ESSAYS ON MACROECONOMIC VOLATILITY AND THE GREAT MODERATION

A Dissertation

Presented to

The Faculty of the Department of Economics

University of Houston

In Partial Fulfillment

Of the Requirements for the Degree of

Doctor of Philosophy

By

Michael W. Clark

May, 2012

ESSAYS ON MACROECONOMIC VOLATILITY AND
THE GREAT MODERATION

____
Michael W. Clark

APPROVED:

____
David Papell, Ph.D.
Committee Chair

____
Bent Sørensen, Ph.D.

____
Christian Murray, Ph.D.

____
Rauli Susmel, Ph.D.
Department of Finance

____
John W. Roberts, Ph.D.
Dean, College of Liberal Arts and Social Sciences
Department of English

ESSAYS ON MACROECONOMIC VOLATILITY AND THE GREAT MODERATION

An Abstract of a Dissertation

Presented to

The Faculty of the Department of Economics

University of Houston

In Partial Fulfillment

Of the Requirements for the Degree of

Doctor of Philosophy

By

Michael W. Clark

May, 2012

Abstract

This dissertation is a collection of two essays on the macroeconomic volatility and the Great Moderation. The first essay examines the causes of the Great Moderation in United States, while the second essay takes an international approach in examining if the Great Moderation was one or multiple events for the industrialized countries.

The first essay analyzes the causes of the large decline in aggregate volatility for the United States, phenomenon known as the Great Moderation, one of the most widely recognized characteristics of the modern U.S. economy. However, the literature found no consensus on what caused it. In order to uncover the causes of the Great Moderation we use a new measure of volatility based on the first difference of quarterly growth rates, and a novel approach, exploiting a test for common features. We first test each series for structural change(s) in volatility, and then test for a common feature of a decrease in volatility between the volatility of output and volatility of potential causes of the Great Moderation for both the period prior to the Great Recession (2007:4) and the whole sample through 2010:4. When all the evidence is considered, structural changes in the economy, including increased globalization and improved inventory management, improved monetary policy, and good luck, all appear to have played a significant role, while financial market innovations are unlikely to be a cause of the Great Moderation.

The second essay analyzes if the Great Moderation is one event internationally, common across countries, or multiple events. The Great Moderation has been identified in several advanced economies as a general decrease in the volatility of GDP growth, and it is still viewed as one time event. We use structural break test to date the onset of the Great Moderation in eleven developed countries and employ the test for common features in order to determine if the moderation in volatility is common across countries (one event), or if it is more than one event.

While we establish that all of the countries studied display a break dating from the late 1970s to mid- 1980s and early 1990s, we discover the moderation of volatility evident in international data is neither concurrent, nor of similar magnitude. We can use this new information to enlighten our search for the cause(s) of the Great Moderation by both eliminating potential causes and increasing the ability to distinguish between causality and coincidence.

Acknowledgements

I would like to express my deepest gratitude to my advisor, David Papell, for all of his guidance and hard work while helping me reach my potential. He has been an excellent mentor. My committee members, Chris Murray and Bent Sørensen, deserve a special thanks for their numerous contributions, advice, and patience. Chris Murray taught me all that I know about theoretical econometrics and time series analysis. Bent Sørensen set the foundation of my knowledge of empirical macroeconomics, and made me realize that this is the field that I wanted to work in. A special thanks to Ruxandra Boul and Rebecca Thornton for their assistance in my development as a teacher.

My colleagues Amelie Carlton, Roberto Coronado, Shreyasee Das, and Juan Urquiza also deserve a special mention for their support, advice, and collaboration in the learning process. Without Brandon Derusha, my life as an undergraduate would have been dull and boring. My childhood friends, Thomas Riley and Jonathan Zande also deserve a great deal of gratitude as they have been by my side almost my entire life.

Early influences, who I will always be grateful to, include Vic Etienne for being an outstanding influence and mentor, as well as Father McLernan for instilling and fostering my love of science. I would also like to thank my parents, Mike and Cindy Clark for their love and support in all my ventures. Finally, I would like to thank my wife, Teodora Stoica, who has helped me in countless ways.

All of the above listed people, and likely many more, deserve more thanks than I can adequately put into words.

Table of Contents

To my wonderful wife, Dora, without whom this would be meaningless.

Chapter I

Common Features of the Great Moderation

"It remains to be seen how economists will assess the Great Moderation and its causes after the crisis recedes" – *This Time is Different*, Carmen M. Reinhart and Kenneth S. Rogoff

1.1 Introduction

One of the most documented characteristics of advanced economies is the dramatic decline in the volatility of the main macroeconomic series known as the Great Moderation. Almost 30 years ago, the United States experienced a sudden decrease in the volatility of quarterly output, inflation, employment, exchange rates, and so on, all of which were visible not only in econometric models, but also to the naked eye. While this phenomenon has been widely documented, dated, and debated in recent years, there is no clear consensus in the literature on what caused it or why it occurred in the early to mid 1980s. The Great Recession, that started in 2007:4, has caused a great deal of uncertainty regarding the current level of volatility, with some hypothesizing the end of the Great Moderation. Knowing what caused the Great Moderation in the 1980s could help policymakers get the economy back to another low volatility regime or sustain it if we have not yet departed from the Great Moderation.

The purpose of this paper is to determine the causes of the decrease in volatility of real GDP. Using a new measure of volatility based on the first difference of quarterly growth rates as well as a novel approach exploiting a test for common features (Engle and Kozicki (1993)), we investigate whether the decline in volatility comes from structural changes in the economy, financial market innovations, improved monetary and/or fiscal policy, or simply good luck. We first search for a change in the volatility of each series, using structural break tests (Bai and Perron (1998, 2003)). We interpret a change occurring near the onset of the Great Moderation (1983:2) as evidence supporting the cause associated with that series. We then test for the presence of a common feature of a decrease in volatility between individual series and output, using the test for common features. We interpret a series that has a common feature with output as a possible cause of the Great Moderation.

Investment and its sub-components play a vital role in this analysis. Inventory investment is a proxy for improved inventory management. Residential investment is used as a proxy for monetary policy, due to the fact that it is the most interest rate sensitive sector, and is generally more insulated from other market factors and innovations. Finally, non-residential investment along with its sub-components, non-residential investment in structures and non-residential investment in equipment and software, are used as a proxy for financial market innovations.

Research addressing structural change in the economy leading to the Great Moderation, generally covers improvements in inventory management techniques, increases in globalization, sectoral shifts, and smaller differences between the growth rates in expansions and recessions, in short, a better ability to absorb shocks. This class of explanations dates back to the first paper published on the topic of the Great Moderation (Kim and Nelson (1999)).[1] McConnell and Perez-Quiros (2000) and Kahn, McConnell, and Perez-Quiros (2002) argue that changes in inventory management techniques and improvements in information technology led to the decline in the volatility of output. This view has also been put forth more recently in the form of decreased inventory mistakes by Morley and Singh (2009).

Better policy is generally viewed as an improvement in the performance of monetary and/or fiscal policy. Increased economic stability is often associated with changes brought

[1] They found that smaller differences between the growth rates during expansions and recessions played an important role in causing the Great Moderation.

forth by the Volcker regime of tight monetary policy and commitment to low and stable inflation, which was continued by Alan Greenspan and Ben Bernanke. In this context, the definition of a “good policy” refers to following a policy rule, captured by the “Taylor rule” with the interest rate as the policy instrument. This point has been emphasized in the literature by Taylor (1999, 2007, 2010), Clarida, Gali, and Gertler (2000), and Bernanke (2004).[2] More countercyclical fiscal policy could also have been a factor, but this explanation has received little to no consideration in the literature, mostly because there is little evidence in favor of it. Hall (2011) states that "The government seems to lack the logistical tools to expand government expenditures significantly," making fiscal policy even less likely to have been the cause of the Great Moderation.

The good luck hypothesis, the reduction in volatility caused by smaller and/or less frequent exogenous shocks hitting the economy, has also been addressed as a potential cause of the Great Moderation.[3] Stock and Watson (2002, 2005) and Ahmed, Levin, and Wilson (2002) provide strong arguments that the reduced magnitude of shocks is the primary cause of the Great Moderation. The good luck hypothesis is the least stable of all potential causes, which can lead to uncertainty about future volatility. If the Great Moderation occurred because of good luck, then there is little reason to believe that we will continue to experience small, infrequent shocks.

Financial market innovations and global integration of financial markets, through new and more effective technologies, have also been suggested as a possible cause. Perri and Quadrini (2008) and Bekaert, Harvey, and Lundblad (2006) find that the financial

[2] Blanchard and Simon (2001) also documented the sharp decline in output and inflation volatility, and the strong relationship between the two across G-7 countries. They concluded that monetary policy played a complex role in the Great Moderation.

[3] Possible candidates for exogenous shocks are oil shocks, generally in the form of oil supply disruption, and productivity shocks, measured by trend growth productivity

liberalization of capital markets plays a role in decreasing volatility, while Dynan, Elmendorf, and Sichel (2006) defend the role of financial innovations in the form of improved assessment and pricing of risk, development of markets for riskier capital, household lending without strong collateral, and widespread securitization of loans. Gonzalez and Ruscher (2008) find some evidence that financial market deepness has a stabilizing role, though only for investment. The financial crisis sheds doubt on the effectiveness of financial innovations in reducing volatility.

The previous explanations are not mutually exclusive and, while most studies lean toward a single potential explanation, a combination would most likely be the full answer, as Ben Bernanke pointed out in his 2004 American Economic Association speech: "Explanations of complicated phenomena are rarely clear cut simple, and each […] probably contains elements of truth."

In order to test these explanations, we make two contributions to the literature on the Great Moderation. We first construct a new measure of volatility based on the first difference of the growth rates. We then perform the test for common features, presented by Engle and Kozicki (1993), which we adapt the feature of interest to be a decline in volatility. Next, we test whether the volatility of each component has a feature, a decline in volatility, in common with real output and interpret a common feature as evidence in favor of that series being a cause of the Great Moderation.

We start by testing each series for structural change(s) around the onset of the Great Moderation. The interpretation is that series displaying a significant break at or around the date of the structural break in the volatility of output (1983:2) are more likely to have caused or contributed to the Great Moderation.[4] At first glance, the most promising series based only on structural change tests are investment, residential investment, and exports of goods, with the break a quarter before the onset of the Great Moderation, in 1983:1. Good luck, represented in this case by Total Factor Productivity (TFP) from a Cobb-Douglass production function, comes second with the break coinciding with the break in GDP. Fiscal policy in the form of state and local government expenditure, although not mentioned in previous studies as a contributing factor, is another potential candidate with a break in 1982:1.

We also examine the mean and variance of the volatility of each candidate series over a few relevant time periods. This is primarily descriptive, but it does provide some useful information on which series can be eliminated as a potential cause. The mean volatility of pre-Great Moderation output is more than twice that of its value during the Great Moderation. Many of the components follow a similar pattern, although the decrease in volatility is not generally as large as the decline in output volatility. However, a few series have very small to no change in the mean volatility between the pre-Great Moderation and Great Moderation periods. These series, which include non-residential investment, non-residential investment in structures, non-residential investment in equipment and software, consumption of services, and imports of services, are effectively eliminated as a cause of the Great Moderation when applying this analysis.

Finally, we test whether each series has a common feature with output. As expected, several series satisfy this criterion: consumption, consumption of goods, investment, residential investment, inventory investment, net exports, exports, exports of goods, state and

[4] My findings are in accordance with those of Stock and Watson (2002), with a date break in 1983:2.

local government expenditures, and TFP.[5] Based solely on this observation, there is evidence in favor of improved policy (investment and residential investment for monetary policy, and state and local government expenditures for fiscal policy), good luck (TFP), and structural changes in the economy (including inventory management (inventory investment), globalization (net exports, exports, and exports of goods), and financial market innovations (non-residential investment, non-residential investment in structures, non-residential investment in equipment and software, consumption, and consumption of goods).

Globalization exhibits strong evidence of being a part of the low volatility story. The common feature between GDP and exports, exports of goods, and net exports (only for the sample ending in 2007:4) together with the favorable result of the structural change test for exports (with a break in 1978:3) and exports of goods (with a break in 1983:1) is evidence of a strong link. As part of the same explanation, improved inventory management also has a common feature and a significant structural break in 1988:1, and while it arises after the onset of the Great Moderation, there are reasons to believe it is not too far off.[6]

Monetary policy receives anecdotal support as a primary cause of the Great Moderation because, following the Volker disinflation, there was a clear shift in the policy regime around that time. We cannot use the test for common features to investigate this hypothesis because the policy shift was not a change in volatility. Instead, we use residential investment, which is very sensitive to changes in the interest rate, as a proxy for monetary policy, and find that it has a common feature with GDP and a structural break in 1983:1. This constitutes evidence that monetary policy played a role in causing the Great Moderation.

[5] The volatility of net exports only has a common feature with the volatility of GDP for the sample ending in 2007:4.

[6] The break date is essentially a point estimate with a non-informative confidence interval, see Stock and Watson (2003), therefore close is good enough.

Fiscal policy has mixed results, with state and local government expenditures having a common feature with GDP and a break in 1982:1. Aggregate government expenditure, federal government expenditure, federal non-defense spending, and federal defense spending do not have a common feature with GDP, and the structural breaks are not close to the beginning of the Great Moderation. There is evidence in favor of state and local expenditures causing the Great Moderation, but it appears to have been completely undone by federal spending, therefore fiscal policy, as a whole, is unlikely to have caused the Great Moderation.

Good luck seems to be a part of the explanation. A structural break in the volatility of TFP occurs along with the onset of the Great Moderation (1983:2), and also passes the second test, displaying a common feature with GDP. The evidence against good luck comes from the fact that there are two other smaller significant structural changes in the volatility of TFP, with the breaks occurring in 1962:1 and 1970:3, without accompanying changes in the volatility of output. Additional breaks in TFP volatility are consistent with the hypothesis that good luck accounts for part of the reduction in volatility, but not all of it. If good luck were the sole cause of the Great Moderation, we would expect to see two more structural breaks in the volatility of output, matching those of TFP.

We find no evidence in favor of financial market innovations. Non-residential investment and its sub-components, non-residential investment in structures and non-residential investment in equipment and software, show no sign of having caused the Great Moderation. The closest that we come to evidence in favor of financial markets causing the Great Moderation is consumption and its sub-component, consumption of goods, both have a common feature with output. However, this evidence is suspect because the structural break comes too late, in 1992:2 for consumption and 1992:1 for consumption of goods. Thus, the decrease in consumption volatility is likely to have been caused by the reduction in output volatility, rather than the reverse.

The remainder of the paper is organized as follows. In section 2, we present a brief description of the data and data sources. Section 3 explains the measure of volatility involved in this study. The empirical techniques and the results are presented in section 4, and we conclude in section 5.

1.2 Data

The key macroeconomic variables include observations from two main sources, The National Income and Product Accounts (NIPA) and the Federal Reserve Economic Data (FRED). Our analysis starts in 1953:4, although data sets are available beginning with 1947:1, in order to avoid the period of high volatility caused by the Korean War. Much of the data comes from NIPA Table 1.1.2. "Contributions to Percent Change in Real Gross Domestic Product" at a quarterly frequency. The growth contributions are calculated according to the formula:

$$\text{Growth Contribution of X to GDP}_t = \frac{X_t - X_{t-1}}{GDP_{t-1}} * 400,$$

where X is an individual variable chosen from a set of variables when decomposing real GDP on what the national income and product account call major product categories; the subscript "*t*" represents current time period; and "*t-1*" is a one quarter lag, or in other words, the annual growth contribution of consumption to GDP in percentage points. Growth contributions are very important in examining the causes of the Great Moderation two reasons. First, they allow calculations of volatility in series for which it would not normally be possible, such as inventory investment and net exports.[7] Second, they control for the size of each component, and as a result, the contribution to the aggregate growth rate is taken care of by carefully assessing individual shares scaled by real GDP.

A second category of series comes from St. Louis Fed Database (FRED): quarterly seasonally adjusted real GDP to three decimal places in billions of chained 2005 dollars, quarterly seasonally adjusted real gross private domestic investment to three decimal places in billions of chained 2005 dollars. Seasonally adjusted civilian employment is also converted from monthly to quarterly frequency by taking the average.

To identify an appropriate measure for good luck, we construct another variable. To measure good luck, or smaller and/or less frequent shocks hitting the economy, is difficult to construct and interpret.[8] The most straightforward way to deal with good luck is to use the Solow residual, or total factor productivity (A) from a Cobb-Douglas production function. To set up the production function, we first construct the value of the capital stock (K) using the perpetual inventory method based on the real gross private domestic investment term as follows: $K_t = K_{t-1} + (1-\delta)I_t$, where the initial value of capital is given by $K_0 = \frac{I_0}{(g+\delta)}$, δ is the capital depreciation of 6% and g is the growth rate of investment over the whole sample.[9] Output (Y) is simply real GDP from FRED, and labor (L) is civilian employment. With all the variables now identified for the production function, it is only left to make the classical assumption of two thirds for the labor share, and one third for the capital share,

[7] See Section 3 for more details.
[8] Giannone, Lenza, and Reichlin (2008) explained that the models for good luck are excessively naive in explaining the Great Moderation.
[9] I follow the value found for depreciation rate in the literature.

resulting in: $Y_t = A_t K_t^{\frac{1}{3}} L_t^{\frac{2}{3}}$.[10] The primary object of interest here is A_t, where volatility of TFP defines good luck.

1.3 Volatility

We define the volatility of a series "X" as the absolute value of the first difference of the growth rate.[11] A few minor adjustments are needed in order to properly use this somewhat novel volatility measure to better examine the causes of the Great Moderation. These changes come almost entirely from issues with the data. The first change is the most important and involves replacing the growth rates for GDP components with growth contributions. Thus, for the growth contribution of X on Y, the volatility becomes:

$$Volatility_t = \left|\left(\left(\frac{X_t - X_{t-1}}{Y_{t-1}}\right) - \left(\frac{X_{t-1} - X_{t-2}}{Y_{t-2}}\right)\right)\right|.$$

The difference is that now it measures the quarter-to quarter-fluctuations in the growth contribution of the component to GDP, rather than measuring the quarter-to-quarter fluctuations in the growth rate of the component. The primary reason the change was necessary is the structure of the inventory investment and net exports data series, both with values fluctuating around zero, which causes the growth rates to be impossible to calculate and even nonsensical. The secondary reason is that it allows us to capture changes in the size of the components in GDP.

The other change is switching to percentage change at annual rate, rather than quarterly growth rates, in order to stay consistent with the methodology adopted by BLS in calculating the growth contributions to GDP. The consequence of adopting this adjustment

[10] Gollin (2001)
[11] Clark, Papell, and Stoica (2011) also use this measure.

slightly alters the formula for volatility (multiplying it by 400), but does not change the interpretation.

Others have constructed different measures of volatility, Blanchard and Simon (2001) use a 20-quarter rolling window of standard deviations of quarterly real output growth. Cecchetti, Flores-Lagunes, and Krause (2006) used the standard deviation of innovations to output growth, Taylor (2000) exploited the standard deviation of the output gap, and Stock and Watson (2009) employed an instantaneous standard deviation. Another way to think about volatility is to use ARCH or GARCH specifications, as in McConnell and Perez-Quiros (2000), or to manipulate the absolute value of the deviations from the mean growth rate as in Ahmed, Levin, and Wilson (2002). Other measures used in the past include the severity of recessions and the length of expansions. We prefer our measure of volatility because it is always positive, which allows us to test for structural change in the mean, it has a short memory, thus it evolves quickly allowing us to date changes more precisely, and finally because it allows for net exports and inventory investment to be included in the analysis, which a measure based only on growth rates would not.

1.4 Empirical Techniques and Results

We start by examining the mean and variance of the volatilities over different periods. Table 1.1 presents the mean and variance of the volatility of each series for 1953:4-1983:2, 1983:3-2007:4, and 1983:3-2010:4.[12] The periods are chosen by using the break date for aggregate output to split the sample, and the analysis of the Great Moderation is conducted

[12] Graphs of the volatility of each series can be found in the web appendix accompanying this paper at http://www.uh.edu/~mwclark/research.html.

both with and without the financial crisis and its aftermath.[13] What is striking about the results in Table 1.1 is that the vast majority of series show a remarkable decline in both mean and variance. The series that do not show much (if any) decrease are consumption of services, nonresidential investment, nonresidential investment in structures, nonresidential investment in equipment and software, and imports of services. These series do not show any significant increase in mean and standard deviation, so the argument that something may have become more volatile in order to absorb the shocks and smooth output does not seem to have much strength here.

1.4.1 Structural Break Tests

Structural break tests are a natural place to start when asking the question of the decrease in volatility over time for real U.S. GDP components. The presence of structural breaks in the volatility of GDP and its component series affect the implications of econometric techniques. Non-linear models used in the first papers to be published on the topic, by Kim and Nelson (1999) and McConnell and Perez-Quiros (2000), do not necessarily offer an improvement over the classical structural change models if the break is not known explicitly, which may also invalidate the test statistics.[14] Therefore, the best way to answer the question is to use a structural break test that endogenously chooses the break date by maximizing the evidence for a structural change, as opposed to using a structural break at a known point in time as in Chow (1960). This type of test, first developed by Andrews (1993), and generalized in important ways by Vogelsang (1997), is designed to deal with series containing no more than one break and, as a downside, can have low power to detect a single break in the presence of

[13] We find that the break date for output volatility is 1983:2 which is consistent with Stock and Watson (2002) and not significantly different than the rest of the literature.
[14] They use Markov-switching processes and test formally for a break in the first two moments using the Andrews-Ploberger (1994) test for structural change

multiple breaks, as shown by Bai (1997). In our case, the Andrews (1993) and Vogelsang (1997) test for a single structural break in the mean takes the form:

$$y_t = \alpha + \beta y_{t-1} + \theta DU_t + \varepsilon_{t.}$$

Where y_t is the series of interest, y_{t-1} controls for possible serial correlation parametrically, DU_t is a dummy variable that takes the value of 1 when t > T_b and 0 otherwise, where T_b is the break date, and ε_t is the error term at time t.

The Great Moderation was a single event in the history of the United States, but this does not necessarily say anything about how often the volatility of the affected components decreased. To reduce the likelihood of making any omissions, we also perform the Bai and Perron (1998) test for multiple structural changes at unknown break dates.[15] The test regression includes a dummy variable that takes the value of 1 starting at the break date and chooses the break date to minimize the sum of squared residuals:

$$y_t = x_t^{'}\beta + z_t^{'}\delta_j + u_t \text{ , } for\ j = 1, \ldots, m+1, where\ t = T_{j-1} + 1, \ldots, T_j \text{ ; } T_0 = 0 \text{ ; } T_{m+1} = T.$$

The observed dependent variable at time t is y_t; x_t is a covariate with the corresponding vector of coefficients β; and z_t is a vector of covariates with the corresponding vector of coefficients δ_j ; u_t is the error term at time t.

The measure of volatility is non-trending, so we only search for a change in the mean. When we test for multiple breaks, we include a dummy variable for each break date and choose both the number of breaks and the break date sequentially. Using the methodology proposed in Bai and Perron (2003), we test the null hypothesis of l changes versus the alternative of $l + 1$ changes, based on the $sup\, F(l + 1|l)$ statistic. If the overall minimal value of the sum of squared residuals (SSR) for the model with $l + 1$ breaks is smaller than

[15] As shown in Prodan (2008), this test has a potential issue with size distortions when used on a persistent series. Fortunately, the volatility of real GDP for the United States is not at all persistent.

the SSR for the model with l breaks, we reject the l break model. In the same manner, we use a $\sup - F$ test statistic for the null hypothesis of no change ($m = 0$) versus the alternative of $m = 2$ breaks.

Structural break tests require choosing how much we want to trim the data when searching for a structural change. Trimming the data too much is undesirable because too much trimming may mask either the most significant or a second break. Too little trimming is also a problem because it can lead to false break dates appearing at the very beginning or end of the sample. We use 15% to provide a reasonable balance between having enough, but not too much trimming.

There are two ways to control for the correlation of the residuals. Parametrically, which is our preferred method, involves including lagged values of the dependent variable in the regression. For our analysis, one lag is sufficient. A nonparametric correction could also be used, and involves applying a nonparametric correction to the residuals in order to have proper asymptotic inference. We use the parametric method for the majority of our analysis, but we use the nonparametric approach as a robustness check. In this case, the parametric and nonparametric tests give the same results with very few minor discrepancies. One possible explanation for this is that the series have low degrees of serial correlation. Another possible explanation is that the nonparametric correction is sufficient for correcting the serial correlation present in the errors. The exact nature of the serial correlation is not important for my analysis, but there would be cause for concern different results were obtained with the parametric and nonparametric corrections.

For each series, we first test for one structural break in the mean of the volatility, utilizing the $\sup - F$ statistic to determine if there is a break, and if so, when the break occurs. Table 1.2 reports the $sup - F$ test statistic and the corresponding break date for one break. The primary point of reference is 1983:2, the break date for the volatility of real GDP, which is also known in the literature as the onset of the Great Moderation. This test, on its own, provides little hard evidence on what may have caused the Great Moderation, but it does point to some possibilities based on when the breaks occur. For one break, there is evidence suggesting that a particular series caused the Great Moderation if it has a structural break close to the beginning of the Great Moderation. Several series fit this story - investment, residential investment, and exports of goods - all exposing a break one quarter before the Great Moderation began (break in 1983:1), followed by government expenditure at the state and local level, with a break a year prior, in 1982:1. A little further back, exports has a break in 1978:3 and consumption of nondurable goods in 1978:1. These should be considered, but unless they affect the volatility of GDP with a long lag, they are unlikely to be among the causes.

On the production function side, capital has a break slightly after the Great Moderation(but not significantly different), dated to 1984:3, which is to be expected because of its similarity to investment.[16] The volatility of TFP, my preferred measure for good luck, has a break in 1983:3 if we analyze only the period until the Great Recession (1953:4-2007:4), or 1983:2 for the whole sample, including the recession (1953:4-2010:4). Again, the break is shortly after or identical to the break in output.

For multiple breaks, the Bai and Perron (1998, 2003) test is used, allowing for a maximum of four breaks that are chosen sequentially. If no structural change is found, we allow for the possibility of restricted structural change (offsetting structural changes) and other similar features by testing the null of zero breaks, against the alternative of two breaks.

[16] Recall that capital is constructed using the Perpetual Inventory Method from investment.

More than two breaks, against the alternative of zero breaks, are not considered for this alternative for two reasons. First, when testing sequentially, only the volatility of TFP has more than two breaks. Second, if there are more than two breaks, the possibility of restricted structural change (or a close approximation) is unlikely, as a result, the possibility of three breaks is not considered when there is no evidence of one break.

As a reminder, what is interpreted as evidence of a cause of the Great Moderation is the series having one break near 1983:2. We will deal with those having additional breaks on a case-by-case basis. This is a good way to analyze the possibility of multiple structural changes because there are few series with more than one structural break, and of those series, only the volatility of investment in nonresidential structures and the volatility of TFP have at least two structural breaks for both samples. Additionally, for the sample ending in 2007:4, imports and imports of goods have two breaks, but not one, and for the sample ending in 2010:4, imports of services has a second sequential break. TFP encompasses three structural breaks (1983:2, 1962:1, and 1970:3) and only one of them is close to the establishment of the Great Moderation. Imports has breaks in 1968:3 and 1986:2 while imports of goods has breaks in 1968:3 and 1986:3 both of these appear to be restricted structural change with high volatility in-between the two breaks. This does not hold for the sample ending in 2010:4 largely because the volatility of both increased drastically with the Great Recession. Imports of services exhibits a different trend, with sequential breaks in 1964:1 and 2001:1, with low volatility in-between the two breaks, but in this case the breaks are not offsetting. Finally, non-residential investment in structures has two breaks, but not one, for both samples, with the breaks occurring in 1978:1 and 1988:3 for the sample ending in 2007:4 and 1978:8 and 1988:2 for the sample ending in 2010:4, with high volatility in-between the two break dates.

Any structural break after our central focus, 1983:2, can be interpreted as evidence against the series (and the accompanying explanation) exhibiting the cause of the Great Moderation, as there is no associated additional break in output.

The results of the multiple structural break test are reported in Tables 1.3 to 1.6 for both the full sample (1953:4-2010:4) and the period ending at the Great Recession (1953:4-2007:4), only reporting the results that are not contained in Table 1.2. It is important to note that there are few differences between the two samples; however, there is an active contention that the Great Moderation is over, ending as the Great Recession began. If that is the case, it would not be appropriate to include the post-Great Moderation time period in our analysis.

1.4.2 Common Features

The major innovation of this paper comes from applying the common features test, presented by Engle and Kozicki (1993). This paper is the first in the Great Moderation literature to apply this test and sheds some light on the possible explanations of the phenomenon.

The common feature test is very similar to a cointegration test, but is not restricted to series that have a unit root. The basic procedure of the test involves verifying if two series (output and components) have the feature of interest, which is in this case the reduction in volatility, followed by verification that a linear combination of the two series does not have the feature. If this is the case then it is said to be a common feature. One of the major advantages of the common features test is the fact that the feature can take almost any form (e.g. , serial correlation, trends, seasonality, or heteroscedasticity).

Testing for a common feature is a two-step process. First, it is necessary to test whether each series, on its own, has the feature. This step is important because if one series does not have the feature there will always be a linear combination of the two series that does not have the feature as well (zero weight on the series that has the feature). The second step is to test if there is a linear combination of the series that does not have the common feature.

The basic set up for testing for common features is to use bivariate pairs, which in this case are the volatility of GDP, as the first series of each bivariate pair, and the volatility of the components of GDP as well as the volatility of capital, civilian employment, and TFP as the second series of the pair. The specification for Step 1 is $y_t = x_t\beta + z_t\gamma + \varepsilon_t$, where y_t is the series of interest, x_t represents the controls for the regression, and z_t represents the feature of interest. To test if a series possesses a feature, consider the following hypothesis:

$$H_0: No\ Feature\ (\gamma = 0)$$

$$H_1: Feature\ (\gamma \neq 0),$$

First regression: $(1)\ \ y_t = x_t\beta + e_t$

Second regression: $(2)\ \ e_t = z_t\gamma + u_t.$

Where e_t is the residuals from (1), the test statistic for the LM version (which we are using) is TR^2 from regression (2) and is distributed χ^2_n , where n is the number of regressors in z_t.

The second step involves testing if the feature is common, or in other words, if there is a linear combination of the two series that does not have the feature. To test if the feature is common, we must first have two series that both have the feature, $y_{1t} = x_t\beta + z_t\gamma + \varepsilon_{1t}$ and $y_{2t} = x_t\beta + z_t\gamma + \varepsilon_{2t}$, where x_t and z_t are assumed to be the same for each series. The following hypothesis is then tested.

$$H_0: Common\ Feature$$

$$H_1: Feature\ not\ common$$

The test is done by performing limited information maximum likelihood, or asymptotically two-stage least squares (2SLS). In each case, the general form of the regression is $y_{1t} = \delta y_{2t} + x_t\beta + \varepsilon_t$, where the instrument list is {x, z}. The test statistic is essentially a test for overidentifying restrictions, or TR^2 from a regression of $\varepsilon_t = x_t\beta + z_t\gamma + e_t$ and is distributed χ^2_m where *m* is the number of overidentifying restrictions.[17]

In this general framework, we will test for a decrease in volatility (the Great Moderation), and whether the decrease in volatility is common among the series. In the specification, x_t is a constant, and z_t is a dummy that takes a value of one in 1983:2 or later, 0 otherwise, and a trend term. It is important to note that z_t must have at least two terms, or there will be no overidentifying restrictions in the second step, and therefore it will be impossible to determine whether the feature is common.

Separating coincidence from causality is probably the biggest issue in determining the cause(s) of the Great Moderation. The common features test does not solve that problem and, in fact, does not even attempt to.[18] Consider the following example for clarification. Suppose that there existed two series X and Y, such that X=2Y, and both series have a feature of a structural decrease. If only the two series are observed, and not their direct relationship, it may be of interest to test if the feature is common between them. In this case you would search for a linear combination of X and Y such that there is no structural decrease in the resulting series. In this simplistic example, an acceptable linear combination (Z) would be: Z = X - 2Y, giving a resulting series Z that is zero everywhere and has no structural decrease.

---

[17] The number of overidentifying restrictions(m) will be one less than in the first stage (n)

[18] There is only one structural change in volatility (the beginning of the Great Moderation) or only one observation, making it impossible to distinguish between coincidence and causality.

Thus, the two series would have a common feature. When the feature is the same (or common), the plausibility of coincidence decreases drastically.

The first stage provides some interesting results, as it applies to the causes of the Great Moderation. If a series does not have the feature, it is unlikely to be a cause of the Great Moderation. Consumption of durable goods, consumption of services, nonresidential investment, nonresidential investment in structures, nonresidential investment in equipment and software and imports of services do not have the feature. This is interpreted as evidence against any of these components causing the Great Moderation, and also excludes them from the second stage. All other series reject the null of no feature, which by itself is not to be interpreted as that component being a cause of the Great Moderation, but rather that it qualifies for further testing. The results for the first stage are reported in Table 1.7.

For the second stage, we perform both the limited information maximum likelihood (LIML) and 2SLS procedures, which, while asymptotically equivalent, do not necessarily produce the same results. It is important to note that in comparison with LIML, the 2SLS statistics are necessarily larger, and therefore more likely to reject the null hypothesis of a common feature. We will once again interpret a component having a common feature of a decrease in volatility with GDP as evidence that the component likely has something to do with the Great Moderation. This test only attempts to determine if the feature is common, so the strict interpretation of having a common feature meaning that it caused the Great Moderation is inappropriate. To a certain extent, it will be taken as a positive sign that the series could have caused the Great Moderation if the feature is common. Seventeen components and subcomponents of GDP have the feature of a decrease in volatility. The volatility of the components from the production side (capital and TFP) also have a significant decrease in volatility, while civilian employment registers the same decrease at 10% significance for the 1953:4-2007:4 sample only (no significant decline in the full sample).

The most important part of the common features test is to test whether these series share a common decrease in volatility with GDP. For the sample ending in 2007:4, Tables 8 and 9, nine of the seventeen components have a common feature with GDP: consumption, consumption of goods, investment, residential investment, inventory investment, net exports, exports, exports of goods, and state and local government expenditures. The volatility of capital and TFP also have a common feature with output. The other eight components reject the null of a common feature in favor of that feature not being common. The results are similar for the sample ending in 2010:4, Tables 8 and 10, with the only difference being that net exports no longer has a common feature with GDP and the volatility of civilian employment no longer has the feature at all, so is not included in the second stage.

The results for the LIML specification are reported in Table 1.8, while the results for the 2SLS specification are reported in Tables 1.9 and 1.10. For the sample ending in 2007:4 there are nine components that have a common feature with GDP, and eight for the sample ending in 2010:4. The eight components that share a common feature with GDP are consumption, consumption of goods, investment, residential investment, inventory investment, exports, exports of goods, and government expenditure at the state and local level. The list for the sample ending in 2007:4 is the same with the addition of net exports. In addition to the components, we tested the volatility of TFP, civilian employment, and the capital stock. The volatility of TFP and capital both have a common feature with GDP, while the volatility of civilian employment does not have a common feature with GDP.

The common features test provides us with some compelling results. Residential investment has a common feature, suggesting that improved monetary policy played a role in causing the Great Moderation. TFP also has a common feature, despite having multiple structural changes, which is consistent with the stylized fact that good luck is part of the cause. Finally, Inventory investment, exports of goods, and net exports (for 2007:4 sample only) all have a common feature with output, providing more evidence in favor of the structural changes in the economy hypothesis.

1.5 Conclusions

We examine the causes of the Great Moderation using a novel measure of volatility based on the absolute value of the first difference of the growth rates, as well as tests for endogenous structural changes and the common features test. There is strong evidence in favor of structural changes in the economy, improvements in monetary policy, and good luck influencing the decline in volatility.

Structural changes to the economy have received a lot of attention in the past with substantial evidence in favor of it. Better inventory management techniques including just-in-time inventory methods, ordering systems, and fewer inventory mistakes tell a good story about why the moderation in inventory investment is an important structural change in the economy, with a common feature and a structural break in 1988:1. Another explanation from the same category is increased globalization and risk sharing, the evidence arising from the decline in volatility for exports with a structural break in 1978:3, exports of goods with a break in 1983:1 and net exports, sample ending in 2007:4 only, with a break in 1986:2, all of which have a common feature. These results present strong evidence in favor of structural changes to the economy causing the Great Moderation; however, one could argue that a moderation on both sides of trade would be expected.

Good luck is the hypothesis that has received the most attention and has had the most evidence in favor of it. The predicament when assessing good luck as a cause is that, in the absence of an explanation on why shocks are smaller or less frequent, it is a deeply unsatisfactory explanation. Unfortunately we cannot make the premise more appealing, especially since our measure of good luck is the volatility of the Solow residual from a Cobb-Douglas production function. However, we do present solid evidence in favor of the good luck hypothesis as being at least a contributing cause of the Great Moderation, with a structural break in 1983:3 and a common feature with output.

Better monetary policy contributed to the Great Moderation through residential investment, which we use as a proxy for monetary policy. The volatility of residential investment undergoes a moderation, with a break in 1983:1 and has a common feature with GDP, which suggests that monetary policy is one of the causes of the Great Moderation.

There is mixed evidence as to whether better fiscal policy had anything to do with the Great Moderation. This is seen quite clearly in the common features test. In the first stage, every subcategory of government spending has a moderation in volatility, but in the second stage, only state and local government expenditure has a common feature with GDP. The lack of attention that the "better fiscal policy" explanation has received seems to be justified by a lack of evidence. State and local government expenditure having a common feature with GDP and a structural break in 1982:1 is encouraging, but the fact that overall government expenditure does not have a common feature with GDP suggests that it is overpowered by the federal spending, and therefore improved fiscal policy is unlikely to have caused the Great Moderation.

Finally, there is no evidence that financial market innovation, deepening, or liberalization play a major role in causing the Great Moderation. The lack of evidence for non-residential investment, non-residential investment in equipment and software, and non-residential investment in structures including no decrease in summary statistics, no feature, and only non-residential investment in structures having significant structural breaks (two breaks at 1978:1 and 1988:2) actually provide strong evidence against this theory.

In total, it seems that the economy was hit by smaller, less frequent productivity shocks, that were dealt with through improved monetary policy, as well as state and local fiscal policy, and saw several minor changes in the structure of the economy, including better inventory management and increased globalization. It is important to remember that while all of these seem to have played at least a minor role, with only one realization, it is impossible to ascertain with any confidence whether they play a causal role, if the causal role is reversed, or if they are only coincidental.

1.6 Tables

Table 1.1 Mean and Variance of Volatility

	1953:4 -1983:2		1983:3-2007:4		1983:3-2010:4	
Series	Mean	Variance	Mean	Variance	Mean	Variance
GDP	4.38	10.85	2.02	2.38	2.07	2.30
Consumption	1.95	2.14	1.32	1.04	1.29	1.01
Consumption of Goods	1.69	1.83	1.15	0.87	1.16	0.84
Consumption of Durable Goods	1.28	1.40	1.02	0.81	1.00	0.76
Consumption of Nondurable Goods	0.76	0.29	0.41	0.15	0.42	0.14
Consumption of Services	0.60	0.23	0.48	0.13	0.48	0.13
Investment	3.57	8.55	2.01	2.60	1.99	2.69
Non-residential Investment	0.82	0.52	0.71	0.30	0.75	0.38
Non-residential Investment in Structures	0.36	0.11	0.36	0.09	0.37	0.10
Non-residential Invest. in Equip. & Software	0.72	0.36	0.63	0.22	0.63	0.25
Residential Investment	0.78	0.44	0.30	0.06	0.32	0.07
Inventory Investment	3.37	7.01	1.93	2.58	1.87	2.55
Net Exports	1.29	1.13	0.85	0.48	1.01	0.78
Exports	1.32	1.42	0.63	0.25	0.69	0.37
Exports of Goods	1.11	1.13	0.57	0.16	0.62	0.24
Exports of Services	0.51	0.27	0.34	0.09	0.33	0.08
Imports	1.07	1.32	0.76	0.37	0.97	0.94
Imports of Goods	0.98	1.20	0.73	0.33	0.92	0.85
Imports of Services	0.26	0.08	0.21	0.03	0.22	0.03
Gov. Expenditure	1.14	0.76	0.76	0.36	0.74	0.35
Federal Gov. Expenditure	1.02	0.78	0.68	0.30	0.66	0.29
Federal Defense Gov. Expenditure	0.82	0.42	0.57	0.23	0.56	0.21
Federal Non-defense Gov. Expenditure	0.60	0.36	0.29	0.17	0.27	0.16
State and Local Gov. Expenditure	0.42	0.14	0.24	0.05	0.24	0.05
TFP	1.16	0.74	0.50	0.14	0.54	0.21
Civilian Employment	0.60	0.33	0.39	0.13	0.43	0.17
Capital	0.24	0.02	0.16	0.02	0.18	0.02

Notes: 1. All of the series are volatility of real variables.

Table 1.2 Single Structural Break Test Results

	1953:4-2010:4		1953:4-2007:4	
Series	Break Date	SupF	Break Date	SupF
GDP	1983:2***	26.150	1983:2***	24.340
Consumption	1992:2***	16.833	1992:2***	14.655
Consumption of Goods	1992:1**	11.018	1992:1**	11.251
Consumption of Durable Goods	1990:2	7.117	1990:2	6.612
Consumption of Nondurable Goods	1978:1***	19.903	1978:1***	18.574
Consumption of Services	1993:4**	12.961	1993:4***	13.370
Investment	1983:1***	13.839	1983:1**	12.672
Non-residential Investment	1990:4	2.707	1990:4	4.749
Non-residential Investment in Structures	1978:1	4.239	1991:4	4.219
Non-residential Invest. in Equipment and Software	1961:4	3.823	1988:1	3.626
Residential Investment	1983:1***	20.870	1983:1***	22.096
Inventory Investment	1988:1**	12.549	1988:1**	11.097
Net Exports	1986:2	2.525	1986:2*	8.422
Exports	1978:3**	9.868	1978:3**	10.784
Exports of Goods	1983:1*	7.325	1983:1*	8.200
Exports of Services	1966:4***	13.136	1966:4**	12.161
Imports	1968:1	5.159	1986:2	6.201
Imports of Goods	1968:1	6.130	1968:1	5.052
Imports of Services	1961:4***	18.424	1961:2***	23.770
Government Expenditure	1963:4***	21.784	1963:4***	20.517
Federal Government Expenditure	1963:4***	25.410	1963:4***	23.923
Federal Defense Government Expenditure	1973:4***	21.706	1973:4***	20.101
Federal Non-defense Government Expenditure	1963:4***	24.731	1961:2***	28.337
State and Local Government Expenditure	1982:1**	10.850	1982:1**	9.433
TFP	1983:3***	33.783	1983:4***	39.956
Civilian Employment	1961:2**	12.959	1961:2***	14.962
Capital	1984:3	5.608	1984:3**	10.155

Notes: 1. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.
2. The SupF is the Supremum of the F-Statistic, as the break date is the chosen at the point that maximizes evidence of a break, where the F-Statistic is the largest.

Table 1.3 Multiple Structural Break Test When There is Not One Significant Break

1953:4-2010:4					
Series	Number of Breaks	Break 1	Break 2	SupF 1|0	SupF 2|0
Non-res. Invest. in Structures	0	1978:1***	1988:2***	4.239	11.006

Notes: 1. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.
2. Only series that have additional structural changes, compared to the single break model, are reported.
3. The presence of offsetting structural breaks can mask the presence of one break, therefore we test for the whether a model with two breaks fits the data significantly better than a model with no breaks.
4.The SupF is the Supremum of the F-Statistic, as the break date is the chosen at the point which maximizes evidence of breaks, where the F-Statistic is the largest.

Table 1.4 Multiple Structural Break Test When There are Multiple Sequential Breaks

1953:4-2010:4							
Series	Number of Breaks	Break 1	Break 2	Break 3	SupF 1|0	SupF 2|1	SupF 3|2
Imports of Services	1***/ 2*	1964:1***	2001:1*	x	18.424	9.330	2.591
TFP	1***/3**	1983:2***	1962:1**	1970:3**	33.239	10.179	12.446

Notes: 1. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.
2. Only series that have additional structural changes, compared to the single break model, are reported.
3. The SupF is the Supremum of the F-Statistic, as the break date is the chosen at the point which maximizes evidence of breaks, where the F-Statistic is the largest, the breaks are chosen sequentially, and thus are conditional on the breaks that have already been identified.

Table 1.5 Multiple Structural Break Test When There is Not One Significant Break

1953:4-2007:4					
Series	Number of Breaks	Break 1	Break 2	SupF 1|0	SupF 2|0
Non-res. Invest. in Structures	0	1978:1***	1988:3***	4.219	13.705
Imports	0	1968:3***	1986:2***	6.201	12.705
Imports of Goods	0	1968:3***	1986:3***	5.052	11.723

Notes: 1. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.
2. Only series that have additional structural changes, compared to the single break model, are reported.
3. The presence of offsetting structural breaks can mask the presence of one break, therefore we test for the whether a model with two breaks fits the data significantly better than a model with no breaks.
4. The SupF is the Supremum of the F-Statistic, as the break date is the chosen at the point which maximizes evidence of breaks, where the F-Statistic is the largest.

Table 1.6 Multiple Structural Break Test When There are Multiple Sequential Breaks

1953:4-2007:4							
Series	Number of Breaks	Break 1	Break 2	Break 3	SupF 1|0	SupF 2|1	SupF 3|2
TFP	1***/3**	1983:3***	1961:3**	1970:3**	39.504	11.905	13.024

Notes: 1. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.
2. Only series that have additional structural changes, compared to the single break model, are reported.
3. The SupF is the Supremum of the F-Statistic, as the break date is the chosen at the point which maximizes evidence of breaks, where the F-Statistic is the largest, the breaks are chosen sequentially, and thus are conditional on the breaks that have already been identified.

Table 1.7 Test for Common Features Stage 1 Results

Series	TR^2	
	1953:4-2007:4	1953:4-2010:4
GDP	33.424***	35.196***
Consumption	9.163**	10.015***
Consumption of Goods	8.620**	8.921**
Consumption of Durable Goods	2.044	2.308
Consumption of Nondurable Goods	17.058***	17.766***
Consumption of Services	3.019	3.121
Investment	20.791***	21.892***
Non-residential Investment	0.662	0.248
Non-residential Investment in Structures	0.284	0.442
Non-residential Invest. in Equip. & Software	0.795	0.677
Residential Investment	43.383***	44.868***
Inventory Investment	21.805***	23.369***
Net Exports	13.901***	12.158***
Exports	26.632***	25.787***
Exports of Goods	21.193***	20.615***
Exports of Services	4.905*	5.347*
Imports	9.947***	8.697**
Imports of Goods	9.659***	8.862**
Imports of Services	3.942	2.986
Government Expenditure	7.872**	8.400**
Federal Government Expenditure	7.864**	8.474**
Federal Defense Government Expenditure	6.318**	6.817**
Federal Non-defense Government Expenditure	11.618***	12.776***
State and Local Government Expenditure	14.516***	15.693***
TFP	31.841***	30.675***
Civilian Employment	5.041*	3.371
Capital	12.133***	9.388***

Notes: 1. H_0: Series $does\ not\ have\ the\ Feature$; H_1: $Series\ has\ the\ Feature$
2. The test statistic is TR^2 from a regression of $\varepsilon_{it} = dummy_t + Trend_t + \upsilon_{it}$, where ε_t is the error term from the regression $x_{it} = Constant + \varepsilon_{it}$ where x_{it} is a volatility series and ε_{it} is the error term, $dummy_t = 1$ starting in 1983:2 and 0 otherwise, $Trend_t$ is a linear time trend, and υ_{it} is the error term. The test statistic is distributed χ_2^2.
3. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

Table 1.8 Test for Common Features Stage 2 Results LIML

Series	1954:3-2007:4		1954:3-2010:4	
	GDP		GDP	
	TR^2	δ (row series)	TR^2	δ (row series)
Consumption	0.892	3.921	1.543	3.724
Consumption of Goods	0.119	4.594	0.078	4.635
Consumption of Nondurable Goods	3.930**	6.682	3.754*	6.703
Investment	0.381	1.483	0.120	1.453
Residential Investment	0.807	4.586	1.488	4.661
Inventory Investment	0.449	1.574	0.038	1.512
Net Exports	1.641	5.164	9.285***	6.026
Exports	0.081	3.275	0.670	3.439
Exports of Goods	0.030	4.208	0.437	4.419
Exports of Services	3.570*	13.542	3.826*	13.161
Imports	3.974**	6.407	16.725***	8.901
Imports of goods	6.186**	7.099	21.002***	10.197
Government Expenditure	22.800***	4.126	22.265***	4.240
Federal Government Expenditure	30.692***	3.115	30.705***	3.322
Federal Defense Government Expenditure	22.650***	5.797	22.643***	5.917
Federal Non-defense Government Expenditure	35.679***	2.401	36.364***	2.643
State and Local Government Expenditure	0.018	13.192	0.111	12.808
TFP	1.793	3.557	0.592	3.804
Civilian Employment	7.292***	10.805	x	x
Capital	1.140	28.325	0.216	35.873

Notes: 1.The general form of the regressions is $y_{1t} = \delta y_{2t} + x_t\beta + \varepsilon_t$, where y_{1t} is volatility of output, and y_{2t} is the row series. The test statistic is TR^2 and is distributed χ_1^2.
2. $H_0: Feature\ is\ common$; $H_1: Feature\ is\ not\ common$
3. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

Table 1.9 Test for Common Features Stage 2 Results 2SLS

1953:4-2007:4						
	Normalization 1			Normalization 2		
Series	TR^2	δ (Row)	tstat δ	TR^2	δ (GDP)	tstat δ
Consumption	0.936	3.690	3.614	0.889	0.253	3.522
Consumption of Goods	0.120	4.551	3.398	0.119	0.218	3.383
Consumption of Nondurable Goods	4.126**	5.897	4.153	3.987**	0.137	4.082
Investment	0.383	1.469	5.561	0.381	0.623	5.541
Residential Investment	0.809	4.524	5.011	0.812	0.214	5.021
Inventory Investment	0.452	1.553	4.956	0.449	0.632	4.838
Net Exports	1.766	4.633	3.420	1.639	0.188	3.294
Exports	0.081	3.267	4.214	0.081	0.305	4.213
Exports of Goods	0.030	4.204	4.080	0.030	0.237	4.079
Exports of Services	4.606**	9.209	2.675	3.578*	0.066	2.358
Imports	5.229**	4.294	2.894	3.944**	0.144	2.513
Imports of goods	9.175***	3.748	2.789	6.106**	0.123	2.275
Government Expenditure	24.297***	2.046	3.065	22.875***	0.137	2.934
Federal Gov Expenditure	29.532***	1.416	2.345	32.284***	0.112	2.452
Federal Defense Government Expenditure	25.704***	2.189	2.324	23.372***	0.080	2.216
Federal Non-defense Gov Expenditure	30.954***	1.838	2.676	45.237***	0.103	3.235
State and Local Gov Expenditure	0.018	13.179	3.716	0.018	0.076	3.715
TFP	1.801	3.453	5.117	1.812	0.271	5.133
Civilian Employment	10.026***	5.922	2.827	7.304***	0.075	2.413
Capital	1.186	26.540	3.524	1.141	0.034	3.456

Notes: 1. The general form of the regressions is $y_{1t} = \delta y_{2t} + x_t\beta + \varepsilon_t$, where for Normalization 1, y_{1t} is the Volatility of GDP, and y_{2t} is the row series, and for Normalization 2, y_{1t} is the row series, and y_{2t} is the Volatility of GDP. The test statistic is TR^2 and is distributed χ_1^2.
2. H_0: $Feature\ is\ common$; H_1: $Feature\ is\ not\ common$
3. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

Table 1.10 Test for Common Features Stage 2 Results 2SLS

1953:4-2010:4						
	Normalization 1			Normalization 2		
Series	TR^2	δ (Row)	tstat δ	TR^2	δ (GDP)	tstat δ
Consumption	1.647	3.412	3.911	1.535	0.265	3.775
Consumption of Goods	0.079	4.607	3.466	0.078	0.216	3.456
Consumption of Nondurable Goods	3.928**	5.986	4.310	3.799*	0.138	4.238
Investment	0.12	1.448	5.740	0.120	0.688	5.734
Residential Investment	1.495	4.545	5.071	1.503	0.208	5.085
Inventory Investment	0.038	1.510	5.093	0.038	0.661	5.091
Net Exports	13.857***	2.844	3.015	9.081***	0.140	2.441
Exports	0.677	3.361	4.190	0.672	0.287	4.172
Exports of Goods	0.441	4.340	4.041	0.437	0.224	4.022
Exports of Services	1.535	9.127	2.831	3.834*	0.068	2.514
Imports	30.536***	1.244	1.831	15.754***	0.080	1.315
Imports of goods	34.415***	0.893	1.405	19.441***	0.061	1.056
Government Expenditure	24.186***	2.194	3.322	22.290***	0.144	3.189
Federal Government Expenditure	30.195***	1.556	2.620	32.065***	0.120	2.700
Federal Defense Govt Expenditure	26.013***	2.389	2.571	23.261***	0.085	2.432
Federal Non-defense Govt Expenditure	31.847***	1.987	2.977	45.341***	0.110	3.552
State and Local Gov Expenditure	0.111	12.742	3.238	0.111	0.078	3.929
TFP	0.594	3.761	5.118	0.594	0.260	5.116
Capital	0.22	35.113	2.894	0.216	0.028	2.869

Notes: 1. The general form of the regressions is $y_{1t} = \delta y_{2t} + x_t\beta + \varepsilon_t$, where for Normalization 1, y_{1t} is the Volatility of GDP, and y_{2t} is the row series, and for Normalization 2, y_{1t} is the row series, and y_{2t} is the Volatility of GDP. The test statistic is TR^2 and is distributed χ^2_1.

2. H_0: $Feature\ is\ common$; H_1: $Feature\ is\ not\ common$

3. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

Chapter II

Is the Great Moderation Common Across Countries?

2.1 Introduction

Over the past three decades, the volatility of output growth in most industrialized countries has declined substantially, and consequently, a moderation of the business cycle occurred. While the magnitude of the decline is similar across countries, the timing and nature of the reduction in volatility varies widely, but we can say with certainty that is a widespread phenomenon. This remarkable feature of the worldwide macroeconomic landscape is called The Great Moderation. In nearly all the countries, the output volatility was higher in the early part of the sample. In United States (US), France, Germany, and Italy, the change from high to low volatility regime seemed to have happened relatively quickly, while in Australia, Canada, South Africa, Switzerland, and the United Kingdom (UK), the volatility seems to have multiple swings from high to low.

In this paper, we analyze if the Great Moderation is one event internationally, common across countries, or multiple events. We first search for structural changes in the volatility of real GDP growth for each country, using structural break tests for one and multiple changes, as described in Bai and Perron (1998, 2003), and determine whether or not the Great Moderation has occurred domestically. We then employ the common features test developed by Engle and Kozicki (1993) to examine if the decline in volatility is common across pairs of countries. We interpret the similarities in the experiences of all countries might suggest that there is only one single event and one common explanation assessing the cause(s) of the Great Moderation. The cross-country differences in both timing and the lack of common features might support the multiple unrelated events hypothesis.

The Great Moderation in the US has been extensively documented and its causes debated since the seminal work of Kim and Nelson (1999), McConnell and Perez-Quiros (2000), and Blanchard and Simon (2001). Even though these papers use different econometric techniques, they individually assess the substantial reduction in the variability of US real GDP growth in mid 1980s by more than half of its previous value rather suddenly, or more gradually, taking place over several quarters, respectively. Stock and Watson re-examine the low volatility regime and find a rather sudden break occurring in 1983:2.

Although the moderation of real GDP growth volatility has manifested in other developed countries, there is no clear consensus on the timing of its occurrence. Mills and Wang (2000), Stock and Watson (2005), and Smith and Summers (2009) studied the onset of the Great Moderation in G7 countries and found the reductions to be neither concurrent, nor of similar magnitudes when searching for one structural change. The results show that the output volatility stabilized around 1980s and 1990s for most countries, but there is almost no tendency towards international synchronization of business cycle fluctuations.[1]

In the empirical literature on the Great Moderation, structural break tests for one or multiple breaks are predominant in detecting the change from low to high volatility regimes. This type of model has the advantage of capturing the timing of the break endogenously. For this study, we use Bai and Perron's (2003) structural break test to identify the change(s) in the volatility of eleven industrialized countries (G7, except Japan, and including other OECD countries, such as Australia, South Korea, South Africa, Spain, and Switzerland) real GDP growth, using a new definition for the volatility based on the first difference of quarterly growth rates.

The results confirm the findings in previous studies. Not only the countries do not have the same number of structural changes, but also these changes do not occur at the same time. South Korea is the only country that does not display a structural change, Germany, France, Italy and USA, display one break, whereas more than a half of the countries,

[1] See Doyle and Faust (2002, 2005), Heathcote and Perri (2004)

Australia, Canada, the UK, South Africa, Spain, and Switzerland, have two breaks in volatility. However, the change in volatility does not always mean a decrease, even though for almost all the countries this seems a reasonable rule. The exception is Spain, which has a restricted structural break with an increase in volatility in 1984:1, followed by a second break in 1995:2, as a decrease in volatility returning to the pre-increase levels.

The structural break test is also giving the first preview in answering the question of how synchronized the changes are at the global level. The answer is not as much as we would like to believe. For our 11 countries, the earliest structural break is observed in Canada in 1974:1, and the latest, about 20 years later, in Spain and Switzerland, in 1995:2.[2] Even for the countries that present only one break, the break is generally not concurrent, Germany in 1991:2, France in 1980:3, Italy on 1984:4, and USA in 1983:2. Not even the European countries appear to have seen the decrease around the same time. The outlier is Germany, with a break about 7 years later in 1991:2, the delay occurred most likely because of the end of the communist regime in East Germany.

The next step in our analysis and the main contribution of this study, is to formally analyze if each pair of two countries has the feature of the decrease in volatility and if this feature is common across the countries. To achieve our objective, we employ the test for common features developed in 1993 by Engle and Kozicki. If the feature is common, then the Great Moderation is one common event across countries and we can further proceed in eliminating some of the causes which we know happened at different times in different places (such as improvements in the performance of monetary policy). Conversely, if the event is not common, then, with more than one event, we can start to analyze each cause for coincidence versus causality. Each country in the pair takes the role to be what we call the

[2] Canada, Spain, and Switzerland have two structural changes in the volatility.

“base country”, or the country that dictates the instrument used for the test. The feature is defined by the base country as dummy variable that takes the value of 1 for the date of the structural change and afterwards, and 0 otherwise. Where we have two structural changes, we create a second dummy constructed in the same manner as the first instrument. Regardless of the number of breaks, we always include a linear trend as part of our common feature test. We already got a preview on the results from the structural change tests and we would expect to see the Great Moderation as multiple events across our sample of countries.

Indeed, across all 11 countries the Great Moderation is definitely not only one phenomenon, and the conclusion stays valid even for smaller subsamples. USA shares the common feature of Great Moderation with UK, France, and Italy, yet, not with Canada or Australia. Australia shares the feature with Canada, but Canada does not have the feature common with Australia. South Africa and Italy have the feature of a sudden decline in volatility with the same six countries: Australia, Canada, France, Italy, UK, and USA. Germany and UK are the only two countries to have the feature with Korea, the only country the sample that does not display a moderation, defined as a significant structural decline in mean volatility.

The results are somewhat unexpected. One would anticipate that United States and Canada to have the same feature of moderation, but the results show the opposite. Surprisingly, US has the common feature with three European countries: France, Italy, and the UK. Canada has also the common feature with two European countries, Germany and Italy, and South Africa. Despite the fact that international trade had increased largely and the markets had become more integrated, the output fluctuations have not become more correlated or synchronized across countries, a result also presented in Stock and Watson (2003).

The structure of the paper is as follows. Section 2 briefly describes the international data and volatility measure, accompanied by summary statistics for each of the eleven countries analyzed. In Section 3, we present the structural change tests utilized for identifying the breaks in volatility of GDP growth and interpret the results. Section 4, the main contribution of this study, describes the two stages of the common feature test and analyzes if the Great Moderation is one event among pairs of country. Section 5 concludes.

2.2 Data and the Decline in the Volatility of GDP Growth

In this section, we briefly present the data necessary to construct the volatility series for each of the eleven countries, and present the summary statistics pre- and post- country specific moderation(s). At a glance, the path of real GDP growth suggests that the volatility dropped considerably for all of the countries, except South Korea and Spain, somewhere in early 1980s to early 1990s. As a result, countries have experienced milder recessions and longer and more stable expansions.

2.2.1 International Data

The historical time series data of the first difference in the real GDP growth rate of all the countries are taken from the statistical portal of the Organization of Economic Cooperation and Development (OECD). The data begins at different times based on the country, and we lose three quarters from the beginning of the sample when constructing the volatility measure. All the data ends in 2011:4, the last quarter available in the database. The country with the earliest available data is US, starting in 1953:2, and the first record of volatility measure in 1953:4, followed by the UK, with data available starting in 1955:1, and volatility series in 1955:3. Next, we have a group of three countries, Australia, South Africa, and Germany, with the first data available in 1960:1, and volatility measure in 1960:3. The Canadian time series volatility starts in 1961:3, while Switzerland in 1965:3. The last group of countries, France, Italy, Korea, and Spain, has data starting in 1970:1 with volatility starting in 1970:3, the latest acceptable beginning for the structural change and common features tests. France and Italy actually have data beginning in 1960, but each has a one-quarter spike in volatility several times higher than any other value of volatility for the entire series, therefore, we consider data starting only with 1970:3. All the series are seasonally adjusted at source.

2.2.2 Volatility measure

There are several ways to measure output growth volatility in the international moderation context. One of the first studies, Blanchard and Simon (2001), defines volatility as the rolling standard deviation of quarterly real GDP growth. The rolling window selected is twenty quarters, with the information at moment *t* estimated from *t-19* to *t*. The same measure is also used more recently by Summers (2005) and Chen (2011). Bezemer (2009) defines GDP volatility similarly, with the exception the uses an annual standard deviation of quarterly nominal GDP growth over non-overlapping intervals of four quarters. Stock and Watson (2005) consider transformation of the data that filter out the highest frequency, quarter-to-quarter fluctuations, while Dijk, Osborn, and Sensier (2002) test for discrete changes in volatility of univariate autoregressive models for first differences of each series. The literature does not stop here, there are also measures based on the recession severity, expansions length, size of real output fluctuations around trend, standard deviation of the output gap, etc. Practice has shown that all of these measures lead to the same main conclusion: there is a pronounced drop in volatility for all the country except South Korea, although the magnitudes and timing differ across these countries.

Our measure of choice is the absolute value of the first difference in growth rates of real GDP, defined in Clark, Papell, and Stoica (2011). We prefer this measure over all the above mentioned because in its construction we lose only three observation from the beginning of the sample, whereas the others lose a significantly larger number. The larger the sample, the most accurate the analysis. For each country, we are calculating volatility at time t as follows:

$$\textit{Volatility } \mathrm{y_t} = \left| (\ln Y_t - \ln Y_{t-1}) - (\ln Y_{t-1} - \ln Y_{t-2}) \right|$$

where $\ln Y_t$ is the natural logarithm of real GDP in quarter *t*. Figure 2.1 provides a comprehensive visual summary of the volatility measure.

We start by examining the mean and variance of the volatilities over different periods. Table 2.1 presents these characteristics for each country for up to three time periods (1) beginning of the data series until the first found break, (2) the first break until either the second break or 2011:4, and, if applicable,(3) the second break until 2011:4. We chose to split the sample based on the timing of the break(s) of the aggregate output for each country. The results presented in Table 2.1 are striking in the sense that the vast majority of series (nine out of eleven) show a remarkable decline in both mean and variance. The countries that behave differently are Spain and South Korea. South Korea does not have a significant decrease in the output volatility, and therefore the summary statistics are only reported for the entire sample. Spain, on the other hand, has two significant structural changes, and is very close to a restricted structural change environment, where the second change is of equal magnitude and opposite sign as the first change. It is also interesting to note that countries presenting evidence of only one change in their volatility tend to have post-moderation values about 50% less than pre-moderation levels, whereas countries with two sequential breaks (which excludes Spain) tend to have a larger decline, with post-moderation volatility being between 61% to 85% less than pre-moderation levels.

Group 1 ranges from a low of 41% decline in Italy, to a high of 56% in Germany. Group 2 ranges from a low of 61% in the UK to a high of 85% in Switzerland. This is consistent with the findings of Stock and Watson (2003) where they find that volatility fell by 50% to 80% in US, France, Germany, Italy, Japan, and the UK, using a different measure of volatility and splitting the sample at the break date for the US.

2.3 Structural Break Test

In this section, we introduce the structural change tests for our empirical setup. When searching for a moderation in output volatility, structural break tests seem to be the appropriate place to ask the question if the decline ever occurred and if it did, was it permanent or transitory. The presence of structural breaks in the volatility of GDP affects the implications of econometric techniques. In the first papers to be publish on the topic, Kim and Nelson (1999) and McConnell and Perez-Quiros (2000), rely on the two-state Markov switching framework to detect the underlying states of the economic volatility.[3] This framework, however, does not necessarily offer an improvement over the classical structural change models if the break is not known explicitly, which may also invalidate the test

[3] In 1989, Hamilton proposed a regime switching model in showing shifts between positive and negative output growth

statistics.[4] Therefore, the best way to answer the question is to use a structural break test that endogenously chooses the break date by maximizing the evidence for a structural change, as opposed to using a structural break at a known point in time as in Chow (1960).

2.3.1 Structural Break Test Methodology

Testing for structural breaks with unknown break dates has materialized in the literature in the early to mid- 1990s, first developed by Andrews in (1993) and Andrews and Ploberger (1994), and generalized in important ways by Vogelsang (1997). The downside with this test is that it was designed for identifying no more than one break. For the series with more than one break, it has low power to detect a single break in the presence of multiple breaks, as shown by Bai (1997). Nevertheless, the endogenous structural break test was a breakthrough in the empirical work because conventional test statistics are not applicable under these circumstances.

The Great Moderation was a single event in the history of the United States, but several other studies show that this is not necessarily the case for all European countries and other developed economies in the world. While the Andrews and Ploberger (1994) or Vogelsang (1997) tests are appropriate for the economies known to have only one structural change in the volatility, they will be considerably misbehaved in the presence of two or three structural changes. To reduce the likelihood of any omissions, we perform the Bai and Perron (1998, 2003) test for multiple structural changes at unknown break dates.[5] The test regression includes a dummy variable that takes the value of 1 starting at the break date and chooses the break date to minimize the sum of squared residuals:

---

[4]They use Markov-switching processes and test formally for a break in the first two moments using the Andrews-Ploberger (1994) test for structural change

[5] As shown in Prodan (2008), this test has a potential issue with size distortions when used on a persistent series. Fortunately, the volatility of real GDP for the analyzed countries is not at all persistent.

$y_t = x_t'\beta + z_t'\delta_j + u_t , for\ j = 1, \dots , m + 1, where\ t = T_{j-1} + 1, \dots , T_j ; T_0 = 0 ; T_{m+1} = T.$

The observed dependent variable at time t is y_t; x_t is a covariate with the corresponding vector of coefficients β; and z_t is a vector of covariates with the corresponding vector of coefficients δ_j ; u_t is the error term at time t.

The measure of volatility is non-trending, so we only search for a change in the mean. When we test for multiple breaks, we include a dummy variable for each break date and choose both the number of breaks and the break date sequentially. Using the methodology proposed in Bai and Perron (2003), we test the null hypothesis of l changes versus the alternative of $l + 1$ changes, based on the $sup\ F(l + 1|l)$ statistic. If the overall minimal value of the sum of squared residuals (SSR) for the model with $l + 1$ breaks is smaller than the SSR for the model with l breaks, we reject the l break model. In the same manner, we use a sup $- F$ test statistic for the null hypothesis of no change ($m = 0$) versus the alternative of $m = 2$ breaks, as the sequential test has low power to detect one break if there are two breaks of opposite sign and similar magnitude.

Structural break tests require choosing how much we want to trim the data when searching for a structural change. Trimming the data too much is undesirable because it may mask either the most significant or a second break. Too little trimming is could also be an issue because it can lead to false break dates appearing at the very beginning or end of the sample. The procedure requires a large enough number of quarters in between the true break points for identifying purposes, so we use 15% to provide a reasonable balance between having enough, but not too much trimming.

There are two ways to control for the correlation of the residuals. Parametrically, which is our preferred method, involves including lagged values of the dependent variable in the regression. For our analysis, one lag is sufficient. A nonparametric correction could also be used, and involves applying a nonparametric correction to the residuals in order to have proper asymptotic inference. We use the parametric method for the majority of our analysis, but we use the nonparametric approach as a robustness check. In this case, the parametric and nonparametric tests give the same results with very few minor discrepancies. One possible explanation for this is that the series have low degrees of serial correlation. Another possible explanation is that the nonparametric correction is sufficient for correcting the serial correlation present in the errors. The exact nature of the serial correlation is not important for our analysis, but there would be cause for concern if different results were obtained with the parametric and nonparametric corrections.

For each country, we test for structural changes in the mean of the real GDP growth volatility utilizing the $\sup - F$ statistic. We determine if there is a significant break, and date the occurrence of the break. For multiple breaks, the Bai and Perron (1998, 2003) test is used, allowing for a maximum of three breaks that are chosen sequentially. After carefully performing the structural change test on all the volatility series, we discover that no country displays more than two breaks. If no structural change is found, we allow for the possibility of restricted structural change (offsetting structural changes) and other similar features by testing the null of zero breaks against the alternative of two breaks. We do not consider testing for more than two breaks against the alternative of zero or no breaks for two important reasons. First, when testing sequentially, no country has more than two breaks. Second, if there are more than two breaks, the possibility of restricted structural change (or a close approximation) is unlikely, as a result, the possibility of three breaks is not considered when there is no evidence of one break.

2.3.2 Structural Break Test Results

In interpreting the structural break results, we can group the countries into three categories: one significant break, two sequential significant breaks, and no moderation. The first group represents what is conventionally called the Great Moderation because the drastic decline in volatility occurred only at one point in time. Part of the first group is the United States, with the break in volatility happening in 1983:2, followed by France, with one significant break in 1980:3, Italy in 1984:4, and Germany, 1991:2. The volatility after the break date is approximately half of what it was prior to the break for all countries in group one. The timing of the breaks for group one is in the early 1980s, around the time that the Great Moderation began in the United States, with the exception of Germany, likely delayed due to the reunification. Based only on the timing, we could potentially believe that the moderation occurred in US, France, and Italy as a consequence of the same cause(s), and represents only one historical event.

The second category is also quite important, countries with two sequential breaks have a larger overall decline in volatility, generally between 66% and 85%. Members of the two break category, with the break dates in parenthesis and in order of significance, Australia (1976:2, 1984:2), Canada (1974:1, 1987:2), United Kingdom (1979:3, 1990:4), South Africa (1976:4 1986:2) and Switzerland (1977:2, 1995:2). The United Kingdom, Australia, Canada, and South Africa have one of their structural breaks near the onset of the Great Moderation, suggesting that the volatility reduction may be one event. Switzerland has breaks that are further away from the early 1980s, suggesting less of a connection and the possibility of considering the international Great Moderation as multiple events, caused by different factors. Switzerland has the largest decline in volatility at slightly over 85%, much higher than of the countries with the earlier onset.

Each of these categories has one country that does not quite fit the pattern, Germany and Switzerland for category one and two respectively. Germany is very much like any other single break country, except that the break comes much later, in 1991:2. With the reunification, the volatility likely increased for a short time both before and afterwards. Switzerland has the latest break date found, which happens to be the same as the second break for Spain, coming in 1995:2, much later than the Great Moderation seems to have started.

Finally, the third group of countries consists of only South Korea and Spain. South Korea has no significant break in volatility, and thus does not have a Great Moderation. Spain, on the other hand, has a very close approximation of restricted structural change, as the breaks are of similar magnitude and opposite sign occurring in 1984:1 and 1995:2. These results as well as their $\sup - F$ statistics can be found in Table 2.2

The earliest breaks come in the mid 1970s, when volatility is generally thought to be high due to the 1973 and 1979 oil shocks. The volatility of so many countries falling during this time is therefore quite interesting. Furthermore, because monetary policy in the United States did not change until 1979, and later in other countries, these breaks cast doubt on the story of monetary policy causing the Great Moderation. Finally, the late 1980s and early to mid 1990s are generally considered a time on good monetary policy in the United States, so for monetary policy to have caused a moderation in Germany, Switzerland, or even Spain, is very unlikely. These countries must have been very late in the adoption of the Taylor Principle, where interest rates respond to inflation by more than one to one.

2.4 Common Features Test

The major innovation of this paper comes from applying the common features test, presented by Engle and Kozicki (1993), in understanding the international Great Moderation. This approach is unique to this analysis and sheds some light on whether the Great Moderation is only one event internationally, caused by the same factors, or if it is different for each country or group of countries. In other words, is the Great Moderation one or multiple events?

2.4.1 Common Features Test Methodology

The common feature test comes in very handy when analyzing the commonality between two volatility pairs. It is very similar to a cointegration test, but is not restricted to series that have a unit root. The basic procedure of the test involves verifying if two series (country pairs of real GDP volatility) have the feature of interest, which is in this case the reduction in volatility, followed by verification that a linear combination of the two series does not have the feature. If both of these two conditions are fulfilled, then the pair it said to have a common feature. The ingenuity of this test consists in the major advantage that the feature can be almost any characteristic (e.g.: serial correlation, trends, seasonality, or heteroskedasticity).

The common feature test is a two-step process. First, it is necessary to test whether each series, on its own, has the feature. This first step is important because if one series does not have the feature there will always be a linear combination of the two series that does not have the feature as well (zero weight on the series that has the feature). The second step is to test if there is a linear combination of the series that does not have the common feature.

The basic set up for testing for common features is to use bivariate pairs, in our case two countries. The specification for Step 1 is $y_t = x_t\beta + z_t\gamma + \varepsilon_t$, where y_t is the series of interest, x_t represents the controls for the regression, and z_t represents the feature of interest. To test if a series possesses a feature, consider the following hypothesis:

$$H_0\text{: } No\ Feature\ (\gamma = 0)$$

$$H_1\text{: } Feature\ (\gamma \neq 0),$$

$$\text{First regression: (1) } y_t = x_t\beta + e_t$$

$$\text{Second regression: (2) } e_t = z_t\gamma + u_t.$$

Where e_t is the residuals from (1), the test statistic for the LM version (which we are using) is TR^2 from regression (2) and is distributed χ_n^2 , where n is the number of regressors in z_t.

The second step involves testing if the feature is common, or in other words, if there is a linear combination of the two series that does not have the feature. To test if the feature is common, we must first have two series that both have the feature, $y_{1t} = x_t\beta + z_t\gamma + \varepsilon_{1t}$ and $y_{2t} = x_t\beta + z_t\gamma + \varepsilon_{2t}$, where x_t and z_t are assumed to be the same for each series. The following hypothesis is then tested.

$$H_0\text{: } Common\ Feature$$

$$H_1\text{: } Feature\ not\ common$$

The test is done by performing limited information maximum likelihood, or asymptotically two-stage least squares (2SLS). In each case, the general form of the regression is $y_{1t} = \delta y_{2t} + x_t\beta + \varepsilon_t$, where the instrument list is {x, z}. The test statistic is essentially a test for overidentifying restrictions, or TR^2 from a regression of $\varepsilon_t = x_t\beta + z_t\gamma + e_t$ and is distributed χ_m^2 where *m* is the number of overidentifying restrictions.[6]

[6] The number of overidentifying restrictions(m) will be one less than in the first stage (n)

2.4.2 Common Features Test Results

In this general framework, we will test for a decrease in volatility (the Great Moderation), and whether the decrease in volatility is common across countries. In the specification, x_t is a constant, and z_t is a dummy variable that takes a value of one starting at the first structural break in the base country and continuing until 2011:4, 0 otherwise, a dummy variable that takes a value of one starting at the second structural break in the base country, where applicable, and continuing until 2011:4, 0 otherwise, and a trend term. It is important to note that z_t must have at least two terms, or there will be no overidentifying restrictions in the second step, and therefore it will be impossible to determine whether the feature is common.

The first stage provides some interesting results, with South Korea, France, Italy, Germany, and Spain not having the feature for certain base countries. This result is expected for South Korea because there is no structural change in the volatility, and as a result, there are seven base countries for which South Korea does not have the feature. One might anticipate Spain not to perform well in the first stage because its breaks are so different from every other country, but since the instruments do not specify the magnitude or sign of the breaks, it performs fairly well and loses the feature only for Germany as the base country. Germany has a late break in 1991:2 and performs quite poorly at this stage, not having the feature for five different base countries. Italy and France do not have the feature for one and three base countries, respectively, but all of these base countries have more than one structural break, while Italy and France both only have one. This has the important effect of excluding them from the second stage for the base countries that they do not share a feature with. All other series reject the null of no feature, qualifying for further testing. The results for the first stage are reported in Table 2.3.

For the second stage, we perform the limited information maximum likelihood (LIML) procedure. For robustness we also use two stage least square (2SLS), which is asymptotically equivalent and confirms our results. We will interpret two countries having a common feature of a decrease in volatility of GDP as evidence of one event. Each country with a significant structural break is considered as a base country, defining the instruments based on its own volatility. The results for the second stage (LIML) are reported in Table2.4.

The results vary by country pair and base country. In forming the country pairs, each of the countries in our sample has a double role. First, each country will be considered the base country, with the exception of South Korea, and second, it will be tested against the other base countries with the exception of those above mentioned excluded from this stage. Concretely, when Australia is the base country, we have three instruments: (1)dummy variable that takes the value of one starting in 1976:2 and continuing until the end of the sample, in 2011:4, zero otherwise, (2)a dummy variable that takes the value of one starting in 1984:2 and continuing until the end of the sample, 2011:4, zero otherwise, and (3) a linear trend. Countries that have a common feature with Australia include Canada, Italy, South Africa, and Switzerland. Similarly, when Canada is the base country, there are three instruments, the first two being dummy variables defined by the structural breaks in Canada's volatility series, and the third one being a linear trend. Italy, South Africa, and Germany have a common feature with Canada. With France as the base country, we find that Australia, Italy, United Kingdom, and Switzerland have a common feature with France. Australia, Canada, France, United Kingdom, United States, South Africa, and Switzerland have a common feature with Italy. When Germany is the base, we find that Canada, South Korea, United Kingdom, United States, and South Africa have a common feature with it. The United Kingdom, France, and Italy have a common feature with the United States. With the United Kingdom as the base country, Canada, France, United States, South Korea, and South Africa have a common feature. South Africa as a base shows that countries sharing a common feature with it are Australia, Canada, France, Italy, United Kingdom, United States, and Switzerland. Finally, countries that have a common feature with Switzerland include Australia, Canada, France, Italy and South Africa.

All in all, there are fifteen country pairs that have a strong common feature, where the feature is common regardless of which country is the base, and twelve additional country pairs that have a weak common feature, or a feature that is common only when one of the countries is the base. This distinction is due to the instruments changing to match the base country volatility experience. The weak common features will not be interpreted as a common event in those countries, leaving only the fifteen country pairs with a strong common feature experiencing the same event.

The results from the common features test imply that there is more than one moderation event internationally, and the structural break tests show that in many countries there is more than one moderation event domestically as well. Countries seem more likely to have a common feature with the base country if the base country is a member of their group, the exception to this being group three, where there is no moderation.

2.5 Conclusions and Future Research

The Great Moderation is one of the most widely agreed upon characteristic of the United States economy, also experienced by other industrialized countries. The literatures is mostly concerned with dating the moderation and identifying the causes leading to a decline in output volatility over time, lacking to ask the question if the Great Moderation is only one event internationally or multiple events. In this study, we attempt to answer the question of how many world incidences could we observe by engaging the common features test and structural break tests.

The first step in our analysis is to re-examine the number of structural changes in the output volatility of eleven developed countries: Australia, Canada, France, Germany, Italy, South Korea, Spain, South Africa, Switzerland, United States, and the United Kingdom. Even though we are not the first to document the abrupt decline in the volatility, we extend the data until the last quarter available (2011:4) with important changes in the previous results, and we are also the first to take interest in South Korea and South Africa. We find that there are two primary categories that countries fall into: first category has a single structural change and a clear decline in volatility (France, Germany, Italy, and US), and a second category with two structural changes and also a decline in volatility (Australia, Canada, UK, South Africa, Spain, and Switzerland). With a quick examination of the break dates, it is clear that 1983:2, the onset of the Great Moderation in the US is a major hotspot. If we look at what countries have at least one of their breaks around this onset, in between 1979:2 and 1987:2 (four years either direction), we find that Australia, Canada, France, Italy, US, UK, and South Africa all have breaks that fall within that interval.

The main contribution of this paper is in the novel approach of testing for one or multiple events internationally. In this sense, the common features test provides a plethora of information on the similarity of the break date(s) and magnitude of the decrease in volatility. There are fifteen country pairs that have a common feature, regardless of which country is the base, and twelve country pairs that have a common feature only with one of the countries as the base. Only the fifteen country pairs that have the strong common feature of the Great Moderation are considered to be affected by the same event. The fifteen country pairs include: United States-Italy, United States-UK, Australia-Italy, Australia-South Africa, Australia-Switzerland, Canada-Italy, Canada-South Africa, Canada-Germany, United Kingdom-France, United Kingdom-South Africa, South Africa-Italy, South Africa-Switzerland, France-Italy, France-Switzerland, and Italy-Switzerland.

Overall, we find that there are multiple events internationally, as well as multiple events domestically in several cases. This can help us in determining the international causes of the Great Moderation. Having more than one event can help us distinguish causality from coincidence. Diverse studies on countries with multiple breaks can be very enlightening but may not tell the entire story. Ideally, the framework to examine the causes of the Great Moderation should include international explanations and evidence in addition to what is domestically available.

The next step is to take this information and analyze the potential causes of the Great Moderation by country, which will hopefully allow us to eliminate some of the potential causes and hone in on the true source.

2.6 Figures and Tables

Figure 2.1 Output Volatility by Country

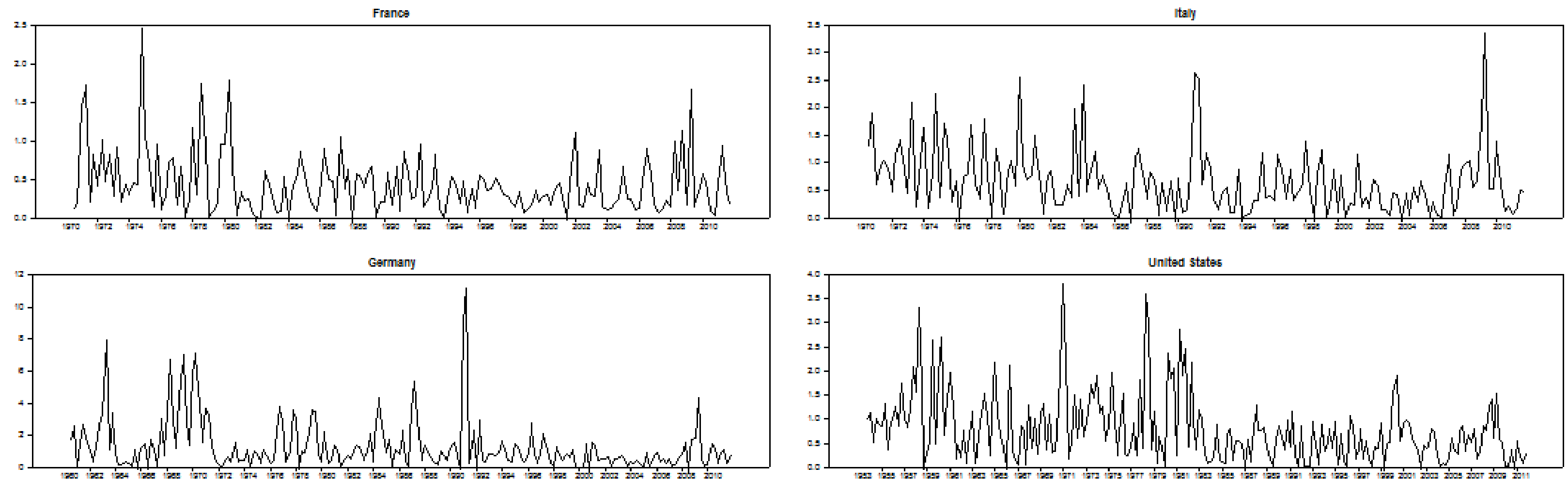


Figure 2.1 (continued) Output Volatility by Country

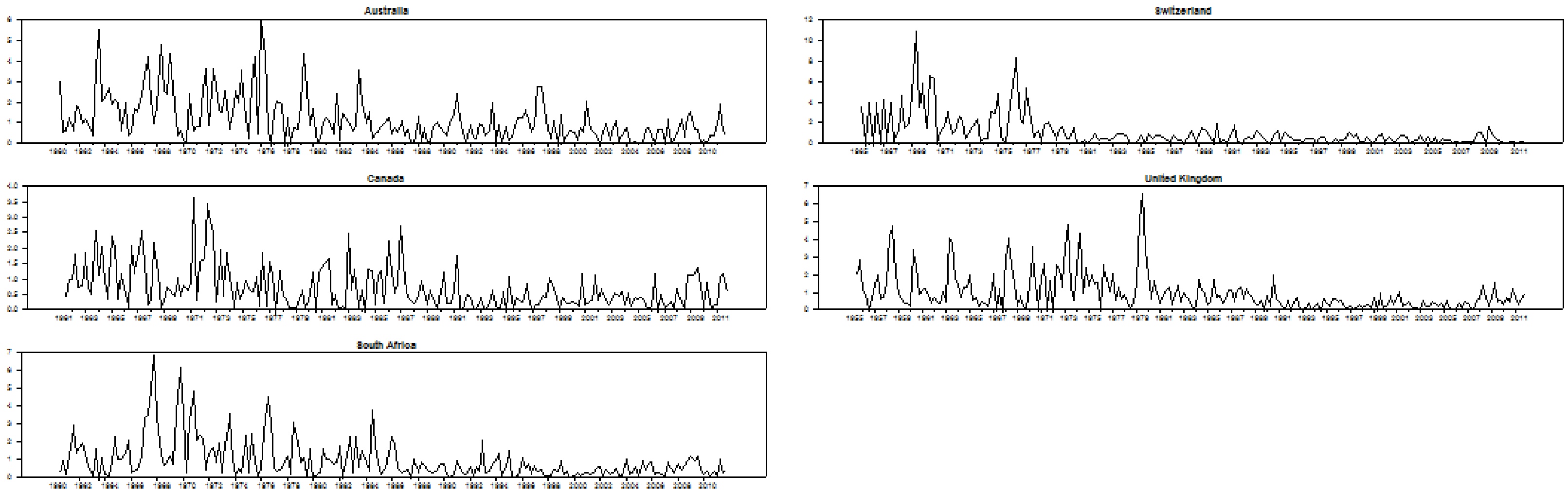
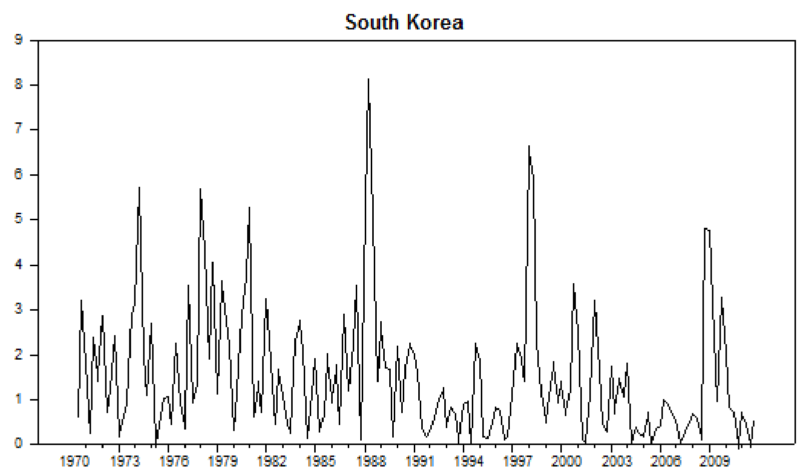


Figure 2.1 (continued) Output Volatility by Country



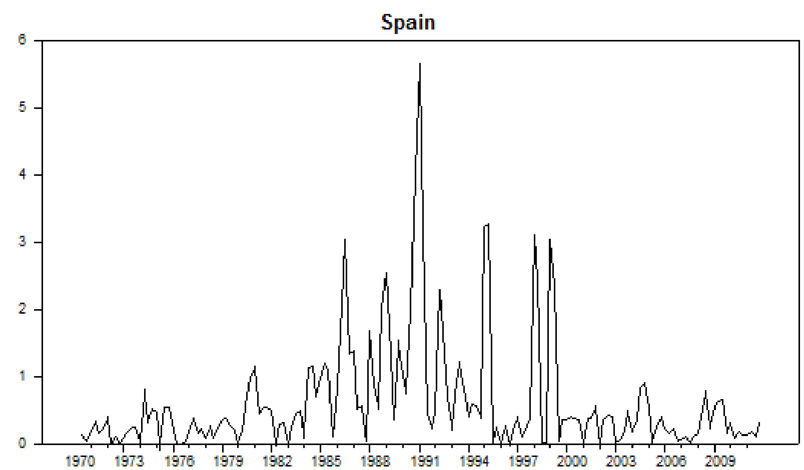


Table 2.1 Mean and Variance of Volatility Series

Country	Mean 1	Variance 1	Mean 2	Variance 2	Mean 3	Variance 3
Australia	1.981	1.836	1.252	0.97	0.664	0.308
Canada	1.22	0.738	0.762	0.415	0.417	0.13
France	0.664	0.309	0.361	0.078	-	-
Germany	1.707	3.701	0.757	0.475	-	-
Italy	0.912	0.384	0.539	0.293	-	-
South Africa	1.671	2.324	1.055	0.699	0.41	0.121
South Korea	1.542	2.154	-	-	-	-
Spain	0.298	0.059	1.361	1.319	0.43	0.401
Switzerland	2.601	5.216	0.648	0.246	0.394	0.106
UK	0.956	1.087	0.88	0.361	0.371	0.084
US	1.071	0.649	0.507	0.151	-	-

Notes: 1. Mean 1 and Variance 1 are the mean and variance from the beginning of the sample until the first structural break. Mean 2 and Variance 2 are the mean and variance from the first break to either the second structural break (if applicable) or the end of the sample. Mean 3 and Variance 3 are the mean and variance from the second structural break until the end of the sample.

Table 2.2 Structural Break Test Results

Country	SupF1|0	Break 1	SupF 2|1	Break 2	SupF 2|0	Break 1	Break 2
Australia	29.196***	1976:2	9.469**	1984:2	-	-	-
Canada	31.130***	1974:1	14.027***	1987:2	-	-	-
France	19.321***	1980:3	-	-	-	-	-
Germany	9.812**	1991:2	-	-	-	-	-
Italy	11.362**	1984:4	-	-	-	-	-
South Africa	18.389***	1976:4	29.624***	1986:2	-	-	-
South Korea	6.433	-	-	-	-	-	-
Spain	4.277	-	-	-	10.609***	1984:1	1995:2
Switzerland	46.983***	1977:2	8.274*	1995:2	-	-	-
UK	20.652***	1979:3	16.665***	1990:4	-	-	-
US	25.185***	1983:2			-	-	-

Notes: ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively

Table 2.3 Test for Common Features Stage 1 Results

	Base Country									
	Australia	Canada	France	Germany	Italy	South Africa	Spain	Switzerland	UK	USA
O.I.R.	3	3	2	2	2	3	3	3	3	2
Country	TR^2	TR^2	TR^2	TR^2	TR^2	TR^2	TR^2	TR^2	TR^2	TR^2
Australia	47.167***	29.951***	29.119***	44.381***	33.758***	41.812***	37.814***	36.011***	40.047***	29.241***
Canada	19.513***	45.918***	10.362***	31.833***	16.758***	29.713***	19.182***	30.480***	27.003***	15.382***
France	5.273	5.438	16.278***	4.833*	5.215*	7.621*	5.668	8.316***	9.050**	5.881**
Germany	3.335	7.119*	4.122	13.368***	4.335	4.149	12.016***	13.397***	6.654*	2.800
Italy	10.799***	6.736*	6.819**	10.114***	12.567***	8.066**	13.417***	7.498*	5.641	5.200**
South Africa	29.043***	41.472***	21.022***	38.208***	33.558***	48.631***	33.287***	39.159***	38.455***	26.021***
South Korea	7.477*	6.038	0.950	7.254**	1.933	5.619	4.697	5.420	11.249**	2.084
Spain	31.74***	19.592***	22.277***	0.065	23.087***	27.002***	44.879***	16.766***	20.248***	25.537***
Switzerland	39.438***	22.937***	38.626***	46.346***	23.899***	41.777***	31.009***	56.822***	50.651***	28.191***
UK	38.359***	36.749***	40.482***	39.131***	38.487***	39.160***	40.858***	29.907***	51.929***	40.329***
US	28.34***	18.633***	14.362***	23.553***	26.528***	21.388***	30.538***	9.954**	19.108***	36.114***

Notes: 1. H_0: Series does not have the Feature ; H_1: Series has the Feature
2. The test statistic is TR^2 from a regression of $\varepsilon_{it} = \text{dummy}_t + \text{Trend}_t + \upsilon_{it}$, where ε_t is the error term from the regression $x_{it} = \text{Constant} + \varepsilon_{it}$, where x_{it} is a volatility series and ε_{it} is the error term, $\text{dummy}_t = 1$ starting in 1983:2 and 0 otherwise, Trend_t is a linear time trend, and υ_{it} is the error term. The test statistic is distributed χ^2_n.
3. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.
4. O.I.R is the number of overidentifying restrictions (n) that the instruments for the base country provides

Table 2.4 Test for Common Features Stage 2 Results

	Base Country									
	Australia		Canada		France		Germany		Italy	
Country	Test Stat	DELTA	Test Stat	DELTA	Test Stat	DELTA	Test Stat	DELTA	Test Stat	DELTA
Australia	-	-	7.619**	0.636	2.691	0.269	4.330**	0.831	0.513	0.382
Canada	2.630	2.129	-	-	8.572***	0.573	0.756	1.7	1.887	0.77
France	-	-	-	-	-	-	4.173**	5.409	0.553	2.054
Germany	-	-	3.978	0.886	-	-	-	-	-	-
Italy	1.561	3.22	3.146	2.321	1.854	0.788	3.719*	2.466	-	-
South Africa	1.107	1.169	1.425	0.601	7.209***	0.277	2.322	0.933	0.396	0.403
South Korea	8.392**	2.96	-	-	-	-	0.232	0.987	-	-
Spain	25.775***	-1.606	8.177**	-1.309	4.743**	-0.402	-	-	8.387***	-0.382
Switzerland	1.753	0.67	10.050***	0.39	1.133	0.209	7.522***	0.512	1.529	0.336
UK	5.077*	1.267	8.545**	0.756	1.458	0.231	0.383	1.048	0.255	0.35
US	6.520**	2.608	4.928*	1.988	3.788*	0.471	0.144	2.469	0.007	0.612

Notes: 1. The general form of the regressions is $y_{1t} = \delta y_{2t} + x_t\beta + \varepsilon_t$, where y_{1t} is volatility of output, and y_{2t} is the row series. The test statistic is TR^2 and is distributed χ^2_m.

2. H_0: Feature is common ; H_1: Feature is not common

3. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively

Table 2.4 (continued) Test for Common Features Stage 2 Results

	Base Country									
	South Africa		Spain		Switzerland		UK		USA	
Country	Test Stat	DELTA	Test Stat	DELTA	Test Stat	DELTA	Test Stat	DELTA	Test Stat	DELTA
Australia	1.138	1.011	28.322***	-0.936	3.633	1.668	11.213***	0.918	8.575***	0.5
Canada	0.533	2	22.357***	-5.188	0.600	3.519	3.904	1.882	14.024***	1.019
France	1.200	4.884	-	-	0.280	6.776	0.560	5.609	0.971	3.812
Germany	-	-	6.937**	1.683	7.618**	2.574	6.946**	1.562	-	-
Italy	0.769	3.101	10.859***	-4.114	1.944	4.497	-	-	2.621	2.354
South Africa	-	-	46.525***	-1.481	2.681	1.489	1.902	0.991	7.781***	0.542
South Korea	-	-	-	-	-	-	2.966	1.626	-	-
Spain	22.322***	-1.645	-	-	28.973***	-3.881	16.782***	-2.407	13.880***	-0.972
Switzerland	2.929	0.743	37.017***	-1.03	-	-	9.068**	0.569	8.440***	0.348
UK	1.520	1.221	39.828***	-0.875	5.419**	2.224	-	-	0.907	0.588
US	3.586	2.834	20.399***	-1.599	7.976**	5.994	2.278	2.268	-	-

Notes: 1. The general form of the regressions is $y_{1t} = \delta y_{2t} + x_t\beta + \varepsilon_t$, where y_{1t} is volatility of output, and y_{2t} is the row series. The test statistic is TR^2 and is distributed χ^2_m.

2. H_0: Feature is common ; H_1: Feature is not common

3. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

Bibliography

Ahmed, Shaghil, Andrew Levin, and Beth Anne Wilson. "Recent U.S. Macroeconomic Stability: Good Luck, Good Policies, or Good Practices?" *Review of Economics and Statistics* 86 (2004): 824-32.

Alcala, Francisco, and Israel Sancho. "Output composition and the US output volatility decline." *Economics Letters* 82.1 (2004): 115-20.

Andrews, Donald. "Test for Parameter Instability and Structural Change with Unknown Change Point." *Econometrica* 61 (1993): 821-56.

Andrews, Donald, and Werner Ploberger. "Optimal Tests When a Nuisance Parameter is Present Only Under the Alternative." *Econometrica* 62 (1994): 1383-414.

Bai, Jushan. "Estimation of a Change Point in Multiple Regression Models." *Review of Economics and Statistics* 79 (1997): 551-63.

Bai, Jushan. "Estimating multiple breaks one at the time." *Econometric Theory* 13 (1997): 315-52.

Bai, Jushan, and Pierre Perron. "Estimating and Testing Linear Models with Multiple Structural Changes." *Econometrica* 66 (1998): 47-78.

Bai, Jushan, and Pierre Perron. "Computation and Analysis of Multiple Structural Change Models." *Journal of Applied Econometrics* 18 (2003): 1-22.

Bernanke, Ben S. "The Great Moderation Speach." Meetings of the Eastern Economic Associa. Washington DC. 2004. <http://www.federalreserve.gov/BOARDDOCS/SPEECHES/2004/ 20040220/default.htm>.

Blanchard, Oliver, and John Simon. "Long and Large Decline in U.S. Output Volatility." *Brookings Papers on Economic Activity* (2001): 135-74.

Chauvet, Marcelle, and Simon Potter. "Recent Changes in the US Business Cycle." *Manchester School* 69 (2001): 481-508.

Cecchetti, Stephen, Alfonso Flores-Lagunes, and Stefan Krause. "Has Monetary Policy become more Efficient? A Cross-Country Analysis." *The Economic Journal* 116 .511 (2006): 408-33.

Cecchetti, Stephen G., Alfonso Flores-Lagunes, and Stefan Krause. "Assessing the Sources of Changes in the Volatility of Real Growth." *NBER Working Paper* (2006).

Clarida, Richard, Jordi Gali, and Mark Gertler. "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory." *Quarterly Journal of Economics* 115 (2000): 147-80.

Clark, Michael W., David H. Papell, and Teodora A. Stoica. "If the Great Moderation is Over, When Will We Know?" *Working Paper* (2011).

Doyle, Brian, and Jon Faust. "An Investigation of Co-movements among the Growth Rates of the G-7 Countries." *Federal Reserve Bulletin* Oct. (2002): 427-37.

Dynan, Karen E., Douglas W. Elmendorf, and Daniel E. Sichel. "Can Financial Innovation Help to Explain the Reduced Volatility of Economic Activity." *Journal of Monetary Economics* 53 (2006): 123-50.

Enders, Walter, and Jun Ma. "Sources of the Great Moderation: A Time-Series Analysis of GDP Subsectors." *Journal of Economic Dynamics and Control* 35 (2011): 67-79.

Engle, Robert F., and Sharon Kozicki. "Testing for Common Features." *Journal of Business and Economics Statistics* 11.4 (1993): 369-80.

Gali, Jordi, and Luca Gambetti. "On the Sources of the Great Moderation." *American Economic Journal: Macroeconomics* 1.1 (2009): 26-57

Gert, Bekaert, Campbell R. Harvey, and Lundblad Christian. "Growth Volatility and Financial Liberalization." *Journal of International Money and Finance* 25 (2006): 370-403

Giannone, Domenico, Michele Lenza, and Lucrezia Reichlin. "Explaining The Great Moderation: It Is Not The Shocks." *Journal of the European Economic Association* 6.2-3 (2008): 621-33.

González Cabanillas, Laura, and Eric Ruscher. "The Great Moderation in the euro area: What role have macroeconomic policies played ?" *European Economy - Economic Papers* 331 June (2008).

Gordon, Robert. "What Caused the Decline in U.S. Business Cycle." *NBER Working Papers 11777* (2005).

Hall, Robert E. "Separating the business cycle from Other Economic Fluctuations." *Proceedings, Federal Reserve Bank of Kansas City* Aug. (2005).

Hall, Robert E. "The Long Slump." *American Economic Review* (2011): 431-69.
Kahn, James, Margret McConnell, and Gabriel Perez-Quiros. "On the Causes of the Increased Stability of the U.S. Economy." *FRBNY Economic Policy Review* (2002): 183-202.

Kim, Chan-Jin, Charles Nelson, and Jeremy Piger. "The Less Volatile US Economy: A Bayesian Approach Based on a Markov-Switching Investigation of Timing, Breadth, and Potential Explanations." *Federal Reserve Bank of St. Louis Working Paper* (2001-016A).

Kim, Chan-Jin, and Charles Nelson. "Has the U.S. Economy become more Stable? A Bayesian Approach Based on a Markov-Switching Model of the Business Cycle." *Review of Economics and Statistics* 81 (1999): 608-16.

Liu, Yanjun, and Bing-Sun Wong. "Estimating Structural Breaks in the Volatility of Canadian Output Growth." *Working Papers-Department of Finance Canada* 203.20 (2003)

McConnell, Margret, and Gabriel Perez-Quiros. "Output Fluctuations in the United States: What Has Changed Since the Early 1980s?" *American Economic Review* 90 (2000): 1464-76.

Mills, Terence, and Ping Wang. "Have Output Growth Rates Stabilized? Evidence from the G-7 Economies." *Scottish Journal of Political Economy* 50.3 (2003): 232-46.

Morley, James. "The Great Moderation: What Caused It and Is It Over?" *Macroeconomic Advisers' Macro Focus* 4.8 (2009).

Morley, James, and Aarti Singh. "Inventory Mistakes and the Great Moderation." *Working Paper (http://artsci.wustl.edu/~morley/ms.pdf)* (2009).

Perri, Fabrizio, and Vincenzo Quadrini. "Understanding the International Great Moderation." *Working Paper* (2008).

Prodan, Ruxandra. "Potential Pitfalls in Determining Multiple Structural Changes with an Application to Purchasing Power Parity." *Journal of Business and Economics Statistics* 26 (2008): 50-65.

Reinhart, Carmen, and Kenneth Rogoff. *This Time is Different: Eight Centuries of Financial Folly*. N.p.: Princeton University Press, 2009.

Sensier, Marianne, and Dick van Dijk. "Testing for Volatility Changes in U.S. Macroeconomic Time Series." *The Review of Economics and Statistics* 86.3 (2004): 833-39.

Simon, John. "The Decline in Australian Output Volatility." *Reserve Bank of Australia* (2001).

Smith, Penelope, and Peter Summers. "Regime Switches in GDP Growth and Volatility: Some International Evidence and Implications for Modelling Business Cycles." *Melbourne Institute Working Paper Series 21* (2002).

Stock, James, and Mark Watson. "Has the Business Cycle Changed and Why?" *NBER Macroeconomics Annual* (2002): 159-218.

Stock, James, and Mark Watson. "Has the Business Cycle Changed? Evidence and Explanations." *Monetary Policy and Uncertainty: Adapting to a Changing Economy*, *proceedings of symposium sponsored by Federal Reserve Bank of Kansas City, Jackson Hole, Wyo.* (2003): 9-56.

Stock, James, and Mark Watson. "Understanding Changes in International Business Cycle Dynamics." *Journal of the European Economic Association* 50 (2005): 968-1006.

Summers, Peter. "What Caused the Great Moderation? Some Cross-Country Evidence." *Federal Reserve Bank of Kansas City – Economics Review* (2005).

Taylor, John B. "Recent Changes in Trend and Cycle." *Structural Change and Monetary Policy Conference sponsored by Federal Reserve Bank of San Francisco and the Stanford Institute for Economic Policy Research* (2000).

Taylor, John B. "Housing and Monetary Policy." *Housing, Housing Finance, and Monetary Policy, Federal Reserve Bank of Kansas City* (2007).

Taylor, John B. "Getting Back on Track: Macroeconomic Policy Lessons from the Financial Crisis." *Reserve Bank of St. Louis Review* (2010).

Taylor, John B., and John C. Williams. "Simple and Robust Rules for Monetary Policy." *NBER Working Paper* (2010).

Vahid, F., and R. F. Engle. "Common Trends and Common Cycles." *Journal of Applied Econometrics* 8.4 (1993): 341-60.

van Dijk, Dick, Denise Osborn, and Marianne Sensier. "Changes in Variability of the Business Cycle in the G7 Countries." *Econometric Institute Report* 282 (2002)

Vogelsang, Timothy. "Wald-Type Tests for Detecting Breaks in the Trend Function of a Dynamic Time Series." *Econometric Theory* 13 (1997): 818-49.