SFB 649 Discussion Paper 2011-060

On the Continuation of the Great Moderation: New evidence from G7 Countries

Wenjuan Chen*

* Freie Universität Berlin, Germany

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

http://sfb649.wiwi.hu-berlin.de
ISSN 1860-5664

SFB 649, Humboldt-Universität zu Berlin
Spandauer Straße 1, D-10178 Berlin

SFB 649 ECONOMIC RISK BERLIN

On the Continuation of the Great Moderation: New evidence from G7 Countries

Wenjuan Chen *
Institute of Statistics and Econometrics, Free University of Berlin

September 30, 2011

Abstract

This paper employs a Markov regime-switching approach to investigate whether the Great Moderation is over since the start of the late 2000s recession. The results confirm that the recent financial crisis did cause a simultaneous high-volatility period among the G7 countries. However, the financial crisis may not mark the end of the Great Moderation. There is strong evidence that each G7 country has again returned to the low-variance state since 2009 or the beginning of 2010.

Keywords: Output fluctuations; Financial crisis; Regime switching.

JEL classification: E20, F01, G01, N10

*This research is supported by the Deutsche Forschungsgemeinschaft through the CRC 649 'Economic Risk'. I thank Dieter Nautz and Juergen Wolters, and participants of Interdisciplinary workshop on Econometric and Statistical Modeling of Multivariate Time Series for helpful comments and suggestions. Email:wenjuan.chen@fu-berlin.de

1 Introduction

For around two decades, the volatility of aggregate economic variables remained persistently and significantly low in most of the developed economies. This phenomenon has achieved lots of attention and has been called 'the Great Moderation'. However, since the turmoil of the recent financial crisis, it seems that the moderation of economic volatility is coming to an end.

Yet for major industrialized countries official data have shown slow and steady recovery from the crisis since 2009. This might be interpreted as the return of the Great Moderation. It is thus of great interest and importance to update research on the output volatility after the outbreak of the late 2000s financial crisis. This paper explores the behavior of the real quarterly GDP growth rate of the G7 countries, in order to investigate the following question: Could the Great Moderation still continue since the financial crisis occurred?

The Great Moderation in the US has been widely discussed by economists. Kim and Nelson (1999), McConnell and Perez-Quiros (2000), and Blanchard and Simon (2001) are among the first who lead the discussion. Kim and Nelson (1999) find that the US real GDP growth switch towards stabilization at 1984 Q1 in a Markov switching model of the business cycle. Blanchard and Simon (2001) also document the long and large decline in the volatility of US GDP growth in the late 1980s and the 1990s, using a simple AR regression over a 5-year rolling window.

Nevertheless, outside the US there is no consensus on timing of moderation of economic volatility. Papers such as Mills and Wang (2003), Smith and Summers (2009), and Stock and Watson (2005) all find that output volatility in G7 countries has stabilized since the late 1980s and 1990s, however, there are discrepancies among their studies about the timing and magnitude of the Great Moderation. To the best of the author's knowledge, this is the first paper that has included data for the recent financial crisis period and has updated research about the Great Moderation phenomenon.

In the empirical literature on the Great Moderation, Markov switching models are predominant to detect underlying economic regimes. This

type of models have the advantage of capturing the timing of structural shifts endogenously. This paper employs the regime switching technique to re-investigate time series of output growth rates of G7 countries till the end of 2010. The estimated timing of switching into the Great Moderation from this paper seems consistent with those from Mills and Wang (2003), Stock and Watson (2005) and Smith and Summers (2009). In contrast of Canarella, Fang, Miller, and Pollard (2010), however, my findings indicate that there is a very high probability of being in a low-volatility regime for each G7 country in 2010. The main results suggest that the Great Moderation is probably still continuing after the outbreak of the late 2000s crisis.

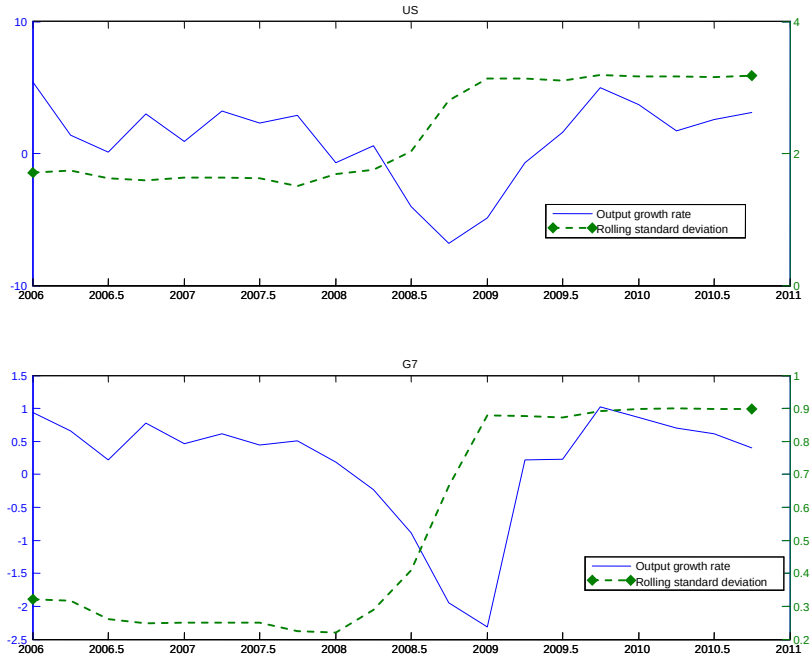
Moreover, this paper sheds light on whether shifts in output volatility are originated from switching volatility regime of the economy, or from switching dynamics in absorbing the disturbances. Among the three different specifications of models, the most appropriate model for the majority of G7 countries turns out to be the model with regime switching in only the variances. According to literature such as Blanchard and Simon (2001), these results would imply that there is little role of policy making in causing output fluctuations. In light of the new evidence on the high volatility period during the global economic recession in 2008, this interpretation on the role of luck or policy in causing output fluctuations should be viewed with caution.

The structure of the paper is as follows. Section 1 briefly describes the output growth rates of each G7 country. In Section 2 I introduce the details of the AR model and the three different specifications of Markov-switching AR models that are estimated. Section 3 presents the estimation results and show that the Markov-switching model in variance fits the data best for most G7 countries. Section 5 concludes.

2 Output Growth and Volatility in G7 Countries

The historical time series of the quarter-to-quarter GDP growth rates for most G7 countries are obtained from the statistical portal of the Organization of Economic Cooperation and Development(OECD). Among the

Figure 1: Output Growth Rate before and during the Crisis



Notes: This figure depicts the quarter-to quarter GDP growth rates and volatility for the US and the G7 aggregate data. The volatility of output growth is calculated as rolling standard deviation over 20 quarters.

European countries, the French data starts from 1969 Q1 and ends at 2010 Q4, while the Italian data cover a shorter period from 1981 Q1 to 2010 Q4. The UK data starts from 1955 and ends at 2010 Q4. The Canadian data are available from 1961 Q1 to 2010 Q4. For Japan, the data are from 1981 Q1 to 2010 Q4. Data of the United States covers the period from 1969 Q1 to 2010 Q4.

The time series of the German GDP growth rates come from the Bundesbank since the available time series covers longer periods from 1970 Q1 to 2010 Q4. Beside the time series for each individual G7 country, we also consider the aggregate data for all G7 countries. All these series are seasonally adjusted at source and computed as the change from the previous period. The Augmented Dicky-Fuller test is carried out and test statistics show that no unit root exists for each time series.

As a representative example, Figure 1 depicts the process of the quarterly output growth rate and its volatility for the US and the G7 aggregate data from 2006 Q1 to 2010 Q4. The whole data sample for each G7 country that is used in estimation is shown in the appendix. Following Blanchard and Simon (2001), the volatility is measured as the twenty-quarter rolling standard deviation, i.e., the standard deviation for time period t is the estimated standard deviation from nineteenth quarter before till the current quarter.

It is noticeable that the output volatility has sharply increased since the outbreak of the recent financial crisis. At the end of 2010, it seems that most G7 countries still exhibits high volatility in output growth. However, this preliminary look at the output volatility might be misleading since it is only based on a simple moving-average analysis. As a consequence, at the very end of the sample period, a decline in volatility could not be detected. In the next section, I rely on a regime switching framework to have a more precise inspection on the status of the output volatility.

3 The Regime Switching Approach to Model Output Volatility

In this section, I introduce the empirical setup to analyze the output growth process. Since Hamilton (1989) proposed a regime switching model in showing shifts between positive and negative output growth, numerous researchers, such as Kim and Nelson (1999) and McConnell and Perez-Quiros (2000), have employed this framework in studying business cycles and the Great Moderation phenomenon.

Following the empirical literature, I rely on the two-state Markov switching framework to detect the underlying states of the economic volatility. Switches between low variance and high variance states are allowed to be recurrent. The focus of this paper is on structural shifts in the changing volatility of the output growth. Therefore the state variables represent volatility regimes instead of business cycle peaks and troughs. In order to assess the performance of the various regime switching models under con-

sideration, a simple AR model without regime shifts is also introduced as a benchmark. Number of lags are chose according to the Schwarz criterion (see Table 7, 8 and 9 in the Appendix). The following subsections introduce the four different specifications of models on the output growth rates of the G7 countries.

Model 1: The Benchmark AR Model

First I consider a simple AR model with only one regime, where both dynamics and variance are constant over time. Let the benchmark AR model be

$$y_t = \alpha + a_1 y_{t-1} + ... + a_p y_{t-p} + u_t \tag{1}$$

where α represents the intercept, $a_1, ..., a_p$ are the autoregressive coefficients. u_t are the *i.i.d.* error terms, with distribution $N(0, \sigma^2)$.

Model 2: The MS-AR Model with Switching Variance

Following Hamilton (2005), Model 2 assumes that the variance of errors terms from the process of the output growth depends on an unobserved state variable, whose transition between different states follows a Markov Chain. In this paper it is generally assumed that there exist two states, a high-volatility regime s_1, and a low-volatility regime s_2.

In Model 2, only the variances of the errors are allowed to vary over time. The intercept and the AR coefficients are assumed to stay constant over time:

$$y_t = \alpha + a_1 y_{t-1} + ... + a_p y_{t-p} + u_{s_t} \tag{2}$$

where u_{s_t} represents the error terms that depends on a Markov Chain process. When $s_t = 1$, the economy is in the high-volatility state, and $u_t \sim$ i.i.d. $N(0, \sigma_1^2)$. Otherwise, when $s_t = 2$, the economy is supposed to be in the low-volatility state, $u_t \sim$ i.i.d. $N(0, \sigma_2^2)$. The transition probabilities

are assumed to be constant over time. They can be presented in a 2×2 transition matrix:

$$P = \begin{bmatrix} P_{HH} & P_{LH} \\ P_{HL} & P_{LL} \end{bmatrix} \tag{3}$$

where P_{ij} represents the probability of the economy switching from state i to state j. The expected duration of each regime would be $(1 - P_{HH})^{-1}$ and $(1 - P_{LL})^{-1}$.

Model 3: The MS-AR Model with Switching Dynamics

Is regime switching behavior of output originated from switching variances of shocks hitting the economy or switching dynamics of the process in absorbing the shocks? Model 3 is introduced here and its estimation results are compared with Model 2 in the next section. It has the feature of homoscedasticity but changing intercept and autoregressive parameters as follows:

$$y_t = \alpha_{s_t} + a_{1,s_t} y_{t-1} + ... + a_{p,s_t} y_{t-p} + u_t \tag{4}$$

Model 4: The MS-AR Model with Switching Dynamics and Variances

A more general specification of Markov switching models is considered here, in which not only the variances of error terms, but also the dynamics are regime dependent, the intercept α_{s_t}, AR coefficients $a_{1,s_t}, ..., a_{p,s_t}$ and σ_{s_t} are all allowed to vary between two regimes.

$$y_t = \alpha_{s_t} + a_{1,s_t} y_{t-1} + ... + a_{p,s_t} y_{t-p} + u_{s_t} \tag{5}$$

Better policy making has been often mentioned as a plausible cause of the Great Moderation. If there is less persistence of the output growth process during the Great Moderation, it would be reflected in a smaller sum of the AR coefficients in the low-variance state based on estimation of Model 4.

4 Regime Switching in the Output Growth Process

This section presents the empirical results. The Markov switching models are estimated with the iterative Expectation-Maximization algorithm following Krolzig (1997). In the first step, I use a modified likelihood ratio test to compare Model 1 and Model 4, so as to whether there exists regime switching behavior in the output growth rate. In the second step, estimation results of Model 2, Model 3, and Model 4 are compared to select the most appropriate model for each country. Based on estimation from the most appropriate model, the estimated timing of Great Moderation in each country and pictures of smoothed probabilities are presented.

4.1 Single Regime v.s. Two Regimes

Let us first find out whether there is significant regime switching behavior in the output growth process. I compute a modified likelihood ratio statistic proposed by Davies (1977), so as to test whether the difference in the maximum log-likelihood is statistically significant. The standard likelihood ratio test is no longer applicable here because the states are not identifiable in the single-regime AR model, which violates one of the key assumptions of likelihood ratio test. Davies (1977) has proposed the following upper bound for a modified likelihood ratio statistics under the null hypothesis, assuming that a unique global optimum for the likelihood function exists:

$$Pr[(LR(q*)] > M = Pr(\chi^2 > M) + \frac{2M^{(d-1)/2}e^{-M/2}2^{-d/2}}{\Gamma(d/2)} \qquad (6)$$

Where $Pr[(LR(q*)] > M$ is the upper bound critical value, M is the standard likelihood ratio statistics, $q*$ is the vector of transition probabilities under the alternative hypothesis $H1$, and d is the number of restrictions under the null hypothesis.

Table 1 presents the p-value of the modified likelihood ratio test for each G7 country. There is strong evidence of regime switching behavior in the variance of error terms. Smith and Summers (2009) have shown similar

Table 1: Is There Regime Switching in the Output Growth Process?

Countries	P-value of the adjusted-LR test
Canada	0.0000
France	0.0000
Germany	0.0023
Italy	0.0000
Japan	0.0000
UK	0.0000
US	0.0000

Notes: This table reports the test results from comparing the maximum likelihood of the benchmark AR model (Model 1) with the Markov switching AR model with switching dynamics and variance (Model 4).

findings for the output data of G7 countries before the start of the recent recession.

4.2 Switching Variances or Switching Dynamics?

Is regime switching behavior present in the dynamic process of output growth? Or does regime switching exist in the variance of shocks to output? Table 2 reports the Schwarz criterion of Model 2 and Model 3, which is commonly used in choosing competing models that are not nested. It is noticeable that for all countries except Italy, Model 2 outperforms Model 3 [1]. Obviously Model 3, the model with only switching dynamics is the less favorite model compared with Model 2. Switching dynamics alone is not sufficient to account for the Markov switching behavior in the output growth process of G7 countries.

Since Model 2 and Model 4 are nested, a likelihood ratio test could be used to compare estimation results of Model 2 with those of Model 4 (see

[1] Nevertheless, for Italy the Schwarz criterion from Model 4 turns out to be 1.79, lower than the one of Model 3. Further results from a likelihood ratio test to compare Model 3 and Model 4 also rejects Model 3.

Table 2: Regime Switching in Dynamics or in Variances?

Countries	Model 2	Model 3
Canada	2.01	2.09
France	1.49	1.50
Germany	2.85	2.92
Italy	1.86	1.83
Japan	2.99	3.04
UK	2.57	2.74
US	5.15	5.38

Notes: This table reports the Schwarz Criteiron of the Markov switching AR model with only switching variance (Model 2), the Markov switching AR model with only switching dynamics (Model 3).

Table 3: Likelihood Ratio Test for Model 2 and Model 4

Countries	P-value	The Most Appropriate model
Canada	0.431	Model 2
France	0.000	Model 4
Germany	0.463	Model 2
Italy	0.000	Model 4
Japan	0.741	Model 2
UK	0.314	Model 2
US	0.423	Model 2

Notes: This table reports the p-values of the likelihood ratio test to compare the Markov switching AR model with only switching variance (Model 2), and the Markov switching AR model with both switching dynamics and variances (Model 4).

Table 3). To sum up, the most appropriate model for Canada, Germany, Japan, the UK and the US turn out to be Model 2, the one with only switching variances. Model 4 fits the best for France and Italy.

Table 4 and Table 5 reports the estimated transition probabilities, the intercept, the sum of AR coefficients and the variances for Model 2 and Model 4. These estimates share a close similarity across the models except for France and Italy [2]. In general, the probability of remaining in the low-volatility is very high, above 95 percent for the majority of the G7 countries. For the United States, the variance of the high-volatility state is about 6 times as high as the one of the low-volatility state, which is in line with the findings of McConnell and Perez-Quiros (2000). In general, the relative variance ratio of the high-volatility state to the low-volatility state is larger than those found the traditional literature on the Great Moderation. This could be due to the additional extremely volatile period since the end of 2007 included in our data sample.

Above results provide very strong evidence for Markov switching behavior in the variance, which is also found by papers such as Blanchard and Simon (2001), Sims and Zha (2006) and Smith and Summers (2009). Markov-switching behavior in the dynamics of the output growth seems less relevant, only significant for France and Italy. To sum up, the Markov switching model with switching variance is the most appropriate to model the output growth for most of the G7 countries.

4.3 Smoothed Probabilities

Figure 2 and Figure 3 depict the estimated smoothed probabilities of being in a low-volatility regime from the most appropriate model chosen for each individual country. In general the smoothed probabilities estimated from

[2]For France and Italy, the estimated intercept and the sum of AR coefficients differ more dramatically across the models because switching dynamics is significant for these two countries. Besides, note that for France and Italy, the sum of AR coefficients estimated by Model 4 turns to to be negative or explosive in one regime. These complicated properties of regime-dependent AR parameters have also been pointed out by Tjøstheim (1998).

Table 4: Maximum Likelihood Estimates of Model 2

Country	P_{HH}	P_{LL}	σ_H^2	σ_L^2	σ_H^2/σ_L^2	I	AR
Canada	0.94	0.96	0.76	0.15	5.07	0.34	0.53
France	0.99	0.92	1.30	0.15	8.67	0.20	0.69
Germany	0.83	0.92	1.99	0.42	4.74	0.42	0.13
Italy	0.74	0.97	1.67	0.21	7.95	0.26	0.37
Japan	0.89	0.97	4.3	0.47	9.15	0.25	0.42
UK	0.87	0.94	2.23	0.26	8.58	0.24	0.06
US	0.97	0.99	21.99	3.62	6.07	1.66	0.45

Notes: P_{HH} represents the probability that the regime transfer from the high-volatility state to the high-volatility state. P_{LL} represents the probability that the regime transfer from the low-volatility state to the low-volatility state. σ_H^2 represents the variance in the high-volatility regime, while σ_L^2 represents the variance in the low-volatility regime. AR stands for the sum of AR coefficients, and I stands for the intercept.

Table 5: Maximum Likelihood Estimates of Model 4

Country	P_{HH}	P_{LL}	σ_H^2	σ_L^2	I_H	I_L	AR_H	AR_L
Canada	0.94	0.96	0.75	0.15	0.28	0.36	0.50	0.53
France	0.94	0.13	0.15	0.02	0.23	0.35	0.67	-0.01
Germany	0.97	0.96	1.38	0.33	0.55	0.34	0.09	0.11
Italy	0.91	0.38	0.26	0.01	0.31	-0.29	0.23	1.36
Japan	0.85	0.97	4.02	0.52	0.73	0.37	0.15	0.21
UK	0.88	0.94	2.12	0.25	0.39	0.20	-0.08	0.16
US	0.97	0.99	21.43	3.61	1.49	1.64	0.39	0.47

Notes: P_{HH} represents the probability that the regime transfer from the high-variance state to the high-variance state. P_{LL} represents the probability that the regime transfer from the low-variance state to the low-variance state. AR_H stands for the sum of AR coefficients for the high-variance state, while AR_L stands for the sum of AR coefficients for the low-variance state. σ_H^2 represents the variance in the high-volatility regime, while σ_L^2 represents the variance in the low-volatility regime.

Model 2 and Model 4 are very similar [3]. It is noticeable that the US GDP volatility sharply declined in 1984, switched back to a high-volatility regime from the end of 2007 till the mid of 2009, and started stabilizing afterwards. For Canada, France, Germany and the UK, multiple switches happened before the output growth reached a stable period of low variance in the mid 1980s or the beginning of 1990's.

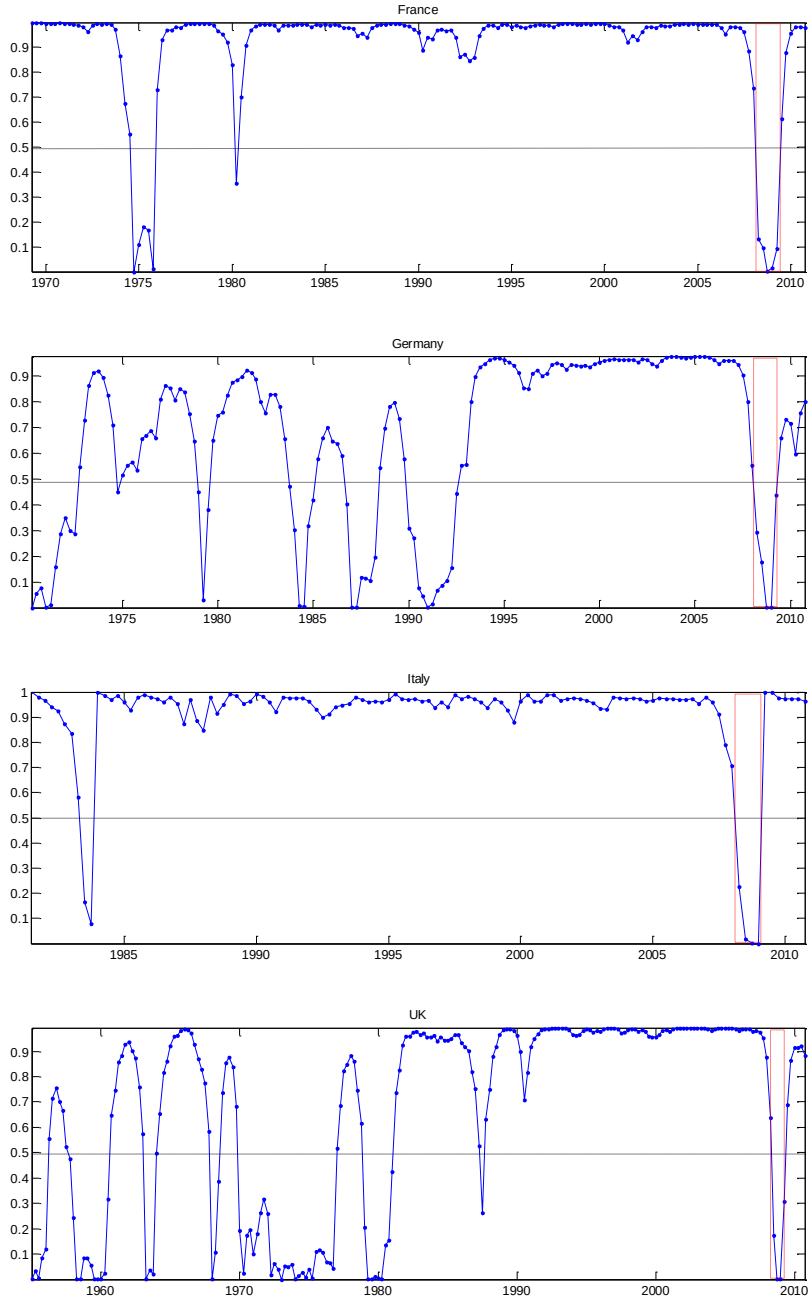
The timing that the economies started switching into the Great Moderation varies across countries, though there is evidence that the switching dates are clustered. Italy, the UK and and the US started the Great Moderation in the 80s, while Canada, Germany and Japan started stabilization in output around the beginning of 1990s. France seems to have an exceptionally earlier start (1976) into a low-volatility state than the rest of the countries. Table 6 compares my estimates of the switching dates with those of Smith and Summers (2009), Mills and Wang (2003) and Stock and Watson (2005).

For France, Germany and US, my estimates are consistent with Smith and Summers (2009). The date of switch for Italy is later than estimates of other papers, which could result from the shorter sample period of data we have. The start of the Great Moderation for the UK is rather controversial, since the output growth switched multiple times between high-volatility and low-volatility regime before the 1990s. However, combining observations from the volatility path, the output growth has been rather stable since 1980 except for one temporary break shortly before the 1990 recession. Thus I identify the dates of switching into the Great Moderation as 1980, which is consistent with findings from Stock and Watson (2005).

Since the start of the late 2000s financial crisis, all the G7 economies have simultaneously fallen into a state of high volatility. However, in contrast to Canarella, Fang, Miller, and Pollard (2010), my results suggest that the Great Moderation could probably continue despite the current low confidence of the public on the economic outlook. Actually since 2009 or the

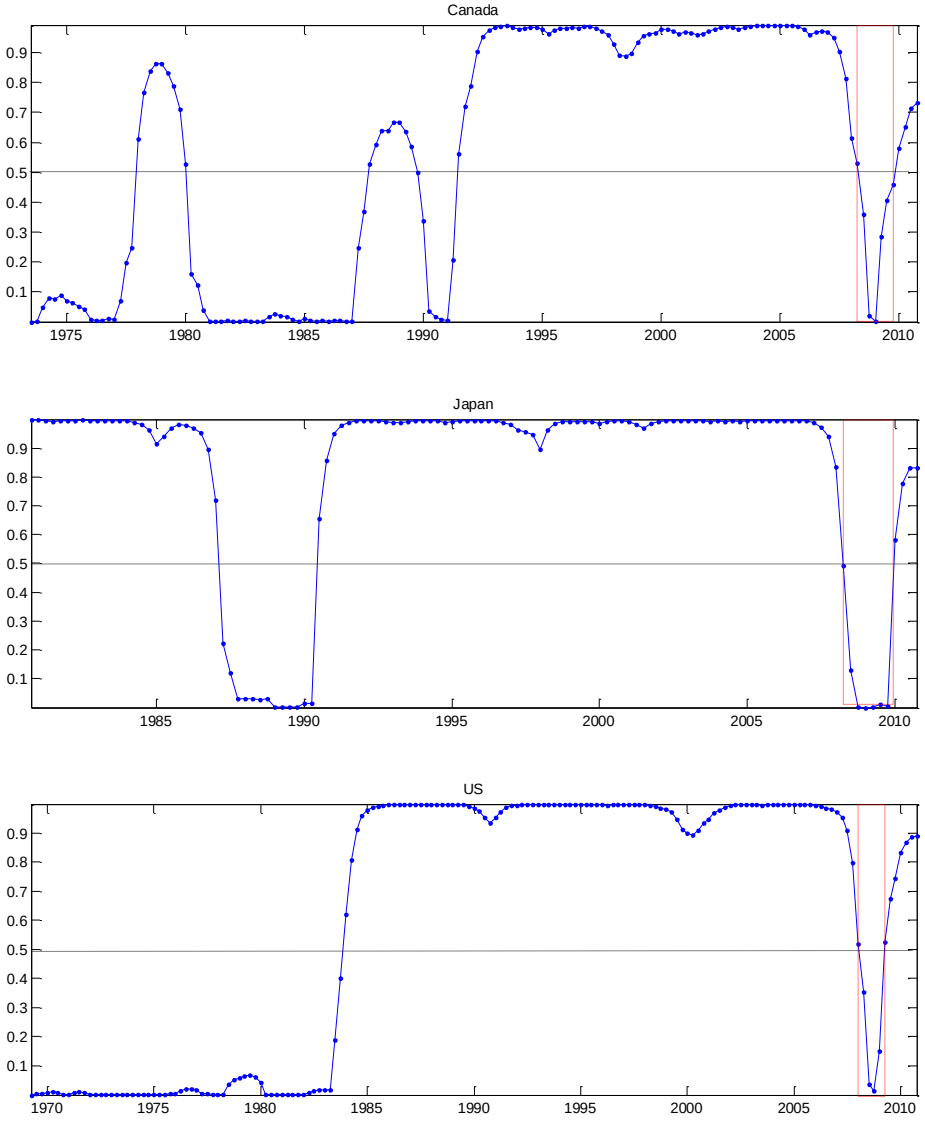
[3] The smoothed probabilities from the second-best model for each G7 country are presented in Figure 6 and Figure 7 in the Appendix. Germany is the only exception where a switch back to the low-variance regime could not be found at the end of the sample period.

Figure 2: Smoothed Probabilities for the Low-volatility State of the Output Growth for Countries Inside the EU



Notes: This figure depicts the smoothed probabilities of the low-variance state for France, Germany, Italy and the UK from the chosen most appropriate model, i.e., Model 2 for Germany and the UK, and Model 4 for France and Italy.

Figure 3: Smoothed Probabilities for the Low-volatility State of the Output Growth for Countries Outside the EU



Notes: This figure depicts the smoothed probabilities of the low-variance state for Canada, Japan, the US from the most appropriate model, i.e., the Markov switching AR model with only switching variance (Model 2) for Canada, Japan and the US.

Table 6: Estimated timing of switching into the Great Moderation

	This paper	Smith and Summers(2009)	Mills and Wang(2003)	Stock and Watson(2005)
Canada	1991	1991	late 1970s	1991
France	1976	1976	1979	1968
Germany	1992	1993	1974	1993
Italy	1984	1980	1982	1980
Japan	1990	1975	1979/1990	n/a
UK	1980	1992	1993	1980
US	1984	1984	1984	1983

Notes: This table reports dates of switches into the low-variance state from various authors. Dates from this paper are the first date for which the smoothed probabilities are larger than 0.5.

beginning of 2010 the probability of returning into low-volatility regime has risen up to the peak of 80 to 95 percent for the output growth rate of each G7 country. These results are robust for either Model 2 or for Model 4. The recent economic recession seems to cause only a temporary switch in the variance of output growth. It is likely that the economy will return in the low-volatility regime.

5 Conclusion

This paper provides new evidence on the regime switching behavior of the output growth process of G7 countries including the volatile period of the late 2000s financial crisis. Three important switches are documented in the output volatility. The first started from the mid 1980s or the beginning of 1990s, when a significant decline in output volatility has been found for each G7 country. The second prominent switch happened around the end of 2007, when all the G7 economies simultaneously fell into the high-volatility state. However, this is only a temporary switch rather than a structural break.

Since the mid of 2009 or the beginning of 2010, all the G7 countries have switched back into the low-volatility regime. These results suggest that the Great Moderation could probably continue despite current pessimism of the public.

According to e.g. Blanchard and Simon (2001), a better policy should imply less persistence in the output growth process, i.e., a smaller sum of AR coefficients. However, the estimation results do not provide evidence that dynamics of the output growth process has changed in most of the G7 countries. This would lead to a puzzling conclusion that policy has played little role in causing output fluctuations for the late 2000s financial crisis. Thus it is recommendable to view this line of interpretation with caution.

This paper is only a first step to document the endogenous switches in the variances of output growth in G7 countries based on a univariate framework. It is therefore interesting to extend the current study to include more variables such as inflation and interest rate in a multivariate structural model to find the causing factors behind the switching disturbances to the economy.

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Appendix

Table 7: Schwarz criterion and Choice of Lags for Model 2

Countries	preferred number of Lags	Schwarz criterion	Maximum Likelihood
Canada	1	2.01	-134.81
France	2	1.48	-105.10
Germany	1	2.85	-215.60
Italy	1	1.86	-95.45
Japan	3	2.99	-160.03
UK	1	2.57	-270.18
US	2	5.15	-409.25

Notes: Schwarz criterion is calculated as -2(l/T)+k log(T)/T, where l is the log likelihood, k is the number of parameters, and T is the sample size.

Table 8: Schwarz criterion and Choice of Lags for Model 3

Country	Lag	Schwarz criterion	Log likelihood
Canada	2	2.09	-131.82
France	3	1.50	-95.65
Germany	1	2.92	-218.60
Italy	1	1.83	-91.37
Japan	1	3.04	-168.65
UK	3	2.74	-272.40
US	1	5.38	-430.95

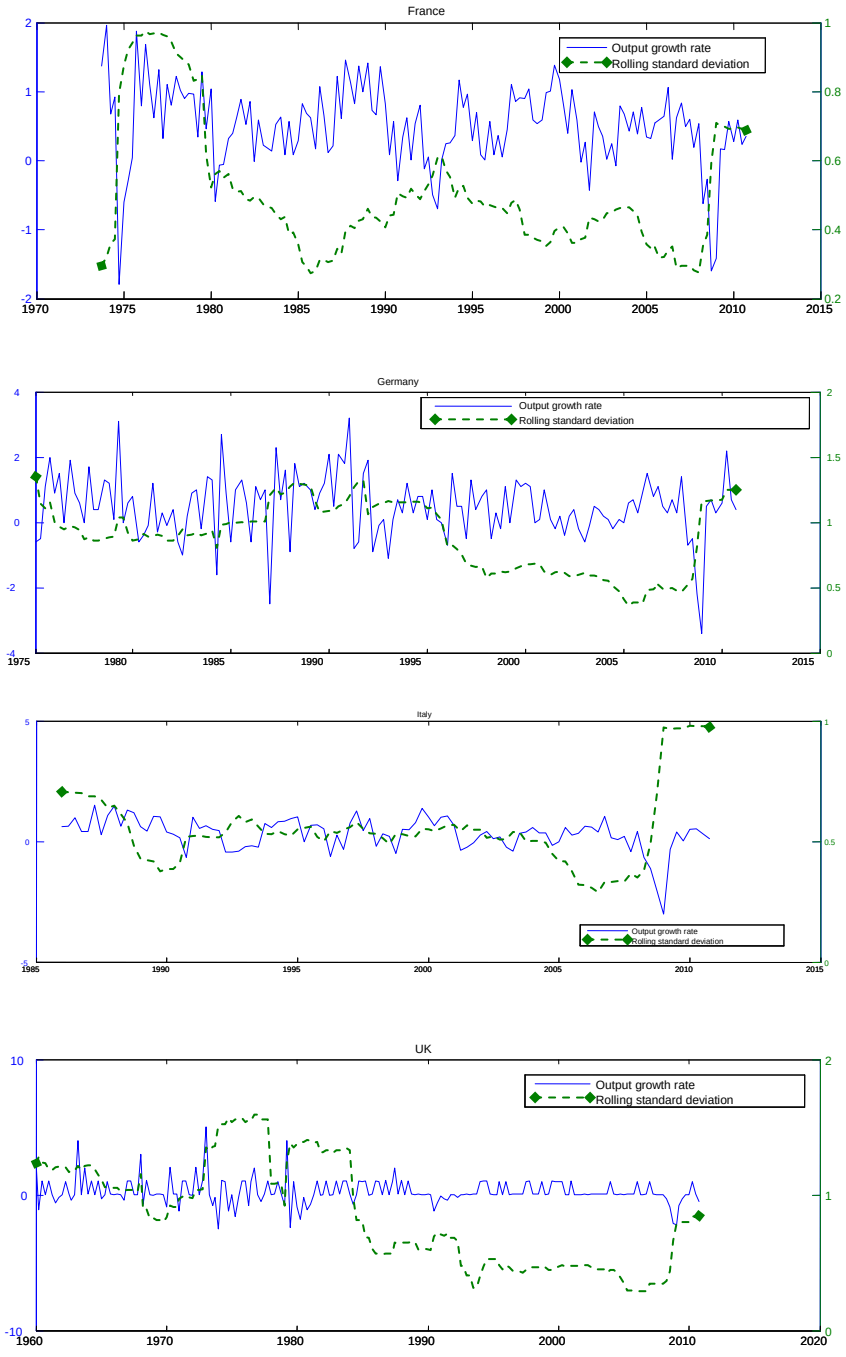
Notes: Schwarz criterion is calculated as -2(l/T)+k log(T)/T, where l is the log likelihood, k is the number of parameters, and T is the sample size.

Table 9: Schwarz criterion and Choice of Lags for Model 4

Country	Lag	Schwarz criterion	LogL
Canada	1	2.07	-134.50
France	3	1.51	-93.73
Germany	1	2.91	-215.00
Italy	1	1.79	-86.46
Japan	1	3.09	-168.98
UK	1	2.61	-269.02
US	2	5.23	-408.39

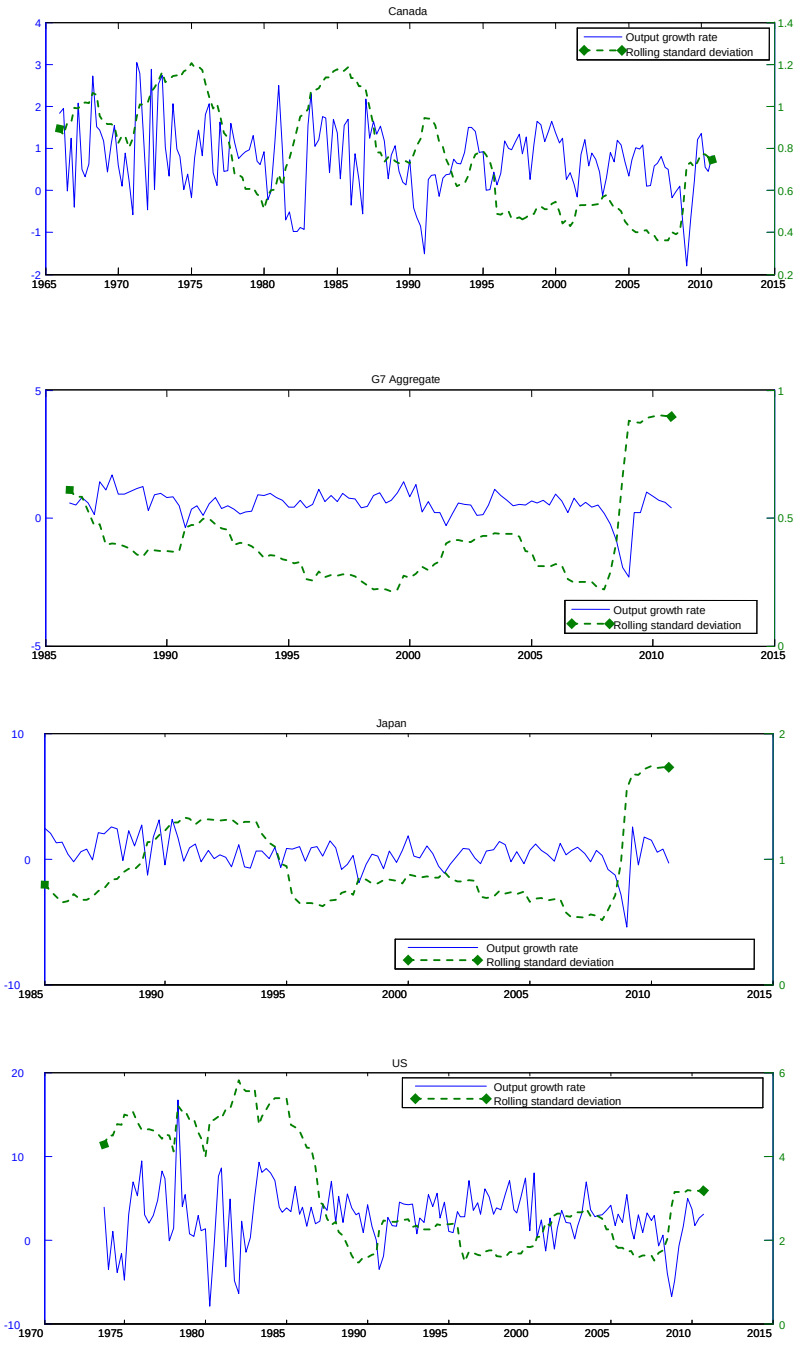
Notes: Schwarz criterion is calculated as -2(l/T)+k log(T)/T, where l is the log likelihood, k is the number of parameters, and T is the sample size.

Figure 4: Output Growth Rate of G7 countries Inside the EU



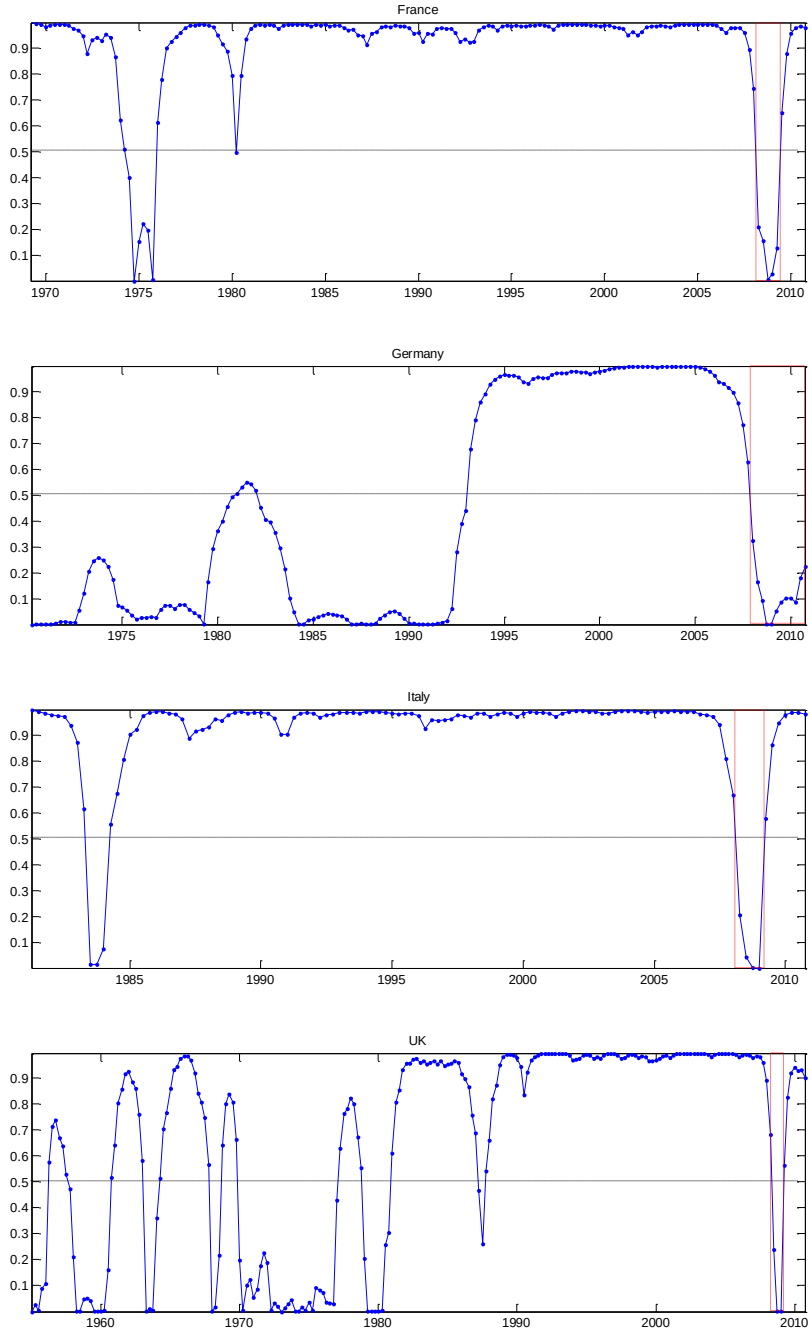
Notes: This figure depicts the GDP quarter-to quarter growth rate of G7 countries Inside the EU. The volatility of output growth is measured as rolling standard deviation over 20 quarters.

Figure 5: Output Growth Rate of G7 countries Outside the EU



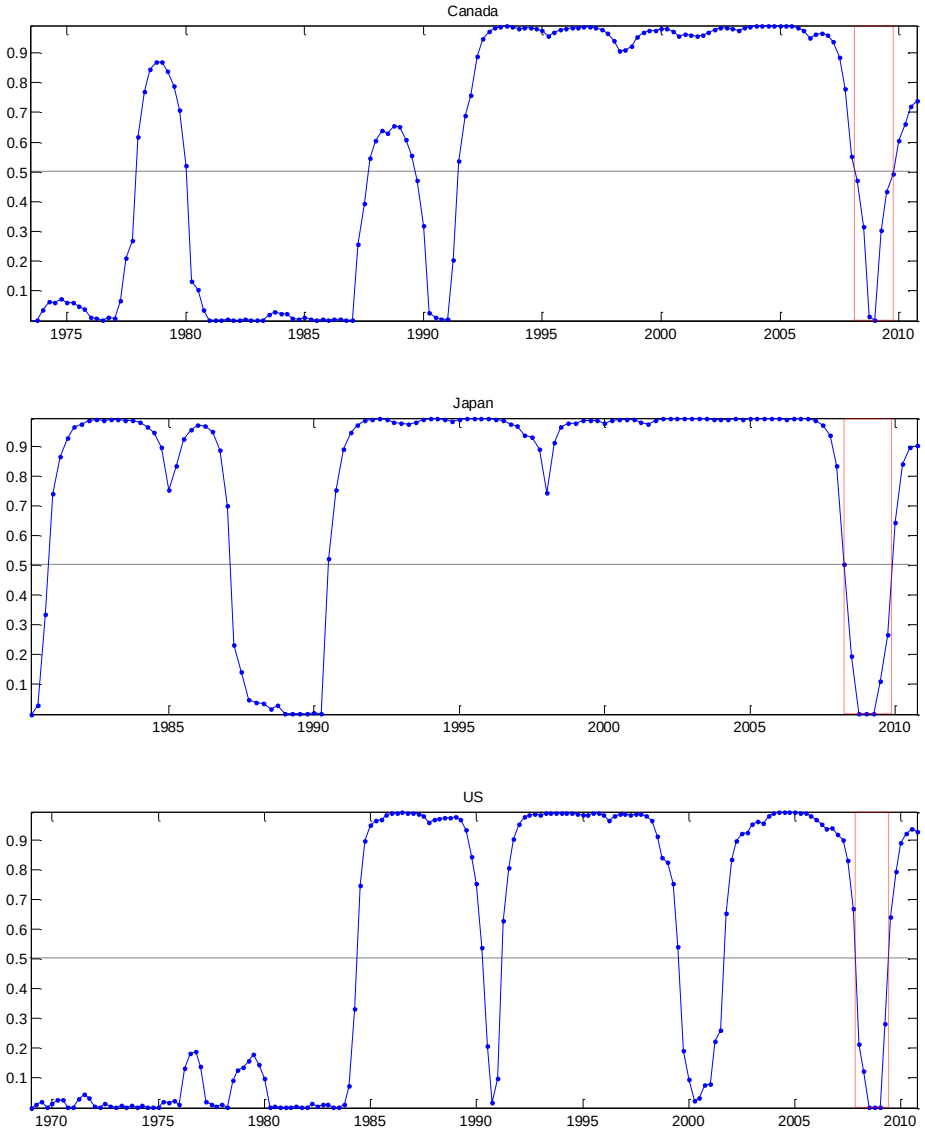
Notes: This figure depicts the GDP quarter-to quarter growth rate of G7 countries Outside the EU. The volatility of output growth is measured as rolling standard deviation over 20 quarters.

Figure 6: Smoothed Probabilities for the Low-volatility State of the Output Growth for Countries Inside the EU



Notes: This figure depicts the smoothed probabilities of the low-variance state for France, Germany, Italy and the UK from the second most appropriate model, i.e., Model 4 for Germany and the UK, and Model 2 for France and Italy.

Figure 7: Smoothed Probabilities for the Low-volatility State of the Output Growth for Countries Outside the EU



Notes: This figure depicts the smoothed probabilities of the low-variance state for Canada, Japan, the US from the second most appropriate model, i.e., the Markov switching AR model with only switching variance (Model 4) for Canada, Japan and the US.

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