Searching for the sources of stabilisation in output growth areas: evidence from the G-7 economies

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SEARCHING FOR THE SOURCES OF STABILISATION IN OUTPUT GROWTH RATES: EVIDENCE FROM THE G-7 ECONOMIES

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1. Introduction

In his influential paper, "A new approach to the economic analysis of nonstationary time series and the business cycle", Hamilton (1989) proposed a regime switching model in which output growth switches between two different states according to a first order Markov process. Applying this model to the U.S., he showed that shifts between positive and negative output growth accord well with the NBER's chronology of business cycle peaks and troughs.

In the wake of this paper, a large number of researchers have explored various aspects of the business cycle, such as asymmetry and the duration of economic fluctuations, using the framework of the Markov switching model. Lam (1990), Sichel (1993), Durland and McCurdy (1994), Kim (1994), and Kim and Nelson (1998, 1999a, 1999b) are examples of papers that have further analysed U.S. output. Simpson, Osborn and Sensier (1999) have modelled U.K. data, while Goodwin (1993) and Mills and Wang (2000) have analysed output from the G-7 countries.

McConnell and Quiros (1999) have recently documented a structural break in the volatility of U.S. output growth, finding a rather dramatic reduction in output volatility in the most recent two decades relative to the previous three decades. Using yet a further extension of the Markov switching model, Kim and Nelson (1999b) propose a model that includes a separate state variable to capture an unknown structural break point. They use this model to investigate further the sources of stabilisation in recent U.S. output, focusing on both the decline in volatility and on the narrowing gap between mean growth rates during recessions and expansions. They find that both sources of stabilisation have a role to play, but with stronger evidence in favour of a narrowing gap between growth rates during expansions and recessions.

Within the context of searching for structural change, our main objective in this paper is to answer the important question of whether this observed stabilisation in output is unique to the U.S. We thus adopt the Kim and Nelson (1999b) model to extend the empirical analysis to the G-7 countries and to present cross-country comparisons.

2. A Markov Chain Model for Output Containing a Structural Break

We follow Kim and Nelson's (1999b) model specification to estimate the date of a structural break in the output growth process. Based on the Markov switching model, this specification defines a separate state variable, D_t, which also undergoes regime switching according to a first-order Markov process. Thus consider the following Markov switching model with a structural break in the hyperparameters:

$$\Phi(L)(y_t - m^*_{s_t}) = e_t, \qquad e_t \sim i.i.d.N(0, s^2_t) \tag{1}$$
$$m^*_{s_t} = m^*_{0t}(1 - S_t) + m^*_{1t} S_t,$$
$$m^*_{0t} < m^*_{1t}.$$

Here y_t is the output growth rate and m^*_{0t} and m^*_{1t} are the expected values of the growth rate during recessions and expansions, respectively. The roots of $\Phi(L) = 0$ are assumed to all lie outside the complex unit circle, and S_t is an unobserved indicator variable that evolves according to a first-order Markov-switching process as in Hamilton (1989).

$$P[S_t = i \mid S_{t-1} = i] = p_{ii}$$
$$P[S_t = j \mid S_{t-1} = i] = 1 - p_{ii}$$
$$0 < p_{ii} < 1, \quad i, j = 0,1$$

We consider the possibility that the two shift parameters, m^*_{0t} and m^*_{1t}, as well as the variance of the white noise innovation e_t, s^2_t, are subject to a one-time structural break with unknown change-point t. To incorporate this possibility, these parameters are specified as follows:

$$m^*_{0t} = m_0 + m_{00} D_t,$$
$$m^*_{1t} = m_1 + m_{11} D_t,$$

$$s^2_t = (1 - D_t) s^2_0 + D_t s^2_1,$$

where

$$D_t = \begin{cases} 0 \text{ for } 1 \le t \le t \\ 1 \text{ for } t < t \le T \end{cases},$$

and where D_t is independent of S_t.

Like the latent variable S_t that determines the recurrent business cycle phases, the ‘structural shift’ variable D_t can also be modelled as a two-state Markov process, as suggested by Chib (1998) and employed by Kim and Nelson (1999b). This is done by appropriately constraining the transition probabilities so that we have a one-time permanent shift from $D_t = 0$ to $D_{t+1} = 1$ at an unknown breakpoint t. To ensure this, the transition probabilities should be constrained so that, conditional on $D_t = 0$, there always exists a nonzero probability that D_{t+1} may be 1 but, conditional on $D_{t+1} = 1$, the probability that $D_{t+2} = 0$ should always be 0, so that we have $D_t = 1$ for

$t \geq t+1$. The following specification for the transition probabilities achieves this goal:

$$P[D_t = i \mid D_{t-1} = i] = q_{ii},$$
$$P[D_t = j \mid D_{t-1} = i] = 1 - q_{ii}, \qquad i, j = 0,1$$
$$0 < q_{00} < 1 \qquad q_{11} = 1$$

where the expected duration of $D_t = 0$, i.e., the expected duration of a regime before a structural break occurs, is given by $E(t) = 1/(1 - q_{00})$.

Under the null hypothesis that there is no structural break in y_t, we have $m_{00} = m_{11} = 0$ and $s_0^2 = s_1^2$, and the above model collapses to the benchmark Hamilton model of the business cycle. To investigate the nature of a potential structural break, we empirically compare four models. They are as follows.

Model I: A benchmark Markov switching model with no structural break

$$m_{00} = m_{11} = 0,\ s_0^2 = s_1^2$$

Model II: A model with a structural break in both the mean and the variance

$$m_{00} \neq 0,\ m_{11} \neq 0,\ s_0^2 \neq s_1^2$$

Model III: A model with a structural break just in the mean

$$m_{00} \neq 0,\ m_{11} \neq 0,\ s_0^2 = s_1^2$$

Model IV: A model with a structural break just in the variance

$$m_{00} = m_{11} = 0,\ s_0^2 \neq s_1^2$$

Wherever necessary, we also test the individual restrictions that $m_{00} = 0$ or $m_{11} = 0$, which we indicate by Model V.

Estimation of the model may either be carried out by maximum likelihood through a straightforward extension of Hamilton's (1989) algorithm, or by using Bayesian techniques that employ Gibbs sampling (see Kim and Nelson, 1999b). While the Bayesian approach has some advantages, maximum likelihood remains a useful and convenient technique in this particular case and is used here.

3. Fitting the Markov Chain Structural Break Model to G-7 Output Data

We analyse the first differences of the logarithms of quarterly real GDP, multiplied by 100, for the G-7 countries, and refer to these series as output growth. All of the data come from Datastream, which in turn takes the data from different sources. The sample periods used for estimation are as follows (see Figures 1 to 7): Canada, 1960:1 – 2000:2; France, 1970:1 – 1999:4; Germany, 1961:1 – 1999:4; Italy, 1971:1 – 1999:4; Japan, 1955:2 – 1999:4; U.K., 1964:1 - 2000:2; U.S., 1955:1 – 2000:3.

Tables 1 to 7 report the results of this exercise for an AR(1) specification for output growth, i.e., $\Phi(L) = 1 - \Phi_1 L$ in (1). Figures 1 to 7 plot each of the observed output growth series, along with the estimated conditional probabilities that, given knowledge of the model, the series undergoes a structural break at time *t*, i.e., $P(D_t = 1 | y_t, \hat{\Theta})$, where $\hat{\Theta}$ is the vector of estimated model parameters. There are several general points worth noting. First, for every country a comparison of likelihood values shows that the benchmark Hamilton model is clearly dominated by models containing a structural break. (Standard likelihood ratio tests calculated as twice the difference in log likelihoods and distributed as chi-squared, with degrees of freedom given by the number of restrictions imposed, may easily be constructed to formally confirm this statement and others made below). Second, the break is always significant, with the transition probability q_{00} always being in excess of 0.93. Third, as shown in Figures 1 to 7, the breakpoint dates are coincident with observed shifts in the output growth processes. In every case except France, there is a sizeable decrease in the volatility of fluctuations of output growth - the innovation variances decline by factors of usually between three and ten - thus suggesting that the G-7 economies have indeed become more stable. A narrower gap between the mean growth rates during expansions and recessions is also found in some countries, but the evidence is not as strong as it is for the decline in volatility.

Looking now at the individual country results, consider first Table 1 for the U.S. The models that allow for a break in variance (II and IV) are clearly preferred to the model containing just a break in mean (III). However, m_{00} is clearly significant but m_{11} is not, thus leading to the restricted model V, which is our preferred specification. The estimates for model V suggest that, before the break, the mean growth rate is $m_1 = 0.81$ per cent per quarter during expansions and $m_0 = -0.78$ per cent during recessions, i.e., almost identical in size. After the break, the mean expansion growth rate remains at 0.81 per cent, but the recession growth rate (or, perhaps more appropriately, the 'low growth' regime) is increased to $m_0 + m_{00} = 0.15$ per cent. The decrease in innovation variance is also sizeable, falling from 0.75 to 0.17. Consequently, our findings are consistent with Kim and Nelson's (1999b) in that there has been a structural break in the U.S. economy, which has moved in the direction of greater stabilisation, with a narrowing gap between the mean growth rates during expansions and recessions and a decline in volatility. Figure 1 dates the structural breakpoint at around 1984, which coincides with the observed shift in the volatility of output growth. The variance of output fluctuations during the period ending in 1983 is about four times as large as the variance for the period since 1984, which is consistent with that reported by Kim and Nelson (1999b) and McConnell and Quiros (1999).

Turning now to the U.K. results in Table 2, we again see that the 'break in variance' models (II and IV) are preferred to the 'break in mean' model (III). Both mean shift parameters are insignificant ($m_{00} = m_{11} = 0$), so attention is focused on model IV. Before the break, mean growth is $m_1 = 0.63$ per cent (equivalent to approximately 2.5 per cent per annum) during expansions and $m_0 = -0.82$ percent during recessions. Since both m_{11} and m_{00} are not statistically significant from zero, this suggests that there has been no narrowing of output growth in expansions and recessions during the whole sample period. This is an interesting finding in that it provides no evidence in favour of the popular view that trend growth has increased in recent years. However, there does appear to have been a major shift in the innovation variance, which declines by a factor of 10 after the break. Figure 2 shows that the structural break occurs around 1993, presumably as a result of the departure in October 1992 of the U.K. from the European exchange rate mechanism.

Tables 3-7 report estimates for the other G-7 countries, and provide us with a variety of processes for output growth rates. The results for Canada (with Model V preferred) show that, before the break, mean output growth was 1.22 per cent during expansions and –1.14 per cent during recessions. After the break, mean growth slows to 0.62 per cent in expansions, while mean growth in recessions remains the same, since the parameter m_{00} is not statistically significant. The decrease in the variance is significant, however, falling to a third of its pre-break level. It would thus seem that the stabilisation of output growth has been achieved at the expense of a slowdown in growth during expansions. Figure 3 shows that the break occurred in the late 1970s, when the Canadian economy was effected by shifts in international trade patterns and by labour market rigidities caused by provincial disparities and structural differences.

Unlike the other countries in our sample, where mean growth is positive in expansions but negative in recessions, the estimates for Germany reported in Table 4 show that mean growth is always positive, irrespective of regime. In this case, Model IV is preferred, so there is no structural break in mean, with m_{11} and m_{00} being insignificantly different from zero. Mean growth is thus estimated to be 1.49 per cent during expansions and 0.34 per cent during 'recessions'. However, there is a shift in volatility, which falls from 3.10 to 0.81. Figure 4 suggests that the break date is around 1974, and the decline in volatility after this date can clearly be observed. This timing is consistent with the floating of the deutschmark in 1973 and the subsequent adoption by the Bundesbank of a tight non-accommodating monetary policy. These changes ended a period of instability in which there were significant changes in work practices and a subsequent loss of discipline by both unions and employers associations, manifesting itself in wild-cat strikes (see Carlin, 1996).

For Italy, model V is preferred with $m_{00} = 0$ and, before the break, mean growth rates of 0.78 and –0.28 per cent during expansions and recessions respectively. After the break, mean growth slows to 0.40 per cent during expansions but remains the same during recessions. There is a significant decline in volatility after the break, with s_0^2 being three times the size of s_1^2. Thus, as with Canada, stabilisation is achieved at the expense of lower expansionary growth rate. Figure 5 shows that the break date is around 1982. This corresponds with Italy moving away from a period characterised by a succession of weak government coalitions and waves of terrorism to an economy committed to exchange rate stability, industrial restructuring and improved labour relations (see Rossi and Toniolo, 1996).

Model III is preferred for France. Before the break, mean growth is 1.25 per cent and -1.17 per cent during expansions and recessions respectively. Both m_{11} and m_{00} are significant, so that mean growth falls to 0.51 per cent during expansions but increases to -0.20 per cent during recessions. Although there is a decline in the variance after the break, this decline is not statistically significant (compare the log likelihoods for Models II and III), suggesting that, although cyclical growth rates have narrowed, there has been only a modest gain, at best, in volatility stabilisation. Figure 6 shows that the break date is around 1979, about the time that France suffered a succession of exchange rate crises. These eventually led to a major shift in macroeconomic policy by the Mitterand administration, which then followed more market-oriented policies to produce a more stable growth path (Sicsic and Wyplosz, 1996)

The data from Japan provides a similar story. The estimated parameters in the preferred Model II suggest that, before the structural break, mean growth is 2.25 per cent during expansions and –3.32 per cent during recessions. After the break, however, mean growth reduces to 0.95 per cent in expansions and increases to -0.34 per cent during recessions. The innovation variance is also reduced from 1.70 to 0.53, about a third of that before the break. Figure 7 suggests that the break date is around 1976, which thus signifies the end of the period of rapid growth accompanying post-war reconstruction. However, it may be argued that a second break, at around 1990 (the time of the Tokyo stock market crash, which ushered in a decade of very low growth), is required to model this series effectively.

Table 1: Estimated Models for the U.S.

	I	II	III	IV	V
Parameters	Benchmark	Break in both mean and variance	Break in mean	Break in variance	Restricted
m_1	0.785	0.950	0.937	0.811	0.807
	(0.084)	(0.147)	(0.245)	(0.140)	(0.104)
m_0	-1.022	-0.798	-1.099	0.237	-0.777
	(0.274)	(0.372)	(1.035)	(0.158)	(0.458)
m_{11}		-0.206	-0.190		
		(0.132)	(0.257)		
m_{00}		0.911	0.218		0.925
		(0.374)	(1.399)		(0.447)
Φ_1	0.272	0.273	0.271	0.318	0.284
	(0.062)	(0.076)	(0.067)	(0.070)	(0.076)
s_0^2	0.528	0.668	0.515	1.062	0.747
	(0.066)	(0.112)	(0.060)	(0.157)	(0.122)
s_1^2		0.171		0.163	0.168
		(0.056)		(0.051)	(0.058)
p_{11}	0.962	0.930	0.959	0.919	0.908
p_{00}	0.638	0.722	0.729	0.880	0.757
q_{00}		0.991	0.985	0.990	0.991
Log likelihood	-233.86	-219.30	-233.29	-220.88	-220.49

Table 2: Estimated Models for the U.K.

Parameters	I Benchmark	II Break in both mean and variance	III Break in mean	IV Break in variance
m_1	0.694	0.701	0.895	0.628
	(0.085)	(0.206)	(0.152)	(0.035)
m_0	-1.068	-0.260	-0.937	-0.824
	(0.449)	(0.580)	(0.335)	(0.447)
m_{11}		-0.100	-0.319	
		(0.179)	(0.206)	
m_{00}		-0.109	1.556	
		(0.534)	(0.510)	
Φ_1	0.042	0.115	0.092	0.119
	(0.051)	(0.101)	(0.091)	(0.046)
s_0^2	0.715	1.200	0.634	1.108
	(0.049)	(0.211)	(0.087)	(0.165)
s_1^2		0.146		0.097
		(0.030)		(0.024)
p_{11}	0.972	0.967	0.914	0.994
p_{00}	0.652	0.822	0.688	0.795
q_{00}		0.983	0.988	0.988
Log likelihood	-200.39	-184.06	-198.18	-184.27

Table 3: Estimated Models for Canada

Parameters	I Benchmark	II Break in both mean and variance	III Break in mean	IV Break in variance	V Restricted
m_1	0.802	1.183	1.321	0.642	1.215
	(0.080)	(0.197)	(0.165)	(0.098)	(0.203)
m_0	-1.212	-1.809	-1.695	-0.984	-1.135
	(0.420)	(0.967)	(0.651)	(0.293)	(0.268)
m_{11}		-0.574	-0.713		-0.597
		(0.193)	(0.187)		(0.198)
m_{00}		0.729	0.601		
		(1.000)	(0.972)		
Φ_1	0.266	0.247	0.200	0.333	0.234
	(0.057)	(0.074)	(0.076)	(0.074)	(0.071)
s_0^2	0.890	1.172	0.748	1.575	1.179
	(0.089)	(0.261)	(0.099)	(0.298)	(0.277)
s_1^2		0.429		0.425	0.429
		(0.083)		(0.093)	(0.085)
p_{11}	0.983	0.977	0.979	0.973	0.975
p_{00}	0.737	0.733	0.711	0.721	0.720
q_{00}		0.986	0.982	0.982	0.985
Log likelihood	-236.31	-222.88	-229.18	-228.64	-223.17

Table 4: Estimated Models for Germany

Parameters	I Benchmark	II Break in both mean and variance	III Break in mean	IV Break in variance
m_1	3.378	2.150	1.680	1.485
	(0.710)	(1.089)	(0.341)	(0.276)
m_0	0.615	0.653	-3.292	0.336
	(0.109)	(0.381)	(1.458)	(0.164)
m_{11}		-0.704	-1.109	
		(0.980)	(0.353)	
m_{00}		-0.326	6.179	
		(0.396)	(1.559)	
Φ_1	-0.093	-0.104	-0.142	-0.105
	(0.076)	(0.075)	(0.069)	(0.069)
s_0^2	1.386	2.788	1.216	3.096
	(0.144)	(0.836)	(0.159)	(0.742)
s_1^2		0.823		0.815
		(0.136)		(0.117)
p_{11}	0.993	0.960	0.992	0.959
p_{00}	0.773	0.872	0.828	0.899
q_{00}		0.980	0.937	0.978
Log likelihood	-256.98	-249.63	-251.64	-250.46

Table 5: Estimated Models for Italy

Parameters	I Benchmark	II Break in both mean and variance	III Break in mean	IV Break in variance	V Restricted
m_1	0.367	0.777	0.950	0.458	0.784
	(0.069)	(0.217)	(0.237)	(0.067)	(0.225)
m_0	-0.682	-0.506	-0.448	-0.207	-0.275
	(0.268)	(0.561)	(0.326)	(0.164)	(0.254)
m_{11}		-0.381	-0.660		-0.376
		(0.198)	(0.274)		(0.208)
m_{00}		0.244	0.606		
		(0.532)	(0.432)		
Φ_1	0.526	0.365	0.441	0.379	0.357
	(0.052)	(0.094)	(0.105)	(0.067)	(0.089)
s_0^2	0.434	0.680	0.357	0.847	0.721
	(0.064)	(0.206)	(0.056)	(0.204)	(0.214)
s_1^2		0.238		0.227	0.233
		(0.058)		(0.042)	(0.052)
p_{11}	0.975	0.947	0.822	0.942	0.943
p_{00}	0.720	0.758	0.632	0.787	0.764
q_{00}		0.975	0.975	0.976	0.975
Log likelihood	-125.14	-118.74	-121.61	-120.34	-118.83

Table 6: Estimated Models for France

	I	II	III	IV
Parameters	Benchmark	Break in both mean and variance	Break in mean	Break in variance
m_1	0.950	1.251	1.296	0.808
	(0.193)	(0.233)	(0.188)	(0.134)
m_0	0.001	-1.166	-1.068	-0.231
	(0.202)	(0.574)	(0.496)	(0.207)
m_{11}		-0.744	-0.526	
		(0.200)	(0.170)	
m_{00}		0.970	0.920	
		(0.583)	(0.535)	
Φ_1	0.088	0.046	0.024	0.129
	(0.112)	(0.123)	(0.109)	(0.105)
s_0^2	0.410	0.422	0.328	0.577
	(0.095)	(0.165)	(0.072)	(0.150)
s_1^2		0.278		0.195
		(0.063)		(0.100)
p_{11}	0.920	0.938	0.939	0.930
p_{00}	0.860	0.798	0.801	0.803
q_{00}		0.968	0.967	0.986
Log likelihood	-136.46	-129.85	-130.43	-133.64

Table 7: Estimated Models for Japan

	I	II	III	IV
Parameters	Benchmark	Break in both mean and variance	Break in mean	Break in variance
m_1	0.873	2.254	2.359	0.815
	(0.145)	(0.208)	(0.204)	(0.109)
m_0	-2.667	-3.319	0.245	-1.016
	(1.598)	(1.493)	(2.209)	(0.559)
m_{11}		-1.298	-1.607	
		(0.192)	(0.207)	
m_{00}		2.983	-3.003	
		(1.518)	(2.308)	
Φ_1	0.373	-0.037	-0.008	0.223
	(0.063)	(0.071)	(0.069)	(0.070)
s_0^2	1.369	1.697	1.015	2.876
	(0.105)	(0.217)	(0.111)	(0.360)
s_1^2		0.531		0.509
		(0.086)		(0.105)
p_{11}	0.989	0.985	0.988	0.972
p_{00}	0.514	0.913	0.630	0.558
q_{00}		0.987	0.988	0.987
Log likelihood	-288.57	-260.13	267.78	-277.75

Figure 1. U.S. growth and conditional structural break probabilities

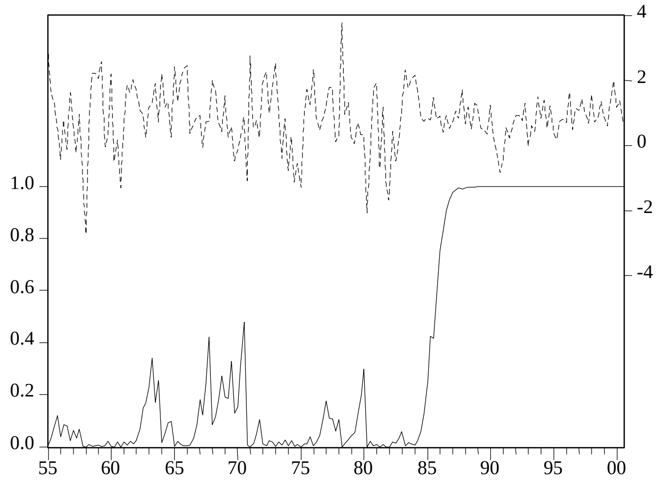


Figure 2. U.K. growth and conditional structural break probabilities

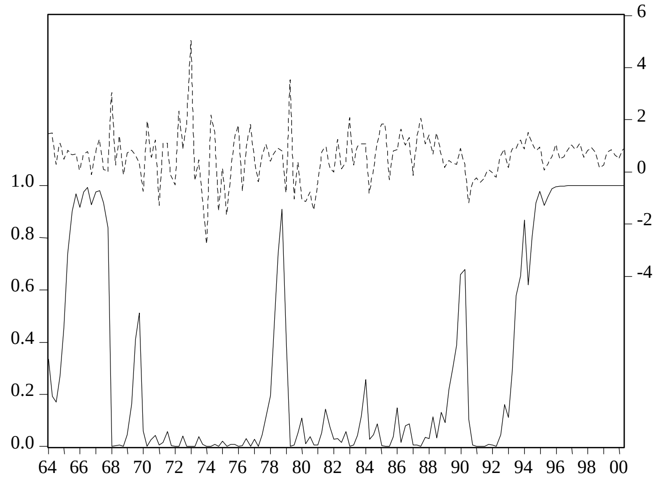


Figure 3. Canadian growth and conditional structural break probabilities

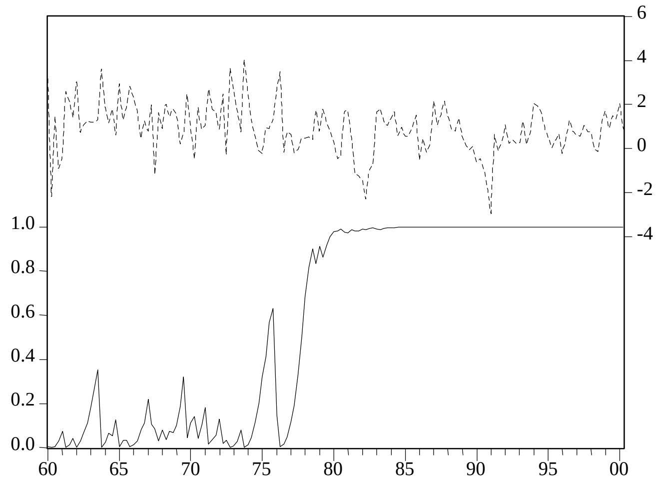


Figure 4. German growth and conditional structural break probabilities

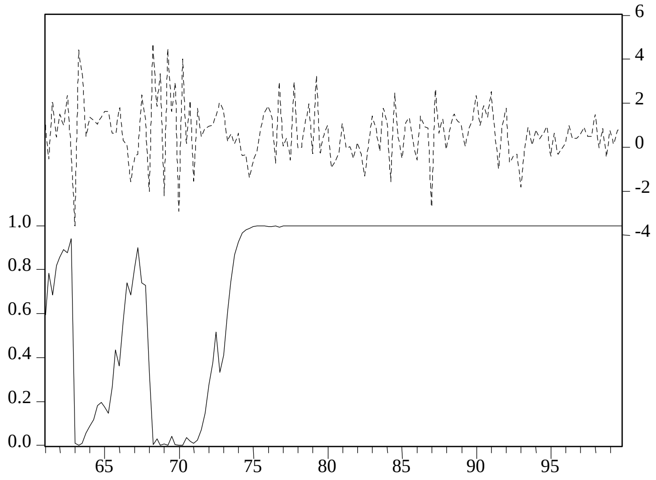


Figure 5. Italian growth and conditional structural break probabilities

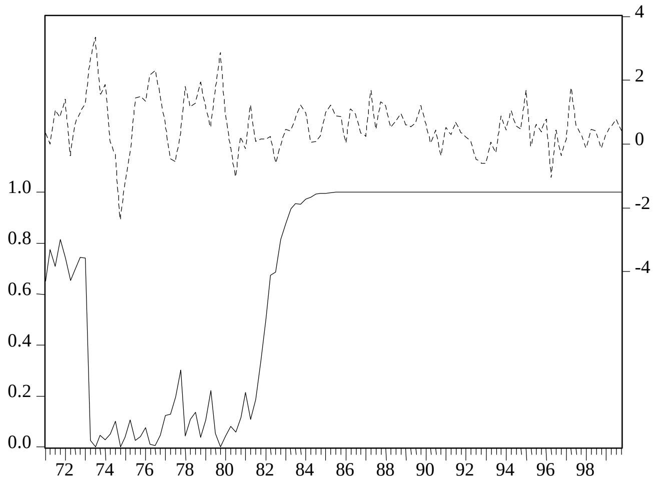


Figure 6. French growth and conditional structural break probabilities

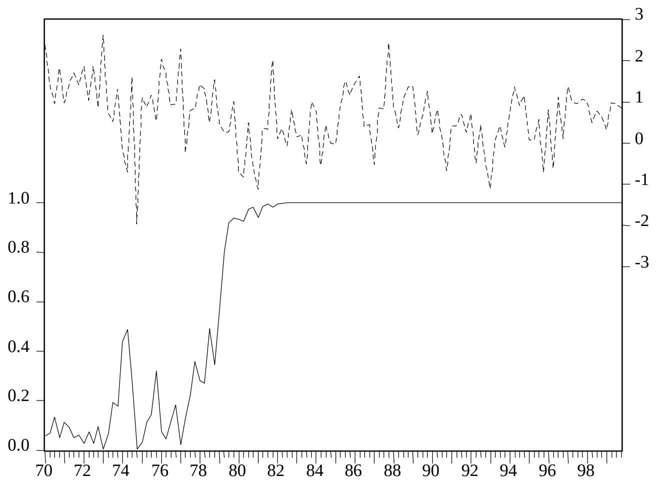
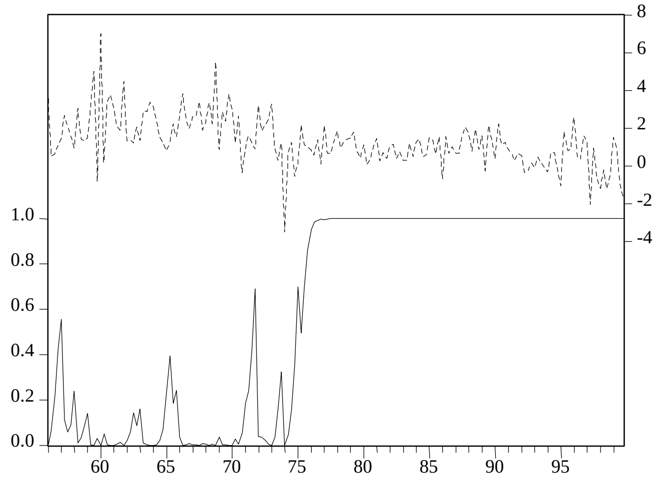


Figure 7. Japanese growth and conditional structural break probabilities



4. Conclusions

Based on an extension of Hamilton's (1989) Markov switching model which allows for structural breaks in the hyperparameters, this paper investigates the possibility that output growth experienced a one-time break for the G-7 countries. Our results suggest that output growth in these countries is best characterised by a switching regime process with a structural break. Although the date of the break differs across countries, stretching from Germany in 1974 to the U.K. in 1993, all seven economies have experienced a decline in output growth fluctuations, some (particularly the U.K. and Japan) by a large amount, France by only an insignificant amount.

There is thus a wide consensus that output growth in the G-7 economies has become less volatile. Has this evidence of stabilisation been achieved at the expense of slower output growth? Here the evidence is rather more mixed. Five countries show a narrowing of growth differentials between expansionary and recessionary regimes. In France and Japan expansionary growth rates have fallen and recessionary growth rates have risen, for Canada and Italy the former has occurred but recessionary growth has remained constant, while for the U.S. constant expansionary growth has been accompanied by rising recessionary growth. The U.K. and Germany, however, show no break in mean growth across regimes. Our conclusion must therefore be that there is evidence that expansion growth rates have generally fallen, but that this has been offset to some extent by increased growth rates in recessions.

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