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The Global Extent of the Great Moderation*

BRUNO ĆORIĆ

Faculty of Economics, University of Split, Matice hrvatske 31, 21000 Split, Croatia (e-mail: bcoric@efst.hr)

Abstract

In 2008 the US financial crisis spilled over into a number of other economies causing declines in GDP across the world. Yet the decades preceding the current downturn had been a period of unprecedented stability for the US economy. This article examines annual data for 98 countries over the period 1961–2007 and finds that lower GDP growth volatility in the period preceding the current crisis was not confined to the US. It is detected in a number of developed and developing countries, suggesting that a reduction in volatility in this period was a more general phenomenon.

I. Introduction

The collapse of the subprime mortgages market at the end of summer 2007 triggered one of the most severe financial crises in US history. By 2008, the crisis had spilled over into a number of other economies, causing a global economic downturn.

Yet the decades preceding the current financial crisis had been a period of very low volatility for the US economy. In particular, analysis of US quarterly GDP growth rates in the period after World War II revealed a large decline in short-run volatility after 1984 (Kim and Nelson, 1999; McConnell and Perez-Quiros, 2000). This decline was sufficiently pronounced to be characterized by the literature as 'The Great Moderation'. Similarly, as is the case with the current economic downturn, such moderation was not confined to the United States alone. The decline in output growth volatility has been detected for most of the G7, as well as for several other developed market economies (Blanchard and Simon, 2001; Dalsgaard, Elmeskov and Park, 2002; Mills and Wang, 2003; Stock and Watson, 2003, 2005; Fritsche and Kuzin, 2005; Del Negro and Otrok, 2008). Yet, the empirical literature does not provide information about the scope of reduction in GDP growth volatility from a global perspective.

The current crisis demonstrates the strong connections among national economies today. This gives new interest to the question of whether the Great Moderation was confined

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to some of the developed countries, or whether it was a pervasive worldwide phenomenon. This study attempts to provide information about GDP growth volatility of both developed and developing countries in the decades preceding the current global downturn. To address this question, we have collected data for 98 national economies from 1961–2007 and tested for structural changes in GDP growth volatility over that period, for each country separately.

The study is organized as follows. Section II describes the data sample, discusses the selection of an appropriate model and testing procedure. Section III presents results considering all economies together and comparing results between different income groups. Section IV discusses the sources of reduction in volatility. Section V concludes.

II. Data, model and methodology

Following McConnell and Perez-Quiros (2000) and Stock and Watson (2003) we test for changes in unconditional and conditional GDP growth volatility within a linear regression framework. This testing procedure allows us to test for structural changes in GDP growth volatility when the date of change is unknown. At the same time, it ensures comparability of our results with the previous findings and facilitates coherent presentation of the results which is important because of the large number of countries included in the analysis.[1]

Data

The data set contains annual real GDP growth rates for the period 1961–07 for 98 countries. The GDP growth rates were obtained from the World Bank's 'World Development Indicators' online database in May 2009.[2]

Contrary to the previous literature, which studied changes in the quarterly growth volatility of US GDP, we use annual data. Since reasonably long time series at quarterly frequencies are not available for the majority of countries, annual data provide the only option for cross-country comparison at the world level. In spite of this difference, our results should be comparable. Namely, consistently with the results of Ahmed, Levin and Wilson (2004) frequency-domain analysis, our results suggest that the so-called 'Great Moderation' in the United States has been evenly distributed at various frequencies. In particular, the results of our tests confirm the findings of Kim and Nelson (1999), McConnell and

[1]Other methods have also been used in this literature. Blanchard and Simon (2001), for example, used visual analysis of a moving window standard deviation of GDP growth rates to detect changes in GDP growth volatility of G7 countries. Although appropriate in the case where volatility of one or a few countries is examined, this method is unsuitable for comparison of a large number of series. Dalsgaard *et al*. (2002) divided GDP growth data into decades and compared the size of the standard deviation across decades. The results displayed in numerical form make this method suitable for a comparison of a large number of series. However, the results might depend on arbitrarily chosen time periods.

[2]The World Development Indicators database contained GDP growth rates for 209 countries. However, for the majority of them the data were not available for the entire period. Since our intention is to investigate possible changes over a longer time period, we include in the analysis only those countries for which data are available for the whole sample period. The only exception is Germany which, because of its importance for the world economy, is included even though data are missing for the period 1961–71. The data for Germany were kindly provided by the Deutsche Bundesbank's Statistics Department. The results of standard augmented Dickey–Fuller tests show that all GDP growth rates are stationary.

Perez-Quiros (2000), Mills and Wang (2003) and Stock and Watson (2003, 2005); that is, they suggest a large decline in US output volatility from the mid-1980s onwards.

According to the World Bank data for 2007, the countries included in our analysis account for more than 82% of world population and almost 90% of world GDP. Moreover, the comparison of the world economy's structure and the structure of the sample in Table 1 does not indicate a large discrepancy between them.

Model and testing methodology

Following McConnell and Perez-Quiros (2000) and Stock and Watson (2003) we first test for breaks in the mean of the absolute values of demeaned GDP growth rates.[3]

This procedure implicitly assumes constant mean GDP growth rate over the entire sample period. In the case of the United States the assumption of constant mean GDP growth rate cannot be rejected at standard levels of statistical significance at quarterly (McConnell and Perez-Quiros, 2000) as well as at annual frequencies (results available on request). However, this might not be the case for other countries in the sample. It is well known that in many countries mean growth of GDP has been lower after the oil shocks in the 1970s than before (Ben-David and Papell, 1998). Ignoring the potential breaks in the mean GDP growth rate may result in the spurious conclusion that volatility of GDP growth has changed. Looking for evidence of instability in the mean GDP growth rate we regress GDP growth on a constant and test for breaks in the value of the constant term for each country separately. The break points are estimated by Bai and Perron's (1998) test for multiple structural breaks with unknown time points. In addition, we include a linear trend in this regression to test for the possibility that some of the countries experienced a gradual rather than an instantaneous change(s) in mean GDP growth. The results revealed statistically significant instability in the mean GDP growth rate for 62 of 98 countries in the sample (detailed results for individual countries are available upon request).

To address the issue of instability in mean GDP growth, we use the Hodrick and Prescott (1997) filter to calculate demeaned GDP growth rates. In particular, instead of the mean GDP growth rate we use the trend component of GDP growth. Given the annual frequency of the data in the sample, following Ravn and Uhlig (2002) the value of the smoothing parameter, λ, is set to 6.25. The test for structural changes in unconditional GDP growth volatility is implemented by testing for breaks in the constant term of a simple linear regression, for each country separately. In particular, we consider the following linear regressions with m breaks ($m+1$ regimes),

$$|y_t - g_t| = \alpha_j + \varepsilon_t, \quad t = T_{j-1}+1, \ldots, T_j, \tag{1}$$

for $j = 1, \ldots, m+1$, where y_t denotes the GDP growth rate at time t and g_t is a trend component of the GDP growth rate at time t. $\alpha_j (j = 1, \ldots, m+1)$ is the constant in the jth regime and ε_t is the regression error at time t. The m-partition, $(T_1, \ldots, T_m)$, represents the break points for different regimes (by convention, $T_0 = 0$ and $T_{m+1} = T$). These points are treated as unknown and are estimated by Bai and Perron's (1998) method for detecting

[3]Absolute values of demeaned GDP growth rates are calculated as $|y_t - \bar{y}|$, where y_t denotes GDP growth rate at time t and $\bar{y}$ is a mean GDP growth rate.

TABLE 1

Countries included in data sample

Countries			
Low income	*Lower-middle income*	*Upper-middle income*	*High income*
Bangladesh	Algeria	Argentina	Australia
Benin	Bolivia	Belize	Austria
Burkina Faso	Brazil	Botswana	Bahamas
Burundi	Cameroon	Chile	Belgium
Central African Republic	China	Costa Rica	Bermuda
Chad	Colombia	Gabon	Canada
Congo Democratic Republic	Congo Republic	Hungary	Denmark
—	Dominican Republic	Malaysia	Finland
Cote d'ivoire	Ecuador	Mexico	France
Ghana	Egypt	Panama	Germany
Haiti	El Salvador	Seychelles	Greece
India	Fiji	South Africa	Hong Kong
Kenya	Guatemala	St Vincent and the Grenadines	Iceland
Liberia	Guyana	—	Ireland
Madagascar	Honduras	Trinidad and Tobago	Israel
Malawi	Indonesia	Uruguay	Italy
Mauritania	Lesotho	Venezuela	Japan
Nepal	Morocco		Korea
Niger	Nicaragua		Luxembourg
Nigeria	Paraguay		Malta
Pakistan	Peru		Netherlands
Papua New Guinea	Philippines		New Zealand
Rwanda	Sri Lanka		Norway
Senegal	Syrian Arab Republic		Portugal
Sierra Leone	Thailand		Singapore
Sudan			Spain
Togo			Sweden
Zambia			Switzerland
			United Kingdom
			United States

Data sample structure according to countries' income classification

Country groups by World Bank's income classification	*% in sample*	*% in world countries*
Low income economies (GNI p.c. $905 or les)	27.5	25.4
Lower-middle income economies (GNI p.c. $906–3595)	25.5	26.3
Upper-middle income economies (GNI p.c. $3596–11,115)	16.3	19.6
High income economies (GNI p.c. $11,116 or more)	30.6	28.7

Notes: Countries are grouped based on the World Bank's 2007 classification in which countries are selected according to gross national income per capita (GNI p.c.) that is provided in brackets. Columns '% in sample' and '% in world countries' denote the share of countries in particular income group in our sample and the share of these countries in the world, respectively.

multiple structural breaks. Since the analysed time period (1961–2007) includes oil shocks and inflation in the 1970s and the debt crisis starting in 1982 we cannot disregard the possibility of more than one break in volatility in some countries. As shown in Andrews (1993), a test for a single change is consistent against an alternative hypothesis of multiple changes.

However, in finite samples its power can be quite low compared to a test that allows for more than one break point (Bai and Perron, 2006).[4] Another useful property of Bai and Perron's (1998) test is that it allows for a relatively general specification when computing the test statistic and confidence intervals for the break dates and regression coefficients. In particular, it allows for different distributions of both regressors and the error terms in the different subsamples (regimes) as well as autocorrelation and heterogeneity in the regression model residuals.

Bai and Perron (1998) proposed several tests for multiple structural breaks with unknown break points. Following Bai and Perron (2003) we use the test for l vs. $l+1$ breaks and sequentially test the hypothesis of l vs. $l+1$ breaks using $\sup F_T(l+1 \mid l)$ statistics. The value of the trimming parameter is set to 0.2, which implies that the number of observations between two breaks must be equal to at least 20% of all observations, that is, to at least 9 years. Since the breaks cannot be placed in the first and the last 20% of the observations, our specification allows for maximally three breaks. To impose the minimum structure on the data we use the most general specification that allows for autocorrelation and heterogeneity in the regression model residuals as well as for different distributions of regressors and the error terms in the different subsamples (regimes).

According to Bai and Perron (2003) in the presence of multiple breaks there are cases when configurations of changes are such that it is very difficult to reject the null hypothesis of 0 vs. 1 break in the model, but is not difficult to reject the hypothesis of 0 vs. a higher number of breaks. The sequential procedure breaks down in such cases. To account for this possibility, following Bai and Perron's (2003) recommendation, in the cases when the sequential procedure suggests no breaks we consider the results of UDmax and WDmax tests. If these tests indicate the presence of at least one break, the results of the $\sup F(1|0)$ test are ignored and the number of breaks is selected upon the results of the $\sup F(2|1)$ and $\sup F(3|2)$ tests.[5]

In addition to the test for structural breaks we also use a simple linear trend regression to investigate the possibility that in some countries changes in GDP growth volatility are characterized by gradual rather than instantaneous changes:

$$|y_t - g_t| = \alpha + \beta \text{ time} + u_t. \tag{2}$$

Taken together, structural changes in unconditional volatility (break changes, trend change, or both) were detected for more than 70% of the countries in the sample at standard levels of significance. A majority (more than 80%) of the significant changes indicate a reduction in volatility (we do not present detailed results of tests for structural changes in unconditional volatility here, but they are available upon request). These findings suggest that reduction in GDP growth volatility, in the decades preceding the current global crisis, might not have been confined to the United States. Moreover, reduction in GDP growth volatility, in this period, was not detected only in developed, but in developing countries as well. Consequently, we proceed with further analysis.

[4]Consistent with Bai and Perron's (2006) findings, the results of Jones and Olken's (2008) Monte Carlo simulations ($T=40$) show that the size of Bai and Perron's (1998) test is appropriate in small samples. The results also indicate that the test is more successful the larger the breaks. That is, the method is conservative in detecting breaks, capturing only major changes.

[5]All tests are implemented using the Bai and Perron (2003) GAUSS code.

Documented changes in unconditional volatility may be a result of changes in the conditional mean or in the conditional variance. To explore this issue, we impose a bit more structure on the problem. Following McConnell and Perez-Quiros (2000) and Stock and Watson (2003, 2005), we model GDP growth as a linear autoregressive (AR) process. Namely, another way to address the issue of changing GDP growth volatility is to examine changes in the variance of the AR innovation and in the sum of the AR coefficients, which measure the persistence of the shock to GDP growth (Stock and Watson, 2005).

The number of lags in the AR model is determined for each country separately using the Bayesian Information Criterion (BIC), with the maximum lags set equal to 4. To check for remaining residual autocorrelation, we apply the Ljung-Box test for residual serial correlation to each AR(p) model selected by BIC. If necessary the lag length p is increased until the null of no residual autocorrelation cannot be rejected at the 5% significance level.

Following Stock and Watson (2003) we first test for structural changes in the conditional mean (i.e. the AR lag coefficients) and then proceed with testing for a structural change in conditional volatility (i.e. residual variance).[6] In particular, we first consider the linear AR model with m breaks ($m+1$ regimes),

$$y_t = \phi_{0,j} + \phi_{1,j} y_{t-1} + \cdots + \phi_{p,j} y_{t-p} + \varepsilon_t, \quad t = T_{j-1}+1, \ldots, T_j, \tag{3}$$

for $j = 1, \ldots, m+1$ and $p = 1, \ldots, 4$, where y_t denotes the GDP growth rate at time t. $\phi_{0,\ldots,4,j} (j = 1, \ldots, m+1)$ are the parameters of the AR model in the jth regime, and ε_t is the regression error at time t. The break points $(T_1, \ldots, T_m)$, are treated as unknown and are again estimated using Bai and Perron's (1998) methodology. After the parameters in equation (3) are estimated, we test for breaks in the mean of the absolute values of the AR model residuals, $\hat{\varepsilon}_t$.

$$|\hat{\varepsilon}_t| = \alpha_j + u_t, \tag{4}$$

where $\alpha_j (j = 1, \ldots, m+1)$ is the constant in the jth regime and u_t is the regression error at time t. The break points are estimated using the testing procedure explained above. As in the case of unconditional volatility, we also use a simple linear trend regression to consider the possibility that in some countries changes in conditional volatility are characterized by gradual rather than instantaneous changes.

$$|\hat{\varepsilon}_t| = \alpha + \beta \text{ time} + u_t. \tag{5}$$

III. Results

Since we are particularly interested in GDP growth volatility in the period preceding the current crisis, the results are selected depending on the volatility in the last period. That is, in the case when the last break concerns an increase in GDP growth volatility, we categorized that country as one with an increase in volatility; and vice versa, in the cases when the last break indicates a reduction in volatility.[7]

[6]To take into account possible breaks in the mean GDP growth rate, we allow for breaks in the constant when testing for breaks in the AR coefficients of the AR model.

[7]In the case when the results of different tests do not point in the same direction, we calculate the standard deviation of GDP growth in the last period and compare it with volatility in the previous period.

TABLE 2

Estimated structural changes in conditional mean and volatility

Volatility	Changes in volatility			Changes in conditional mean			Changes in conditional volatility		
	No. of countries	% of 98	% of 84	No. of countries	% of 98	% of 49	No. of countries	% of 98	% of 67
	84	85.7		49	49.0		67	68.4	
Increase	21	21.4	25.0	20	20.4	40.8	12	12.2	17.9
Reduction	63	64.3	75.0	29	29.6	59.2	55	56.1	82.1

Notes: The column 'Changes in volatility' reports the absolute and relative number of countries for which structural changes in GDP growth volatility were detected either as structural changes in conditional mean, structural changes in conditional volatility, or both. The absolute and relative number of countries for which structural changes were detected in conditional mean is reported in the column 'Changes in conditional mean'. The absolute and relative number of countries for which structural changes were detected in conditional volatility is reported in the column 'Changes in conditional volatility'. Row 'Reduction' reports number of countries for which structural changes indicate a reduction in volatility. Row 'Increase' reports the number of countries for which structural changes indicate an increase in volatility.
Source: author's calculation.

Taken together, structural changes in GDP growth volatility (detected as break changes in the conditional mean, or break or trend changes in the conditional volatility, or both) were detected in more than 85% of the countries at conventional levels of significance. A majority of the significant changes concern a reduction in volatility. In particular, the results indicate significant reduction in GDP growth volatility in 75% of these countries (Table 2). Detailed results for individual countries are given in appendix A.

The results reveal structural changes both in the conditional mean and in the conditional volatility. Significant changes in conditional volatility are detected for 67 countries. For 55 of these, changes indicate a reduction in conditional volatility. The number of countries for which significant changes in conditional mean are detected is also considerable but lower; particularly the number of countries for which changes indicate a reduction in volatility. Namely, the tests revealed significant changes in the conditional mean for 49 countries; and for 29 of these the changes indicate a reduction in GDP growth volatility.

Classification of the break points by year in Figure 1 shows differences in the distribution of break points that correspond to, respectively, a reduction and an increase in GDP growth volatility. The break dates that correspond to a reduction in GDP growth volatility seem to be almost equally dispersed across decades. On the other hand, the break dates that correspond to an increase in volatility mainly date in the 1970s.

Accordingly, the number of significant breaks in GDP growth volatility is the highest in the 1970s and then declines through the two subsequent decades (Table 3). The number of breaks in the 1970s that correspond to an increase in volatility is slightly higher compared to the number of breaks that correspond to a reduction in volatility. After the 1970s the number of breaks that correspond to a reduction in volatility rises compared to the number of breaks that correspond to an increase in volatility. That is, the results indicate a linear increase in the share of breaks that correspond to a reduction in GDP growth volatility from the 1970s to the 1990s. As the results in Table 3 show, an increase in the share of breaks that correspond to reduction in GDP growth volatility is mainly attributable to breaks in conditional volatility. Namely, the number of breaks in the conditional mean

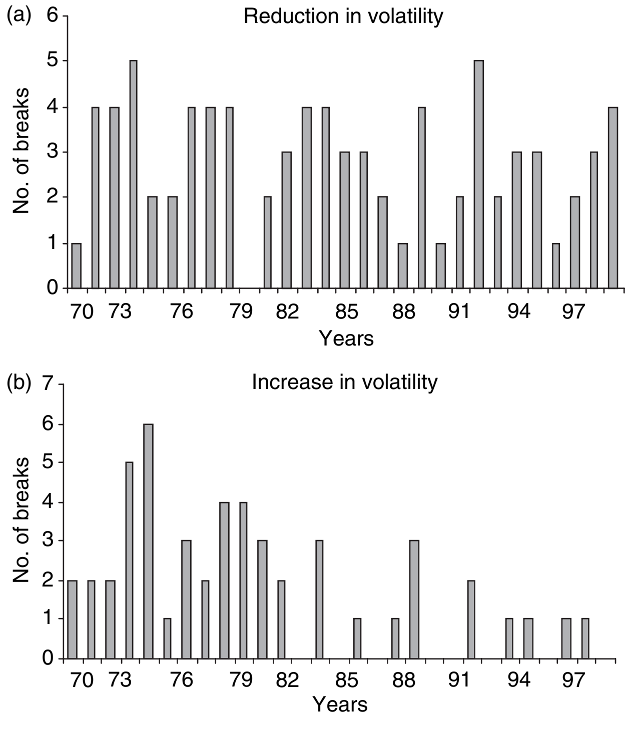

Figure 1. Histogram of estimated break dates in GDP growth volatility

TABLE 3

Estimated break dates in conditional mean and volatility

	Changes in volatility			*Changes in conditional mean*			*Changes in conditional volatility*		
Decades	*No. of breaks*	*Reduction*	*In %*	*No. of breaks*	*Reduction*	*In %*	*No. of breaks*	*Reduction*	*In %*
1970s	61	30	49.18	34	14	41.18	27	16	59.26
1980s	40	27	67.50	18	11	61.11	22	16	72.73
1990s	31	25	80.65	15	10	66.67	16	15	93.75

Notes: The column 'Changes in volatility' reports the number of break points in GDP growth volatility, per decade. The number of break points in the conditional mean, per decades, is reported in the column 'Changes in conditional mean'. The number of break points in the conditional volatility, per decade, is reported in the column 'Changes in conditional volatility'. In each column, the subcolumn 'Reduction' reports the absolute number of break points that correspond to a reduction in volatility. Subcolumn 'In %', in each column, reports the relative number of break points that correspond to a reduction in volatility.
Source: author's calculation.

that correspond to reduction in GDP growth volatility decline together with the overall number of significant breaks from the 1970s to the 1990s. On the other hand, the number of breaks that correspond to a reduction in conditional volatility is almost equal across decades causing a rise in their share.

Low short-run output volatility is commonly seen as a sign of a well-functioning economy. The empirical literature shows that developed countries have, in general, lower volatility compared to developing and underdeveloped economies.[8] In line with these points it may be expected that the reduction in GDP volatility is concentrated among developed economies. Our data sample enables us to assess this assumption. So, according to the World Bank categorization we divide countries into high income, upper-middle income, low-middle income and low income groups and classify the test results accordingly.

As can be seen from Table 4, in each income group structural changes in GDP growth volatility were detected for more than 80% of the countries. In each income group a majority of the significant changes concern a reduction in volatility. In particular, the proportion of countries for which significant changes indicate a reduction in volatility range from almost 82% in the low income group to 64% in the upper-middle income group. In each income group a reduction in GDP growth volatility is detected for more than half of the countries in the group (the proportion ranges from 70% in the high income group to 56% in the Upper-middle income group). Overall, the results suggest that reduction in GDP volatility, in the decades preceding the current economic crisis, was dispersed across countries at all income levels.

On the other hand, it seems that some differences among income groups do exist as far as causes of changes in GDP growth volatility are concerned. In the high-income group significant changes in conditional volatility are detected for 21 countries. In all cases these changes indicate a reduction in conditional volatility. Significant changes in the conditional mean are detected for 13 countries, and in more than half of these cases these changes indicate increase rather than reduction in volatility. Therefore, it seems that the results suggest changes in conditional volatility as the dominant source of reduction in GDP growth volatility among high-income countries. In other income groups changes in conditional volatility are not such a dominant source of reduction in GDP growth volatility. In the upper-middle income group, for example, changes in the conditional mean that indicate reduction in volatility are detected in more countries than changes that indicate reduction in conditional volatility.

The difference between the high-income group and the other groups is also apparent when the break points are classified by decades (Table 5). In the high-income group the break dates that correspond to reduction in GDP growth volatility are mainly dated in the 1970s. Consequently, the number of these breaks is considerably larger in the 1970s than in the 1980s and/or the 1990s. This is not the case for other income groups. In the upper-middle income group the number of the break dates that correspond to reduction in GDP growth volatility is relatively stable across the decades. In the low and low-middle income groups the number of the break dates that correspond to a reduction in GDP growth volatility is higher in the 1980s and 1990s than in the 1970s.

In sum, our findings suggest that the reduction in GDP growth volatility, in the decades preceding the current global downturn, was not confined to the US or to G7 countries. A significant reduction in GDP growth volatility is detected in almost two-thirds of the countries in our sample. These countries are members of all income groups and, according to the World Bank data for 2007, account for 55% of world population and 76% of world

[8] See Loayza *et al*. (2007) for the most recent review of the causes and consequences of higher GDP growth volatility in developing countries.

TABLE 4

Estimated structural changes in conditional mean and volatility per income groups

		Changes in volatility			*Changes in conditional mean*			*Changes in conditional volatility*		
High income countries (30)	*Volatility*	*No. of countries*	*% of 30*	*% of 27*	*No. of countries*	*% of 30*	*% of 13*	*No. of countries*	*% of 30*	*% of 21*
		27	90.00		13	43.33		21	70.00	
	Increase	6	20.00	22.22	9	30.00	69.23	0	0.00	0.00
	Reduction	21	70.00	77.78	4	13.33	30.77	21	70.00	100.00
Upper-middle income countries (16)			*% of 16*	*% of 14*		*% of 16*	*% of 10*		*% of 16*	*% of 11*
		14	87.50		10	62.50		11	68.75	
	Increase	5	31.25	35.71	2	12.50	20.00	5	31.25	45.45
	Reduction	9	56.25	64.29	8	50.00	80.00	6	37.50	54.55
Low-middle income countries (25)			*% of 25*	*% of 21*		*% of 25*	*% of 13*		*% of 25*	*% of 18*
		21	84.00		13	52.00		18	72.00	
	Increase	6	24.00	28.57	6	24.00	46.15	4	16.00	22.22
	Reduction	15	60.00	71.43	7	28.00	53.85	14	56.00	77.78
Low income countries (27)			*% of 27*	*% of 22*		*% of 27*	*% of 13*		*% of 27*	*% of 18*
		22	81.48		13	48.15		18	66.67	
	Increase	4	14.81	18.18	3	11.11	23.08	4	14.81	22.22
	Reduction	18	66.67	81.82	10	37.04	76.92	14	51.85	77.78

Notes: The column ‘Changes in volatility’ reports the absolute and relative number of countries, per income group, for which structural changes in GDP growth volatility were detected as either structural changes in conditional mean, structural changes in conditional volatility, or both. The absolute and relative number of countries, per income group, for which structural changes were detected in conditional mean is reported in the column ‘Changes in conditional mean’. The absolute and relative number of countries, per income group, for which structural changes were detected in conditional volatility is reported in the column ‘Changes in conditional volatility’. Rows ‘Reduction’ report the number of countries for which structural changes indicate a reduction in volatility. Rows ‘Increase’ report the number of countries for which structural changes indicate a increase in volatility. Countries are selected into income groups according to the 2007 World Bank classification. Numbers in brackets indicate the number of countries in a particular income group.
Source: author’s calculation.

TABLE 5

Estimated break dates in conditional mean and volatility per income groups and decades

		Changes in volatility			*Changes in conditional mean*			*Changes in conditional volatility*		
Countries	*Decades*	*No. of breaks*	*Reduction*	*In %*	*No. of breaks*	*Reduction*	*In %*	*No. of breaks*	*Reduction*	*In %*
High income	1970s	19	12	63.16	10	4	40.00	9	8	88.89
	1980s	5	4	80.00	1	0	0.00	4	4	100.00
	1990s	7	5	71.43	3	1	33.33	4	4	100.00
Upper-middle income	1970s	15	5	33.33	9	5	55.56	6	0	0.00
	1980s	7	6	85.71	4	4	100.00	3	2	66.67
	1990s	5	5	100.00	2	2	100.00	3	3	100.00
Low-middle income	1970s	16	5	31.25	10	1	10.00	6	4	66.67
	1980s	14	10	71.43	9	7	77.78	5	3	60.00
	1990s	7	6	85.71	2	1	50.00	5	5	100.00
Low income	1970s	13	7	53.85	7	3	42.86	6	4	66.67
	1980s	14	8	57.14	4	1	25.00	10	7	70.00
	1990s	12	9	75.00	8	6	75.00	4	3	75.00

Notes: The column ‘Changes in volatility’ reports the number of break points in GDP growth volatility, per decade and income group. The number of break points in the conditional mean, per decade and income group, is reported in the column ‘Changes in conditional mean’. The number of break points in the conditional volatility, per decade and income group, is reported in the column ‘Changes in conditional volatility’. In each column, the subcolumn ‘Reduction’ reports the absolute number of break points that correspond to a reduction in volatility. Subcolumn ‘In %’, in each column, reports the relative number of break points that correspond to a reduction in volatility. Countries are selected into income groups according to the 2007 World Bank classification.
Source: author’s calculation.

GDP. Consequently, it also seems that reduction in GDP growth volatility was a global process. Second, the break dates that correspond to reduction in GDP growth volatility are dispersed across years and decades. This suggests that the year 1984, in which the onset of lower volatility was detected for the United States by the previous literature, was not a global turning point in volatility. Third, the results suggest that reduction in GDP growth volatility is mainly attributable to reduction in conditional volatility, especially in the high-income group. Finally, it also seems that the reduction in GDP growth volatility in developed countries, on average, took place earlier than in developing countries.

IV. The sources of reduction in volatility

The existing literature offers several explanations for the reduction in GDP growth volatility in the decades preceding the current crisis. With a few exceptions (Fritsche and Kuzin, 2005; Stock and Watson, 2005; Del Negro and Otrok, 2008) the proposed theoretical rationale and underpinning empirical evidence address volatility reduction in the US economy. Most of these explanations attribute reduction in volatility to structural changes in US economy, better economic policy and/or changes in data construction, in particular: improvements in monetary policy, improvements in inventory investments, financial reforms and innovations, labour market changes and more accurate measurement of GDP (see Romer, 1989, 1994; Clarida, Gali and Gertler, 2000; Kahn, McConnell and Perez-Quiros, 2002; Dynan, Elmendorf and Sichel, 2006; Stiroh, 2006; Gali and Gambetti, 2009; among others). In contrast, Stock and Watson (2002, 2005) and Ahmed *et al*. (2004) argue that reduction in GDP growth volatility should be primarily attributed to smaller and less frequent exogenous economic shocks, that is, to 'good luck'.

The collapse of the subprime mortgages market at the end of summer 2007 triggered one of the most severe financial crises in US history. The ensuing economic crisis seems to shift the balance of evidence towards the good luck hypothesis. Changes in economic structure, policy improvements and/or more accurate measuring of GDP imply a permanent movement towards lower volatility. Conversely, if the main cause of reduction in GDP growth volatility was smaller economic shocks unrelated to changes in economic fundamentals then the 'Great Moderation' could be seen as merely transient. As a result of global economic connections the US economic crisis has spilled over into a number of other economies causing the most serious global economic downturn since World War II. The finding that lower volatility in the decades preceding the current crisis was also a worldwide phenomenon raises the question of whether these results might tell us more about the causes of the Great Moderation.

Our results suggest that reduction in GDP growth volatility is more often related to changes in conditional volatility than to changes in the conditional mean. If the errors of the AR processes are interpreted as economic shocks (see, e.g. Blanchard and Simon, 2001), then these results seem to suggest that reduction in GDP growth volatility should be primarily attributed to 'good luck'. However, it is questionable to what extent the errors of the AR processes should be considered as economic shocks. The regression error term picks up all non-systematic unexplained variations in the regressand. These variations can be attributed to missing regressors and/or to inadequate functional form as well as to genuinely exogenous disturbances. Since we cannot distinguish which parts of errors come from which source, we cannot reliably conclude what causes their changes. So, detection of a statistically significant change in conditional volatility is a necessary but not a sufficient condition to attribute reduction in GDP growth volatility to changes in exogenous economic shocks.

Overall, our results do not provide sufficient evidence to distinguish between the potential sources of reduction in GDP growth volatility. Nevertheless, our results provide an additional testing approach. The finding that lower volatility in the decades preceding the current crisis was detected across the world suggests that it might be useful to test for systematic difference among countries and periods with different GDP growth volatility. The presence of statistically significant differences among country periods with different GDP growth volatility would indicate those economic process(es) which might explain the reduction in GDP growth volatility. Lack of significant differences among country periods with different volatility would, on the other hand, provide additional evidence in support of the good luck hypothesis. Finally, our results indicate that reduction in GDP growth volatility in developed countries, on average, took place earlier than in developing countries. This raises the question of whether lower volatility in developing countries was caused by reduction in the GDP growth volatility of the developed world. Our results suggest this as a possible new line of enquiry.

V. Conclusion

This article presents evidence about changes in GDP growth volatility across the world in the decades preceding the current global downturn. We collected a large data sample from 98 developed and developing countries from 1961 to 2007 and tested for structural changes in GDP growth volatility over that period, for each country separately. The results revealed that reduction in GDP growth volatility, in the decades preceding the current global downturn, was not confined to the United States or developed countries only. A significant reduction in GDP growth volatility is detected for a number of developing countries as well, suggesting that reduction in volatility in this period was a worldwide phenomenon. The break dates that correspond to reduction in GDP growth volatility are dispersed across years and decades. Hence, it seems that the year 1984, in which the onset of lower volatility was detected for the United States by the previous literature, was not a global turning point in volatility. The results also suggest that a reduction in GDP growth volatility in developed countries, on average, took place earlier than in developing countries.

The results reported in this article do not provide sufficient evidence to distinguish among the potential sources of reduction in GDP growth volatility. However, our results provide an additional testing approach that might help to distinguish among the potential explanations. In particular, the finding that lower volatility in the decades preceding the current crisis was detected across the world makes it possible to examine systematic differences across countries and periods with different GDP growth volatility. Finally, our results also suggest a potential new line of enquiry. Namely, the finding that reduction in GDP growth volatility in developed countries, on average, took place earlier than in developing countries raises the question of whether lower volatility in developing countries was caused by the reduction in the GDP growth volatility of the developed world. This question is interesting in itself, but would also be relevant for estimating the likely effect of the 2008 financial crisis on the growth prospects for developing countries.

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Appendix A: Results of tests for structural changes in GDP growth volatility

To preserve tractability we do not report results of all particular tests, but just the direction of change in volatility and year of the observed breaks. In particular, the years in Table A1 indicate break points. D indicates that GDP growth volatility after the break declined. D in columns for trend regressions indicates that the trend variable in regression has a negative sign, indicating a gradual decline in conditional volatility. The opposite is the case for I. The complete set of results for each country included in the analysis is available upon request.

As discussed in the main text, since we are particularly interested in GDP growth volatility in the period preceding the current crisis, the results are selected depending on the volatility in the last period. That is, in the case when the last break concerns an increase in GDP growth volatility, we categorized that country as one with an increase in volatility; and vice versa, in the cases when the last break indicates a reduction in volatility. In the case when the results of different tests do not point in the same direction, we calculate the standard deviation of GDP growth in the last period and compare it with volatility in the previous period. The results of this procedure, for each country, are presented in the last column of the Table A1.

TABLE A1

	Test for multiple structural change in GDP growth volatility							
Country name	*Model*	*Breaks in conditional mean*			*Breaks in conditional volatility*		*Trend regression*	*Overall*
Algeria	AR(1)				1972 D**	1994 D***	D***	D
Argentina	AR(1)							
Australia	AR(1)				1970 D***		D***	D
Austria	AR(1)	1974 I***					D*	I
Bahamas	AR(1)				1973 I*	1984 D***	D***	D
Bangladesh	AR(1)				1975 D***		D***	D
Belgium	AR(2)	1974 I***					D*	I
Belize	AR(1)				1971 I***			I
Benin	AR(1)				1989 D***		D**	D
Bermuda	AR(1)				1991 D***		D***	D
Bolivia	AR(1)	1971 I*	1986 D*				D***	D
Botswana	AR(2)	1971 D***	1988 D***					D
Brazil	AR(1)	1980 D**			1990 D*			D
Burkina Faso	AR(1)	1994 D**					D**	D
Burundi	AR(1)	1991 I***						I
Cameroon	AR(3)	1977 D**	1985 I**		1990 D***		D*	D
Canada	AR(1)	1973 I**						I
Central Afr. Rep.	AR(1)				1978 I***			I
Chad	AR(1)							
Chile	AR(1)	1972 D***	1983 D***	1997 D***	1972 I**	1982 D**	D***	D
China	AR(2)	1972 D**	1981 I**		1978 D**		D***	D
Colombia	AR(1)							
Congo Dem. Rep.	AR(1)	1974 I***						I
Congo Rep.	AR(1)	1982 D**						D
Costa Rica	AR(1)	1973 I***	1982 D*		1974 I*			D
Cote d'lvoire	AR(1)	1978 D***			1985 D*		D***	D
Denmark	AR(1)	1973 D*			1988 D**		D***	D
Dominican Rep.	AR(1)				1973 D*	1983 I*	D*	I
Ecuador	AR(1)							
Egypt	AR(1)				1982 D*		D***	D
El Salvador	AR(1)	1978 I**					D*	I
Fiji	AR(1)	1979 I**						I
Finland	AR(2)							

(*continued overleaf*)

TABLE A1 (*Continued*)

	Test for multiple structural change in GDP growth volatility							
Country name	*Model*	*Breaks in conditional mean*			*Breaks in conditional volatility*		*Trend regression*	*Overall*
France	AR(1)	1974 D***						D
Gabon	AR(1)	1976 D***			1973 I*	1991 D*		D
Germany	AR(1)				1976 D*		D***	D
Ghana	AR(1)	1983 I***	1994 I***		1983 D***		D***	D
Greece	AR(1)	1973 D***	1996 I***		1993 D***		D***	D
Guatemala	AR(1)	1976 I***	1986 D*		1984 D**		D**	D
Guyana	AR(1)	1974 I**	1997 I**				D*	D
Haiti	AR(1)				1996 D*			D
Honduras	AR(1)							
Hong Kong	AR(3)						D*	D
Hungary	AR(2)	1978 I***	1991 D***		1978 I***	1991 D***		D
Iceland	AR(2)				1992 D**		D***	D
India	AR(1)							
Indonesia	AR(1)				1998 D*			D
Ireland	AR(1)	1993 I**						I
Israel	AR(1)				1977 D*		D**	D
Italy	AR(1)	1979 I**			1978 D**		D***	D
Japan	AR(3)				1974 D*		D***	D
Kenya	AR(1)	1971 D***			1973 D**		D***	D
Korea	AR(1)							
Lesotho	AR(2)						D*	D
Liberia	AR(1)	1979 I***	1988 I***	1997 D***	1977 D**	1988 I***	I***	D
Luxembourg	AR(1)						D*	D
Madagascar	AR(1)							
Malawi	AR(1)	1979 I***	1995 D***		1971 D*	1980 I*		D
Malaysia	AR(1)							
Malta	AR(1)				1975 D**		D**	D
Mauritania	AR(1)						D*	D
Mexico	AR(1)	1981 D***						D
Morocco	AR(1)	1977 I**						I
Nepal	AR(3)	1983 I*	1996 D*		1983 D***		D***	D
Netherlands	AR(1)	1970 I***						I
New Zealand	AR(1)				1977 D***		D***	D
Nicaragua	AR(1)				1988 D***		D***	D
Niger	AR(1)				1985 D*		D**	D
Nigeria	AR(1)				1988 D***		D**	D
Norway	AR(1)	1980 I***						I
Pakistan	AR(1)							
Panama	AR(1)	1971 D***			1977 I**		I***	I
Papua New Guin.	AR(1)	1993 D*			1988 I***	1998 D***		D
Paraguay	AR(1)	1970 I***	1980 D***		1979 I**		I*	I
Peru	AR(1)				1980 I*			I
Philippines	AR(1)	1976 I***	1985 D***		1972 I**			D
Portugal	AR(4)	1976 D***						D
Rwanda	AR(1)	1994 D***						D

(*continued overleaf*)

TABLE A1 (*Continued*)

	Test for multiple structural change in GDP growth volatility						
Country name	*Model*	*Breaks in conditional mean*		*Breaks in conditional volatility*		*Trend regression*	*Overall*
Rwanda	AR(1)	1994 D***					D
Senegal	AR(1)	1973 D**		1974 I***	1983 D***		D
Seychelles	AR(1)	1978 D**		1981 D*		D**	D
Sierra Leone	AR(1)			1991 I**		I***	I
Singapore	AR(1)			1972 D**			D
South Africa	AR(1)	1970 I*		1992 D**			D
Spain	AR(1)			1981 D***		D***	D
Sri Lanka	AR(1)						
St. Vincent	AR(4)					D**	D
Sudan	AR(2)	1973 I***	1987D***				D
Sweden	AR(1)	1993 D*				D*	D
Switzerland	AR(1)						
Syrian Arab Rep.	AR(1)			1976 D**		D***	D
Thailand	AR(1)	1987 I***	1998 D***	1997 D***			D
Togo	AR(1)			1998 D***			D
Trinidad and Tob.	AR(1)	1976 I***					I
United Kingdom	AR(2)	1975 I**		1991 D*			D
United States	AR(1)			1984 D***		D***	D
Uruguay	AR(1)			1981 I*		I***	I
Venezuela	AR(1)					I***	I
Zambia	AR(1)						

Note: *,** and *** indicate 10%, 5% and 1% of significance.