditure deflator, the oil price, and the nominal short-term interest rate. Real GDP and consumer expenditure deflator are log-differenced, so as to induce stationarity. The oil price is also differenced, for the same reason, while the nominal interest rate appears in levels. We use these VARs due to their simplicity, and their choice is not central to the contribution of this paper. However, it should be acknowledged that there are known drawbacks from using these simple VARs.[(6)]

The first VAR is an extension of the VAR in Gerlach and Smets (1995). It is identified using zero restrictions, which are justified with reference to delays in the impact of monetary policy shocks, long-run neutrality, and a vertical long-run Philips curve. These restrictions are:

- monetary policy shocks, technology shocks and real demand shocks have a zero impact effect on oil prices, i.e. only oil price shocks affect oil prices on impact
- monetary policy shocks and real demand shocks have a zero long-run effect on real output, i.e. in the long run real output is driven only by oil price and technology shocks
- monetary policy shocks have a zero impact effect on output, so that technology and real demand shocks are the only shocks to affect real output on impact

The second VAR is identified using sign restrictions, which can be derived from the standard IS/LM AS/AD paradigm (see Peersman (2003) for the justification of these identifying

(6) One drawback is that the shocks identified in these simple VARs are highly aggregated - see the discussion of disaggregated supply shocks in Shapiro and Watson (1988) and disaggregated demand shocks in Gali (1992)).

assumptions).

- monetary policy shocks lead to a positive cross-correlation between the responses of output and prices
- oil price shocks lead to a negative cross-correlation between the responses of output and prices
- technology shocks lead to a negative cross-correlation between the responses of output and prices, but have a lesser impact on oil prices
- real demand shocks lead to a positive cross-correlation between the responses of output and prices

The key to what follows is to understand that the series entered in to the VAR are linked to the estimates of shocks and structures. Starting from the data series, the VAR provides estimates of both shocks and structure; starting from the estimates of the shocks and structure, the process can be reversed to retrieve the data series. While this is trivial when estimates of shocks and structure come from the same VAR (in which case the simulated series is simply the data series used in the VAR), it can produce interesting results when the estimates of shocks and structure come from different VARs, as in this case the resulting series is a counterfactual that can be interpreted economically. A simple example is a VAR estimated for two countries, say the UK and the US. In this case, one could simulate a UK output series using some or all of the coefficients estimated for the UK (i.e. the UK structure, or the UK policy rule etc) and the shocks estimated for the US. This could then be used to investigate whether the behaviour of UK output would have been different if the shocks the UK experienced had been the shocks experienced by the US.

In this paper, we apply a similar technique, but using estimates of shocks and structure obtained for different sample periods. In this way, we will be able to judge whether output volatility would have been different under the assumption that either structure or shocks had remained unchanged. In the next two sections, we explain how exactly these estimates are derived. Initially, in Section 4, we base our analysis on the break dates identified above, effectively assuming that changes in output volatility have occurred at discrete time intervals. In Section 5, we then extend this to the more general case in which changes in volatility are assumed to occur continuously. Section 6 concludes.

4 A discrete-time view of changes in output volatility

In this section, we use the results from the break tests discussed in the previous section, and so assume that there has been a structural break for the G7 in 1982 Q3. In the next section, we are going to relax this assumption, and analyse to whether the results are modified when we assume instead that structural change can occur continuously. We therefore need estimates of structure and shocks for the pre- and post-1982 Q3 periods. In order to obtain these estimates, we apply the time-varying coefficients approach used in Labhard (2003).

The basic idea behind this approach is that structure and shocks characteristic for a given time period can be estimated by ensuring the best fit for that particular observation. This idea is implemented by placing weights on the observations according to their distance (in time) from the observation for which the effect of the shock is estimated. Therefore observations close in time to the observation for which the effect is estimated have large weights, and observations that are farther away have lower weights. In other words, the approach consists in downweighting (or discounting) observations that due to their distance in time appear less relevant when estimating the effects of shocks in a particular period. Intuitively, the weighted least squares approach attempts to ensure the best fit for the period on which estimation is centred, while letting the fit worsen as observations become more remote from this period.

Although this approach is most powerful when structural breaks are continuous (see the next section), it can also be used when they occur at discrete time intervals. In this section, we therefore use large weights on observations within the sub-sample and small (but non-zero) weights on observations outside the sub-sample. This is very similar to traditional sub-sample analysis, but has the advantage of using the full sample and hence avoiding short sample constraints. As a result, we obtain sets of estimates for structure and shocks, one each for the pre- and post-1982 Q3 periods. We can then use these estimates to construct (counterfactual) output series, and subject these series to the break tests used Section 2 (for the results see Table C).

Specifically, we first take the structure estimated for the full sample and, alternatively, the shocks from the pre- and post-1982Q3 samples. In the first case, with pre-1983Q2 shocks, the joint test indicates that the break date has shifted forward to 1984Q1, by three quarters, while in the second case, with post-1982Q3 shocks, it remains unchanged. The confidence interval is slightly narrower

Table C: Estimated break dates for real output (varying shocks or structure)

	Structure	Shocks	Break in variance		Joint break in variance, mean and AC	
G7			Estimate	Interval	Estimate	Interval
Actual						
	Full sample	Full sample	82Q4	[73Q4, 91Q4]	82Q3	[73Q1, 92Q1]
Simulated						
	Full sample	Pre-82Q3	82Q4	[73Q1, 92Q3]	84Q1	[74Q1, 94Q1]
	Full sample	Post-83Q3	83Q2	[75Q1, 91Q3]	82Q3	[73Q4, 91Q2]
	Pre-82Q3	Pre-82Q3	82Q4	[73Q4, 91Q4]	82Q3	[73Q1, 92Q1]
	Pre-82Q3	Post-83Q3	83Q2	[75Q3, 91Q1]	83Q1	[75Q1, 91Q1]
	Post-83Q3	Pre-82Q3	84Q2	[73Q2, 95Q2]	82Q4	[74Q4, 90Q4]
			-	-	90Q2	[87Q2, 93Q2]
	Post-83Q3	Post-83Q3	82Q4	[73Q4, 91Q4]	82Q3	[73Q1, 92Q1]
	Pre-82Q3	Full sample	83Q2	[74Q4, 91Q4]	82Q3	[73Q4, 91Q2]
	Post-83Q3	Full sample	82Q4	[72Q4, 92Q4]	84Q1	[73Q4, 94Q2]

Notes: The table shows break date estimates and confidence intervals, based on the methodology described in Andrews (1993), Andrews and Ploberger (1994), Bai (1997b) and Bai (1997a). The simulated series are obtained by using structure and shocks for the periods indicated in the table. The sample period is 1970 Q1-2002 Q4.

in the second case, suggesting that this break is more precisely estimated than the one identified in the first case. This is only weak evidence that the break date is not robust to changes the shocks. Moreover, when we reverse the procedure and use the shocks estimated for the full sample in combination with the pre- and post-1982Q3 structure, we find very similar results, so that overall no clear conclusion emerges form this analysis on the role of structures and shocks. As a further check, we also use the estimates for the pre- and post-1982Q3 periods.(7) Again, the evidence is mixed. While in one case changing the shocks makes the difference between identifying one or two breaks, changing the structure tends to shift the break date by a couple of quarters. However, all the results obtained here to some extent simply reflect the fact that the estimates of structure and shocks used to construct the output series still reflect time averages, given the working hypothesis that breaks occur only at discrete time intervals. In the next section, we therefore simulate output series based on estimates of structure and shocks for each period in the sample, thus effectively allowing continuous change in the parameters governing the output process.

(7) Stock and Watson (2002) and Ahmed *et al.* (2002) have presented a similar analysis for the US. However, while their analysis allows for the simulated output series to be driven by the differences in the standard deviation of the shocks across sub-samples, our approach mainatins the unit variance assumption for each estimation, so that differences in the simulated output series are due solely to the change in the time profile of the shocks.

5 A continuous-time view of changes in output volatility

In this section, we exploit the full potential of the technique developed in Labhard (2003) by allowing for continuous breaks in the output process, using estimates of structure and shocks for each period in the sample. As we will see, this makes it more likely to find changes in the break dates, because the estimates of structure and shocks are specific to individual time series and do not rely on any averaging at all. As in the previous section, we first consider the behaviour of output series simulated under the assumption that structure had remained the same throughout, and varying the shocks (the structure we use is again that estimated for the full sample). This provides a total of 132 output series, compared with two series in the previous section, and hence a much better picture of how varying the shocks affects output volatility. We then obtain another 132 output series by varying the structure, and assuming the shocks had been the same throughout (again, we use the full-sample shocks for this purpose).

5.1 Are changes in output volatility caused by shocks?

Table D presents the results for output series obtained by varying the shocks. Each row in the table shows the estimate and corresponding confidence interval for those samples for which the break date identified by both the joint test and the test on innovation variance remains the same.(8) The results are quite interesting. First, starting with the results of the joint test and using the series based on linear weights, we find that for the shocks up to 1972 Q4, i.e. including the first big oil price shocks, the joint test reveals two breaks in the output series. The first break is in 1982 Q4, only one quarter after the date also identified in the actual output series, and the second one is in 1989 Q2. By contrast, for the shocks from 1973 Q1 onwards, the test indicates only one break, either in the same period or one quarter after the date identified in Section 2. A similar picture emerges from the results using series based on normally-distributed weights. Two breaks are identified for the early shocks (although in this case these are shocks up to 1982 Q3), and while the first break falls on the same date (one quarter after the break in the actual data), the second break occurs a year later, in 1990 Q2. For the other shocks (i.e. all shocks from 1982 Q4 onwards), the break data in the simulated output series coincides with the break date in the actual data.

(8) The confidence intervals change more frequently than the estimate of the break date, but for ease of exposition, we do not show these intervals individually, but instead report the minimum lower and maximum upper boundary for a given estimate of the break date.

Our interpretation of these results is as follows. Using the shocks in the latter part produces output series which have the same break date as the actual series, and hence do not appear to make a difference for output volatility. However, using shocks from the early part of the sample makes a difference. More specifically, had the early shocks persisted, we would have seen a second break in output volatility. This is a result that also obtains for both weighting patterns using the test on the innovation variance only, and hence appears to be robust. Given the difference between the results based on linear and normally-distributed weights, there is some question as to when the nature of shocks has changed, but the message from this set of results is that shocks matter, especially those in the early 1970s. The next question is whether there is similar evidence for the role of economic structure.

Table D: Estimated break dates for real output (varying the shocks)

	Structure	Shocks	Break in variance		Joint break in variance, mean and AC	
G7			Estimate	Interval	Estimate	Interval
Actual						
	Full sample	Full sample	82Q4	[73Q4, 91Q4]	82Q3	[73Q1, 92Q1]
Simulated with linear weights						
	Full sample	70Q1, .., 72Q4 (12)	82Q4	[73Q2, 92Q2]	82Q4	[76Q3, 89Q1]
			-	-	89Q2	[86Q3, 92Q1]
	Full sample	73Q1, .., 87Q4 (60)	"	"	82Q3	[72Q4, 92Q2]
	Full sample	88Q1, .., 95Q2 (30)	83Q2	[74Q2, 92Q2]	"	"
	Full sample	95Q3, .., 97Q4 (10)	"	"	83Q1	[74Q1, 92Q1]
	Full sample	98Q1, .., 02Q4 (20)	82Q4	[74Q2, 91Q2]	"	"
Simulated with normally-distributed weights						
	Full sample	70Q1, .., 71Q1 (5)	83Q3	[74Q1, 93Q1]	82Q4	[73Q4, 91Q4]
			-	-	90Q2	[88Q1, 92Q3]
	Full sample	71Q2, .., 78Q1 (28)	82Q4	[72Q4, 92Q4]	"	"
	Full sample	78Q2, .., 82Q3 (18)	"	"	82Q4	[76Q2, 89Q2]
					89Q2	[86Q3, 92Q1]
	Full sample	82Q4, .., 87Q3 (20)	"	"	82Q3	[73Q1, 92Q1]
	Full sample	87Q4, .., 02Q4 (61)	83Q2	[74Q3, 92Q1]	"	"

Notes: The table shows break date estimates and confidence intervals (minimum lower and maximum upper), based on the methodology described in Andrews (1993), Andrews and Ploberger (1994), Bai (1997b) and Bai (1997a). The simulated series are obtained by using structure and shocks for the periods indicated in the table. The sample period is 1970 Q1-2002 Q4.

5.2 Are changes in output volatility caused by propagation mechanisms?

In this section, we explore the counterfactual output series simulated under the (reverse) assumption that the shocks had remained unchanged and the propagation mechanisms of the shocks changing continuously over time. The results of the break tests for these series are provided in Table E. Again, the results are quite interesting. First, using the assumption of the same shocks, the break tests never find more than one break. Moreover, this finding is robust to the choice of weights. Second, all the break dates identified fall within three quarters of the break date identified in real data, even though the confidence intervals are wider for some of the simulated series than for the actual series. We interpret this as evidence that variance in structure has not affected the behaviour of output, at least not as much as variance in the shocks. Moreover, the break dates identified by the joint test and the test on the innovation variance are within one or two quarter of each other, providing further evidence for the interpretation of the break date in terms of a one-time shift in volatility.

Table E: Estimated break dates for real output (varying the structure)

	Structure	Shocks	Break in variance		Joint break in variance, mean and AC	
G7			Estimate	Interval	Estimate	Interval
Actual						
	Full sample	Full sample	82Q4	[73Q4, 91Q4]	82Q3	[73Q1, 92Q1]
Simulated with linear weights						
	70Q1, .., 74Q1 (17)	Full sample	82Q4	[74Q2, 91Q2]	83Q1	[74Q1, 92Q1]
	74Q2, .., 74Q3 (1)		83Q2	[74Q3, 92Q1]	"	"
	74Q3, .., 74Q4 (1)		82Q4	[72Q4, 92Q4]	"	"
	75Q1, .., 02Q4 (113)		"	"	82Q3	[72Q2, 92Q4]
Simulated with normally-distributed weights						
	70Q1, .., 75Q4 (24)	Full sample	82Q4	[74Q3, 91Q1]	83Q1	[74Q1, 92Q1]
	76Q1, .., 79Q2 (14)	Full sample	83Q2	[74Q4, 91Q4]	"	"
	79Q3, .., 82Q1 (11)	Full sample	82Q4	[71Q1, 94Q3]	"	"
	82Q2, .., 97Q2 (61)	Full sample	"	"	82Q3	[71Q2, 93Q4]
	97Q3, .., 99Q2 (8)	Full sample	"	"	81Q4	[70Q2, 93Q2]
	99Q3, .., 00Q4 (6)	Full sample	82Q2	[70Q4, 93Q4]	"	"
	01Q1, .., 02Q4 (8)	Full sample	82Q1	[70Q4, 93Q2]	"	"

Notes: Table shows break date estimates and confidence intervals (minimum lower and maximum upper), based on the methodology described in Andrews (1993), Andrews and Ploberger (1994), Bai (1997b) and Bai (1997a). The simulated series are obtained by using structure and shocks for the periods indicated in the table. The sample period is 1970 Q1-2002 Q4.

In summary, the evidence presented in this and the previous section suggests that changes in output volatility are less likley caused by changes in structures. Creating a counterfactual under the assumption that the shocks had been the same throughout the sample leads to output series which have the same number of breaks, and at about the same dates, as the actual data. By contrast, simulating output under the assumption that shocks had changed constantly over the sample period, we find that different break dates are identified, and sometimes additional breaks. The latter result suggests that the volatility of output would have changed more frequently than it has in actual fact, and leads us to the conclusion that shocks matter, especially those in the early part of the sample. However, all of our simulated output series have at least one break, in the vicinity of 1982 Q3. In other words, there seems to be no combination of structures and shocks yielding an output series with constant parameters over the postwar sample.

This may be a surprising, but we can think of several possible explanations for this finding. First, and perhaps most importantly, we have based our analysis of the role of economic structure on all the reduced-form relationships in the VARs. A useful extension of our work would be to consider these relationships individually, e.g. the VAR's interest rate rule as a measure of the role of changes in monetary policy. This might create another interesting link to some of the work carried out on the US. But the there are also much more simple explanations for the existence of at least one break in all our simulated output series. One such explanation is that in most of our analysis we have used full-sample structure and shocks for the simulations. Another option, which may yield a different result, would be to use the structure estimated for a specific observations in the sample, e.g. the first or last observation.

6 Conclusions

In this paper, we present a simple approach to identifying changes and the causes of changes in G7 output volatility in the postwar period. We use recent test for multilpe unknown structural breaks, first to identify and characterise changes in the behaviour of output in the G7, and then to assess whether the behaviour is different for G7 output series simulated under the assumption that economic structure, as reflected in the propagation mechanisms, or shocks have remained unchanged. Initially, we assume that structure and shocks are specific to sub-samples, i.e. structural change occurs in discrete time. We then allow for structural change to be continuous, and use time-varying estimates of structure and shocks. The estimates of structure and shocks are derived from two VARs, which are estimated with a simple time-varying coefficients method based on weighted least squares.

Our results suggest that there has been a shift in G7 output volatility in the early part of the 1980s, supporting the evidence produced by several studies on the US. In terms of the causes for the shift in output volatility, our findings indicate that changes in the shocks, especially between the early 1970s and the rest of the sample, may account for the observed behaviour of G7 output. By contrast, we find little indication that changes in structure, as captured by the reduced-form relationships in the VAR, have had an impact on G7 output. Subject to some caveats pointed out in the paper, this provides additional evidence for the 'good luck' interpretation of the decline in output volatility observed since the 1980s.

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