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# What Caused The Great Moderation? Some Cross-Country Evidence

*By Peter M. Summers*

Over the last 20 years or so, the volatility of aggregate economic activity has fallen dramatically in most of the industrialized world. The timing and nature of the decline vary across countries, but the phenomenon has been so widespread and persistent that it has earned the label: “the Great Moderation.”

A growing body of research has focused on The Great Moderation and its possible explanations, especially as it applies to the U.S. experience. The literature documents the international dimension of this volatility reduction, but so far little is known about the possible causes from a cross-country perspective.

This article shows why The Great Moderation has indeed been a common feature of much of the industrialized world. Specifically, the article focuses on the reduction in the volatility of GDP growth that occurred in the G-7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) and Australia. Similarities among these countries suggest there may be one or more underlying global causes. Still, differences in the experiences of these countries indicate the important influence of country-specific factors.

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The most common explanations for increased output stability include better monetary policy, structural changes in inventory management, and—to put it simply—good luck. Sorting out the relative merits of these potential causes has important implications for policymakers. If The Great Moderation happened as a result of improved monetary policy, and to the extent that this moderation has been beneficial, then policy should continue to be made in the “new” way. In contrast, if the moderation happened because of structural changes in the way industrialized economies operate (for example, how inventories of goods and raw materials are organized at various stages of the production process), then public policy should encourage such flexibility and innovation. Finally, if good luck played a primary role, then (apart from hoping that it continues) policymakers should recognize that good luck may not last indefinitely—and they should prepare for a turn for the worse.

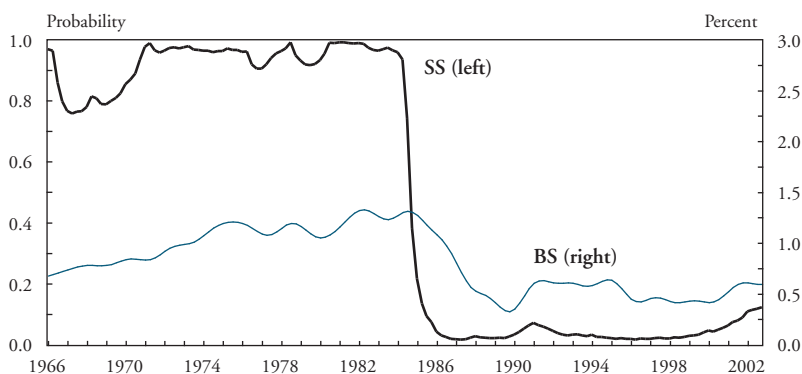
To show how widespread The Great Moderation has been, the first section of this article describes the drop in volatility in the major industrialized countries. The second section discusses the three most frequently cited explanations for The Great Moderation: improved monetary policy, more sophisticated inventory management techniques, and good luck. The third section uses international evidence to evaluate the merits of these potential explanations. The article concludes that, from an international perspective, good luck in the form of smaller energy price shocks is not a compelling explanation for widespread moderation of GDP growth volatility. Rather, The Great Moderation is more likely because of improved monetary policy and better inventory management techniques.

## **I. THE NATURE OF THE GREAT MODERATION**

This section reviews evidence of The Great Moderation in the United States and shows that a similar moderation also occurred in the rest of the G-7 countries and in Australia. The magnitude of the decline in GDP growth volatility was similar across countries, yet the timing differed by more than a decade.

Chart 1

## U.S. GDP VOLATILITY



Source: Author's calculations

Note: SS is the probability that GDP volatility is high. BS is the standard deviation of GDP growth over the prior 20 quarters.

### *Volatility decline in the United States*

Extensive evidence has shown that U.S. output growth volatility has moderated dramatically over the past two decades. This reduced volatility extends to several sectors of the economy, particularly durable goods production (McConnell and Perez-Quiros). Some analysts suggest that increased stability of the U.S. economy occurred rather suddenly—most likely in the first quarter of 1984 (McConnell and Perez-Quiros; Kim and Nelson). Others argue that volatility probably moderated more gradually, taking place over several quarters or years (Blanchard and Simon).

In any case, while methods used to study The Great Moderation differ considerably across studies, the underlying message is remarkably consistent. Macroeconomic volatility fell noticeably in the United States sometime in the early to middle 1980s. Chart 1 shows this decline using two different measures of GDP volatility.<sup>1</sup> One measure assumes that at any given time the volatility of real GDP growth can be characterized as either “high” or “low.” This measure of volatility, labeled SS in the chart, is the probability that GDP volatility in any particular quarter is high, as estimated by Smith and Summers.<sup>2</sup>

A second measure, labeled *BS* in the chart, estimates the volatility of real GDP growth as the standard deviation of GDP growth over the previous 20 quarters (Blanchard and Simon).<sup>3</sup> This measure of volatility is likely to shift more gradually than *SS* because of its “backward-looking” nature. And, as a consequence of the way it is constructed, the measure will not tend to decline noticeably until several quarters of lower volatility growth have already occurred.

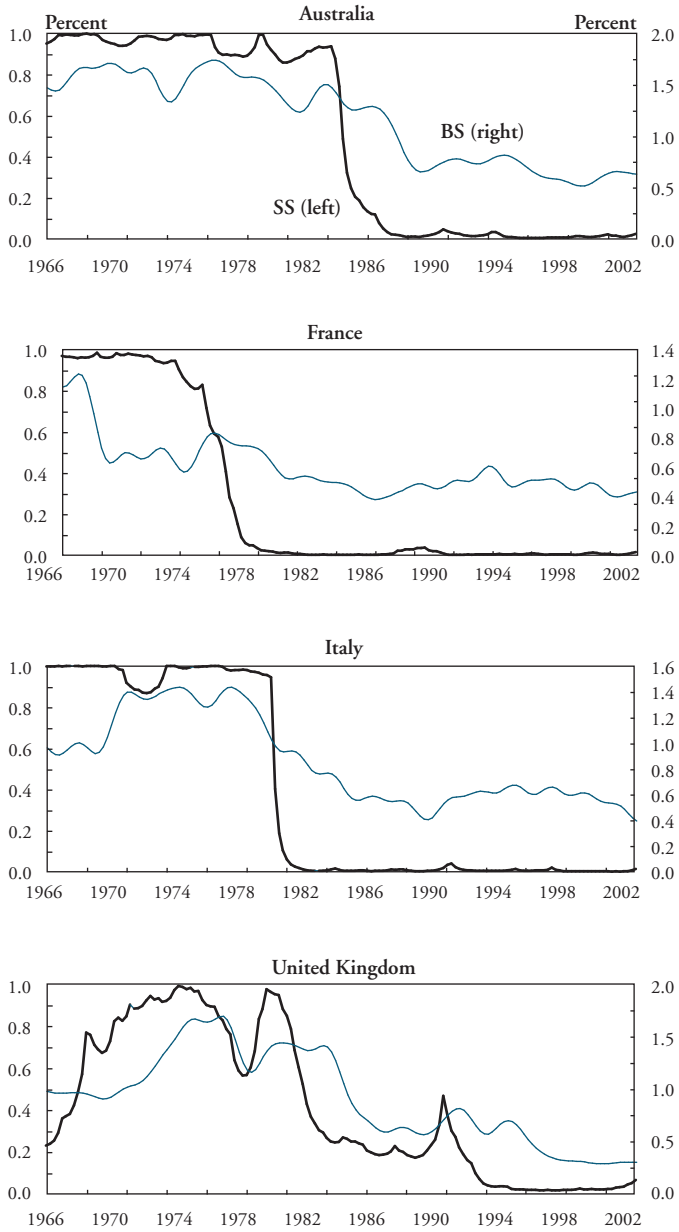
Two regularities are evident in the chart. First, the drop in the volatility of U.S. GDP growth appears to have occurred in the early to mid-1980s. This dating is consistent with both McConnell and Perez-Quiros and Kim and Nelson, who established the first quarter of 1984 as the most likely time of the change in volatility. Second, the size of the reduction in volatility is substantial and similar for both measures—for example, the ratio of low to high volatility is 51 percent for *SS*, and 54 percent for *BS*.

### *Volatility decline in the other G-7 countries and Australia*

A growing body of work documents volatility reductions in (at least) the other G-7 countries and Australia (Blanchard and Simon; Mills and Wang; Stock and Watson; Smith and Summers). Indeed, reductions in volatility appear to have taken place in a wide range of measures of economic activity, including employment and various components of GDP, such as durable and nondurable goods, structures, and inventories (Sensier and van Dijk; Stock and Watson; van Dijk and others).<sup>4</sup>

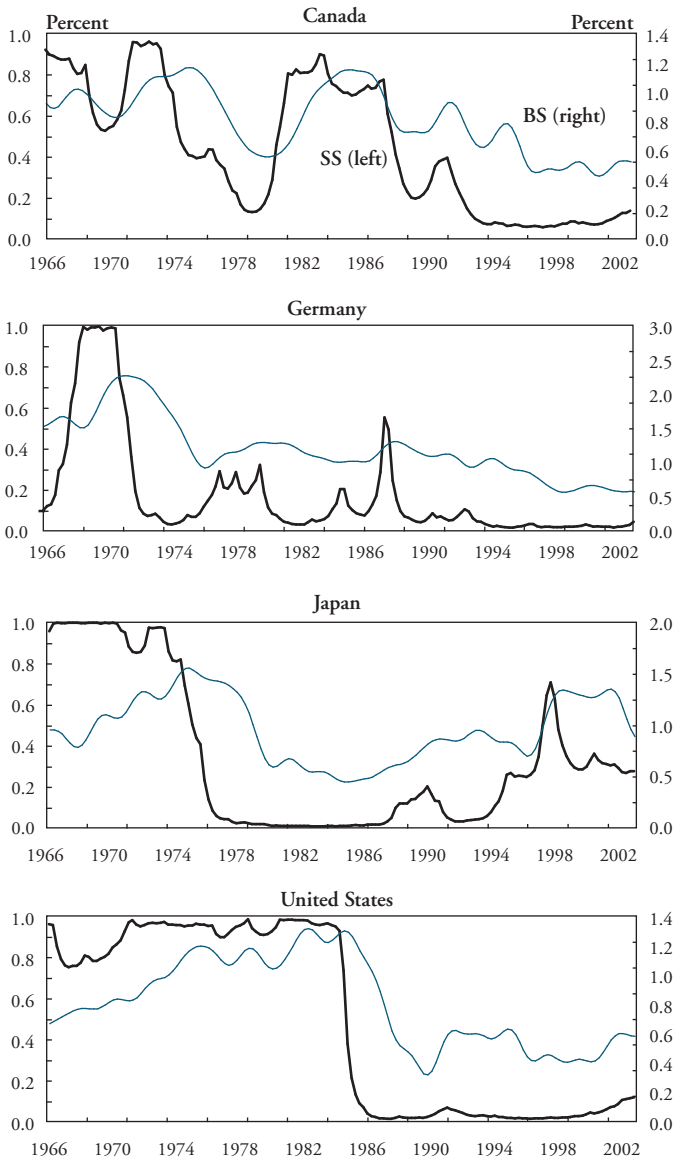
The evidence clearly shows the reductions of volatility in these seven countries and the United States. In nearly all of these countries, output volatility was higher in the early part of the sample than in the past decade or so (Chart 2). That said, the nature and timing of the changes appear to have varied considerably across countries. In Australia, France, Italy, and the United States, the moderation appears to have happened relatively rapidly. In Canada, Germany, Japan, and the UK, the pace appears more varied, with volatility in each of these four countries appearing to swing twice from high to low.

Chart 2  
VOLATILITY OF GDP GROWTH



Source: Author's calculations

*Chart 2*  
VOLATILITY OF GDP GROWTH (continued)



Source: Author's calculations

Table 1

### THE GREAT MODERATION: MAGNITUDE AND DATES OF GDP VOLATILITY REDUCTION

	Ratio of low to high volatility (percent)	Date of switch to low volatility*
Australia	45.8	1984 Q3
Canada	58.0	1988 Q1
France	54.2	1976 Q3
Germany	48.3	1971 Q3
Italy	50.8	1980 Q2
Japan	62.9	1975 Q2
United Kingdom	51.5	1982 Q2
United States	50.8	1984 Q4

\*In the case of multiple switch dates, the reported date is that which most likely coincides with The Great Moderation.

Source: Author's calculations

Using the *SS* measure of volatility, it is possible to quantify the extent of the moderation in GDP and its timing across countries. As in the United States, the volatility of GDP growth in all of the other countries has dropped by roughly half. For example, estimated volatilities as measured by the variance of GDP growth in the latter part of the sample are between 45 and 63 percent of their values in the earlier years (Table 1).

While the magnitude of the moderation was similar across countries, the timing was not. Some countries appeared to experience a moderation in the 1970s. Others did not experience it until the middle to late 1980s. With such large differences in timing, a single global cause of The Great Moderation seems improbable.

## II. WHAT CAUSED THE GREAT MODERATION?

The most commonly proposed explanations for The Great Moderation fall into three broad categories: better monetary policy, structural changes in inventory management, and good luck. This section examines the economic rationale behind each of these potential explanations.

### *Monetary policy*

Analysts have studied extensively whether improved monetary policymaking has been largely responsible for the drop in output volatility. The idea has considerable intuitive appeal, at least for the United States. According to this view, lower output volatility is a result of central bankers' greater emphasis on, and success at, controlling inflation.<sup>5</sup> The explanation does not rest on the idea that monetary policy has *directly* reduced output volatility—in fact, there has been considerable disagreement about whether policy actually has had a direct effect. Instead, the idea holds that monetary policy may have been important in reducing output volatility to the extent that policy changes have resulted in lower and more stable inflation.

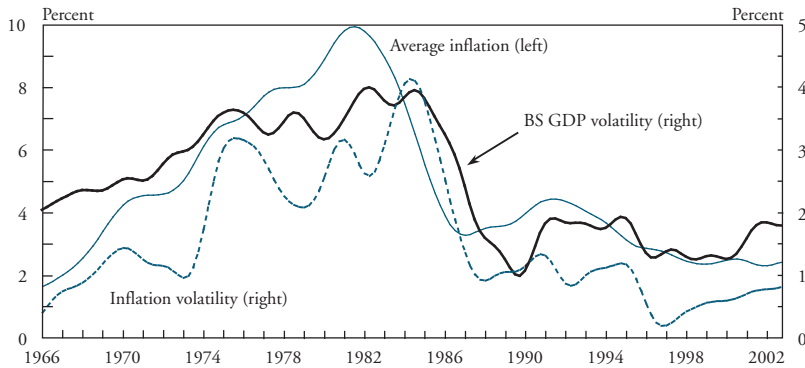
By achieving low and stable inflation, many analysts argue, monetary policy provides a favorable environment for economic activity generally. Such an environment could contribute to more stable output growth in several ways. Lower inflation reduces nominal distortions, such as those that arise from taxation.<sup>6</sup> More stable inflation also removes one source of uncertainty that might cloud firms' investment decisions. Finally, to the extent that low and stable *actual* inflation translates into low and stable *expected* inflation, policymakers might have more flexibility in responding to unforeseen events, such as financial or banking crises.

In the United States, The Great Moderation occurred soon after several major changes at the Federal Reserve. Monetary policy conduct appeared to have changed significantly with the appointment of Paul Volcker as chairman of the Board of Governors. The pre-Volcker period (from 1960 until mid-1979) could be characterized by an “accommodative” stance for monetary policy with respect to anticipated inflation (Clarida and others). During this time, by responding less than one-for-one to changes in inflation, policy sparked further increases in expected (and therefore actual) inflation. In contrast, since 1979 monetary policy appears to have reduced and then stabilized both actual and expected inflation. Moreover, the post-1979 monetary policy may have contributed directly to lower output volatility by mitigating the effects of unforeseen shocks to the economy (Clarida and others).<sup>7</sup>



Chart 3

## GDP VOLATILITY AND INFLATION VOLATILITY FOR THE UNITED STATES



Source: Author's calculations

Note: BS GDP volatility has been multiplied by a factor of 3.

Analysts generally agree that improved policymaking was central to the reduction in both the level and volatility of inflation in the United States (Chart 3). The average level of U.S. inflation dropped from a peak of nearly 10 percent in mid-1981 to 3.3 percent at the start of 1987.<sup>8</sup> The standard deviation of inflation fell from just over 4 percent in the last quarter of 1983 to about 1 percent three years later. Both of these changes preceded the reduction in U.S. GDP volatility.<sup>9</sup>

### *Inventory management*

A second leading explanation for The Great Moderation relates to changes in inventory management. Inventories act as a buffer between production and sales. Excess of production over sales leads to inventory accumulation. Excess sales demand over production can be met by inventory holdings—at least to the extent they are available. The inventory-based explanations of The Great Moderation rest on the observation that the volatility of durable goods *sales* has remained essentially constant, while the volatility of durable goods *production* has declined by an amount similar to that of GDP.<sup>10</sup> According to these explanations, the widespread adoption of information technology

enabled fundamental changes in the nature of production and distribution processes, and their relationship to final sales, especially for durable good.

One inventory-based explanation arises from the idea that firms must make decisions about their production levels before the full extent of demand for their product becomes known (Kahn and others). In such a scenario, better information on the part of firms, or greater flexibility in production (for example, shorter lead times in ordering or hiring decisions), results in lower volatility of goods output. This explanation is consistent with the rapid and extensive adoption of information technology in durable goods production since the early 1980s.<sup>11</sup>

Alternatively, changes in inventory investment behavior may have changed the relationships among different sectors of the economy, especially manufacturing and trade (Irvine and Schuh). In this view, The Great Moderation has been due in large part to less co-movement between output or sales in different industry sectors. That is, an unexpected shortage of inventories (such as spare parts) in one industry is now much less likely to disrupt sales or production in other industries.<sup>12</sup>

Such changes might have occurred in at least two ways. First, by making production or sales less sensitive to inventories, improved sales forecasting or inventory management could have reduced the volatility of inventory investment *within* a particular industry. Second, similar improvements in supply, distribution, and transportation networks might have helped streamline connections *among* industries (such as auto manufacturing and retailing). Both effects could have been brought about by the rapid adoption of information technology and other innovations in supply chain management.<sup>13</sup>

### *Good luck*

The third main explanation for reduced economic volatility since the mid-1980s is that economic conditions have been relatively benign. If volatility is the economic outcome of large adverse events, then volatility will decline if such unlucky events happen less often or temporarily cease.

Internationally, good luck occurs largely as the result of an absence of large adverse events hitting several countries simultaneously and causing widespread volatility. In other words, good luck is the result of the absence of bad luck. When it comes to bad luck, many analysts focus on oil price supply shocks as prime examples. Two particularly large oil price shocks occurred around the time of the Arab oil embargo in 1973-74 and the Iranian Revolution in 1979-80.

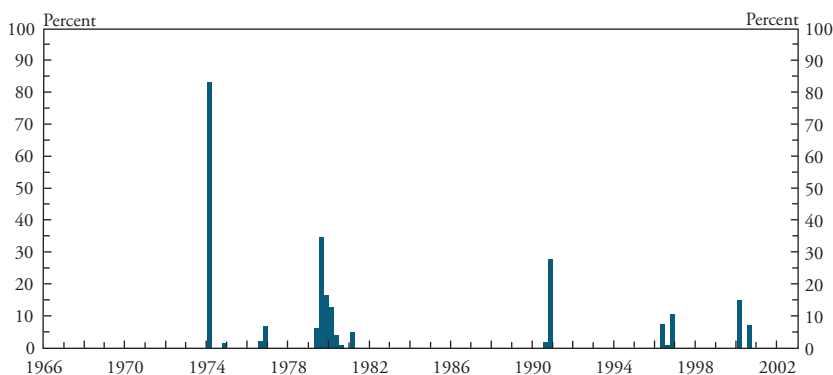
Large oil price increases often dampen economic activity significantly. Most analysts agree that economic activity is more likely to be disrupted by large price hikes than by large declines or by stable (although possibly high) prices. To reflect this idea, this article measures oil price shocks as the percentage increase in the current, inflation adjusted, domestic price of oil over the maximum level attained in the previous three years (Hamilton). Thus, if the current price is below its previous three-year maximum, there is no shock.<sup>14</sup>

While the timing of oil price shocks will be common to all countries, the size of the shock will depend on several factors. First, oil is priced in dollars. Therefore, the size of a shock in a particular country will depend on the price of oil measured in that country's currency. An appreciation of a currency relative to the dollar will tend to mitigate the increase in the price of oil as measured in that currency. Second, because oil price shocks are measured net of inflation, different inflation rates across countries will lead to different sized shocks across countries. Finally, differences in countries' dependence on oil and in their energy efficiency may cause the same dollar increase in oil prices to affect countries differently.

While oil price shocks have not become less frequent, recent shocks have become much smaller than those of the 1970s when measured in inflation-adjusted U.S. dollars. The 1973-74 shock was by far the largest to hit the United States (Chart 4). In the first three months of 1974, the real price of imported oil increased by more than 80 percent over its previous three-year peak. Although only slightly larger than more recent shocks, the price shock associated with the Iranian Revolution was considerably more persistent. Thus, at least in the United States, the hypothesis that good luck in the form of smaller oil price shocks might explain The Great Moderation appears compelling.

Chart 4

## REAL OIL PRICE SHOCKS FOR THE UNITED STATES



Source: Author's Calculations

### III. ASSESSING THE INTERNATIONAL EVIDENCE

This section assesses the evidence in favor of each of the three main explanations of The Great Moderation. On one hand, similarities in the experiences of all eight countries might suggest that a single global explanation could apply to all. On the other hand, cross-country differences in the timing of The Great Moderation might support other explanations, particularly given differences in the countries' monetary policy, inflation experience, and economic structure.

The three explanations discussed earlier are unlikely to be independent of each other. In particular, if monetary policy changes have credibly lowered and stabilized inflation, the resulting drop in expected inflation may have given central bankers more flexibility to respond to adverse unforeseen events. Consequently, without a clean measure of shocks (other than oil prices), it becomes difficult to disentangle the good luck theory that shocks have become smaller from the theory that monetary policy has more effectively responded to shocks.

Likewise, monetary policy and the behavior of inventory investment may also be linked. If lower inflation variability has reduced some of the risk associated with business investment, firms may have been more confident in the economy. Thus they may have been more willing to make needed investments in information technology, new assembly lines and distribution networks, and other improvements needed to bring about more efficient management of inventories.

Of the three main explanations, the good luck theory appears the weakest. In contrast, better monetary policy and improved inventory management appear more likely explanations of The Great Moderation.

### *Good luck*

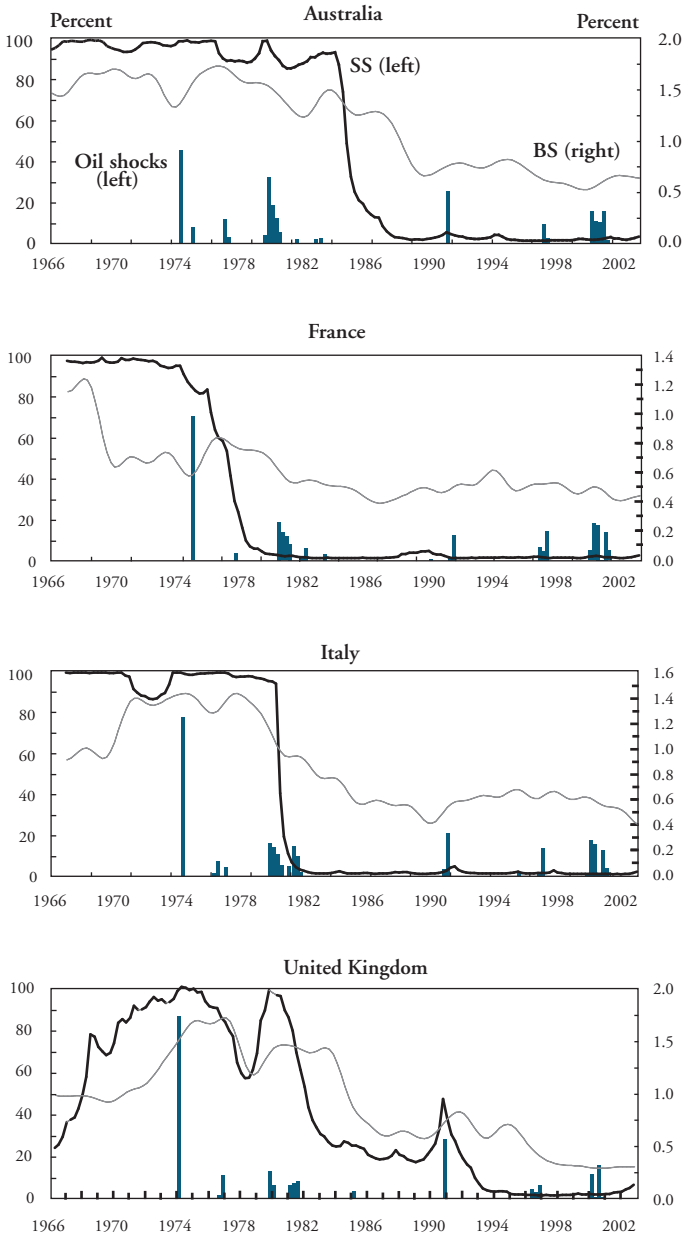
The good luck theory suggests that less volatile GDP growth reflects a reduction in large adverse shocks. Although supply-induced oil price spikes are the primary example of such shocks, other adverse events could also lead to elevated economic volatility. Clearly, the September 11 terrorist attacks had significant implications for economic activity in the United States and elsewhere. Yet arguing broadly that such adverse events have been smaller or less frequent since The Great Moderation is problematic—particularly as they are difficult to quantify. In any case, given measurement difficulties, the analysis in this section will focus on quantifiable oil price shocks.

The luck theory as applied to oil price shocks can be evaluated based on two premises. First, to explain a reduction in volatility, the luck theory requires that oil shocks have become smaller. Second, because oil price shocks are synchronized globally, the luck theory implies that GDP volatility reductions should also be synchronized across countries.

Evidence on the first premise is weak. The size of oil price shocks differs considerably across countries, depending on exchange rate movements and domestic inflation. And some countries have experienced similarly sized shocks both before and after The Great Moderation (Chart 5).<sup>15</sup> While the oil shock associated with the OPEC oil embargo of 1973-74 was large for all countries—ranging from a 46 percent increase in the inflation-adjusted domestic price of oil in Australia to more than 80 percent in the United States and UK—it is not at all clear that the average magnitude of oil shocks has fallen since The Great Moderation. The 1990 shock due to the first Gulf War hit Canada and Japan particularly hard, causing oil prices to rise more than 40 percent in both countries. Further, the *cumulative* effect of other persistent oil shocks was at times similar in size to the OPEC shock. For example, in Australia the cumulative increase in the price of oil between July 1999 and December 2000 exceeded 50 percent.

Chart 5

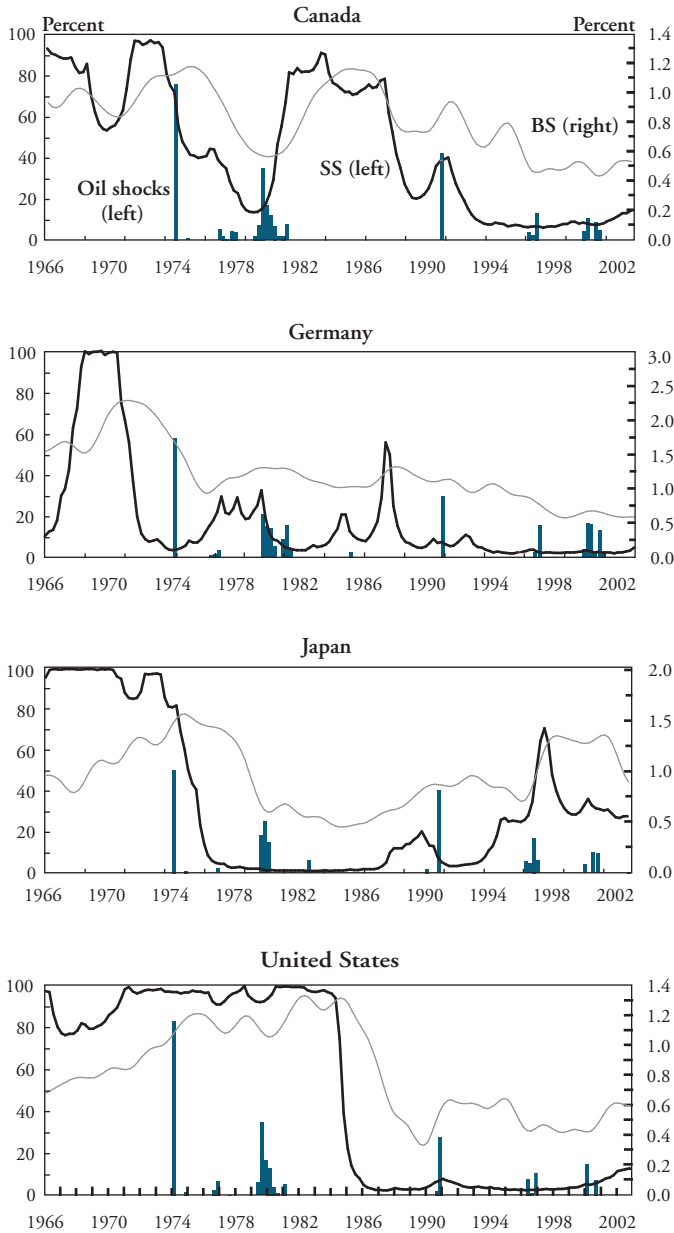
VOLATILITY OF GDP GROWTH AND OIL PRICE SHOCKS



Source: Author's calculations

Chart 5

VOLATILITY OF GDP GROWTH AND OIL PRICE SHOCKS (continued)



Source: Author's calculations

*Table 2*  
OIL SHOCKS AND VOLATILITY

	Australia	Canada	France	Germany	Italy	Japan	United Kingdom	United States
Could smaller oil price shocks explain The Great Moderation?	Yes	No	No	No	Yes	No	Yes	Yes

The fact that the shifts in volatility in these eight countries have *not* been tightly synchronized casts further doubt on the oil shock explanation. Oil shocks are global shocks. The *size* of the shocks in each country is influenced by exchange rate and domestic price movements, but the *timing* of the shocks is synchronized across countries. In contrast, as previously shown, the timing of The Great Moderation varied considerably across countries (Chart 2; Table 1).

Although smaller oil price shocks do not appear to explain The Great Moderation from an international perspective, they still may have played a role in some of the countries examined. To assess the plausibility of the oil shock explanation, it is helpful to consider the following question: Did the oil shocks decline before or at the same time as The Great Moderation?<sup>1</sup>

If for a particular country the answer is no, some other factor or factors may have been important in explaining the volatility reduction in that country. Based on a visual inspection of Chart 5, the evidence is mixed. In four of the eight countries, oil price shocks may have helped explain The Great Moderation (Table 2). Yet, even in those four countries, the evidence over a longer horizon can be ambiguous. Since the mid-1980s, output volatility has remained low in Australia, Italy, and the United States despite sizable shocks.

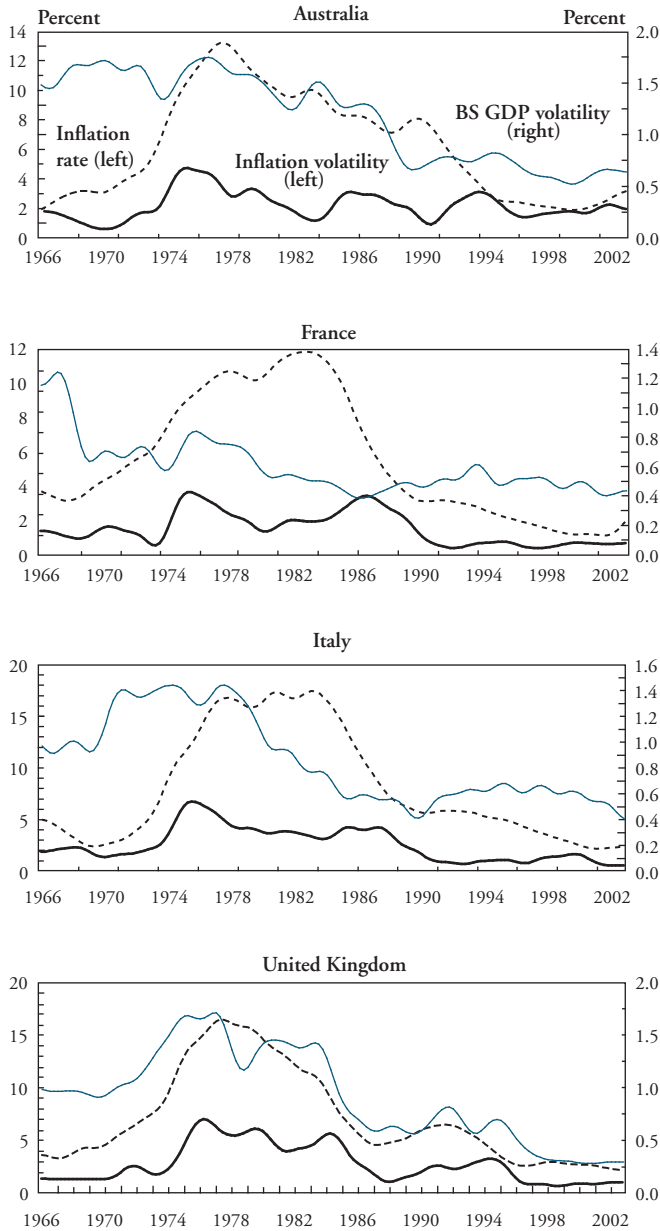
### *Monetary policy*

Improved monetary policy may have contributed to The Great Moderation by lowering or stabilizing inflation. In fact, both lower and more stable inflation appeared to have played a role, in at least some of the eight countries examined. In five of the eight countries, movements



Chart 6

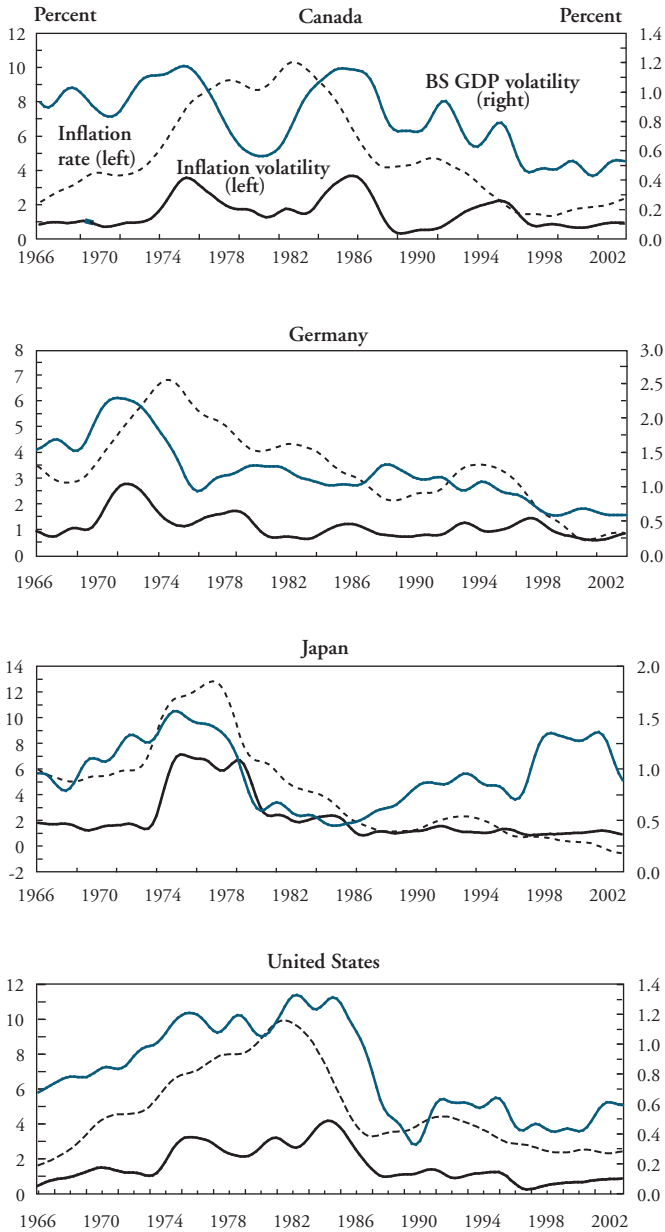
VOLATILITY OF GDP GROWTH, INFLATION, AND INFLATION VOLATILITY



Source: Author's calculations

Chart 6

VOLATILITY OF GDP GROWTH, INFLATION, AND INFLATION VOLATILITY (continued)



Source: Author's calculations

Table 3

## INFLATION, INFLATION VOLATILITY, AND GDP VOLATILITY

	Australia	Canada	France	Germany	Italy	Japan	United Kingdom	United States
Could lower inflation explain The Great Moderation?	Yes	Yes	No	No	No	Yes	Yes	Yes
Correlation with GDP volatility	<b>.49</b>	<b>.39</b>	.09	<b>.60</b>	<b>.32</b>	<b>.42</b>	<b>.86</b>	<b>.83</b>
Could lower inflation volatility explain The Great Moderation?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Correlation with GDP volatility	<b>.19</b>	<b>.56</b>	.09	<b>.63</b>	<b>.51</b>	<b>.40</b>	<b>.77</b>	<b>.88</b>

Note: Entries in bold are statistically significant at 10 percent.

in the average inflation rate declined either before or with the reduction in GDP growth volatility (Chart 6; Table 3).<sup>17</sup> However, in France, Germany, and Italy, the decline in GDP volatility appears to have occurred well in advance of the decline in average inflation.

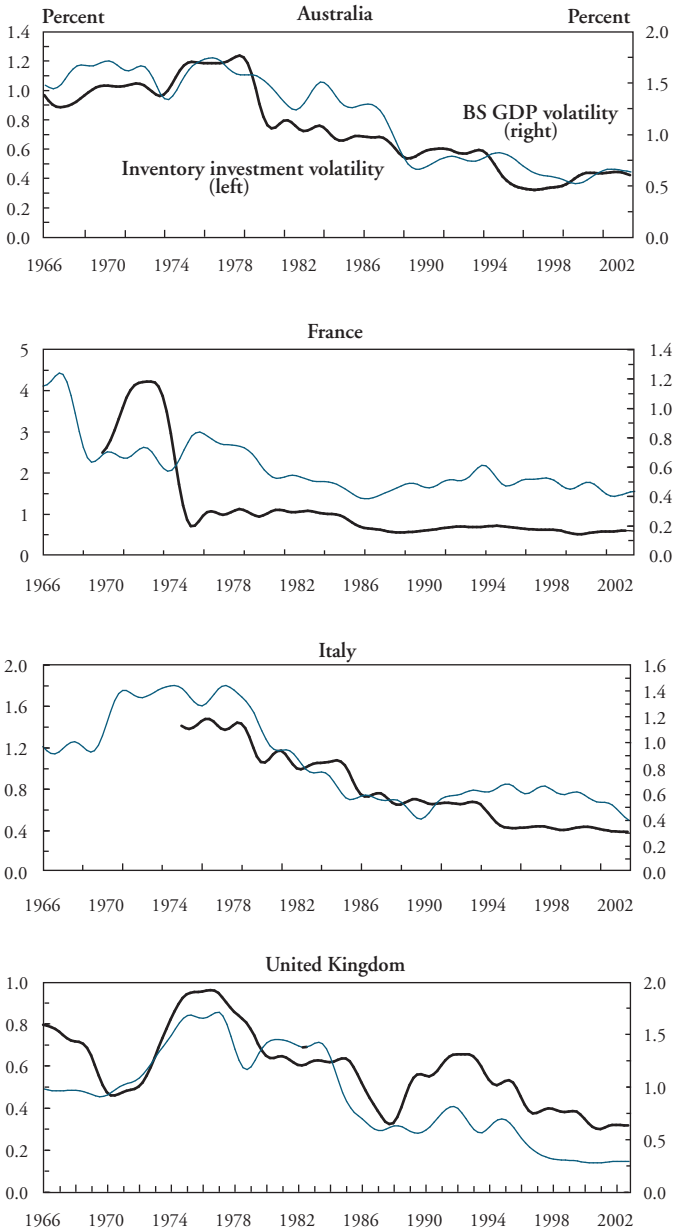
Evidence linking more stable inflation to The Great Moderation is widespread. In all countries, inflation volatility dropped noticeably with or prior to The Great Moderation (Chart 6; Table 3). Such reductions can be interpreted as movements toward better monetary policy (Cecchetti and others).

The evidence of a link between inflation volatility and GDP volatility is more compelling for the period after 1975 than before. In all eight countries, both the level and volatility of inflation were relatively low at both the beginning and end of the sample period. Inflation increased and became more volatile from the 1960s until about the mid-1970s, whereas (with the exception of Japan) the volatility of GDP growth was noticeably higher in the 1960s than at the end of the sample.<sup>18</sup>

Overall, the correlations of both average inflation and inflation volatility with GDP volatility generally support a link between good monetary policy and low GDP volatility (Table 3). The correlations are all positive (as economic reasoning would suggest) and statistically different from zero for all countries but France.<sup>19</sup> Still, correlations are much stronger for some countries than others, suggesting considerable variation in the nature of the relationship between inflation and GDP volatility.

Chart 7

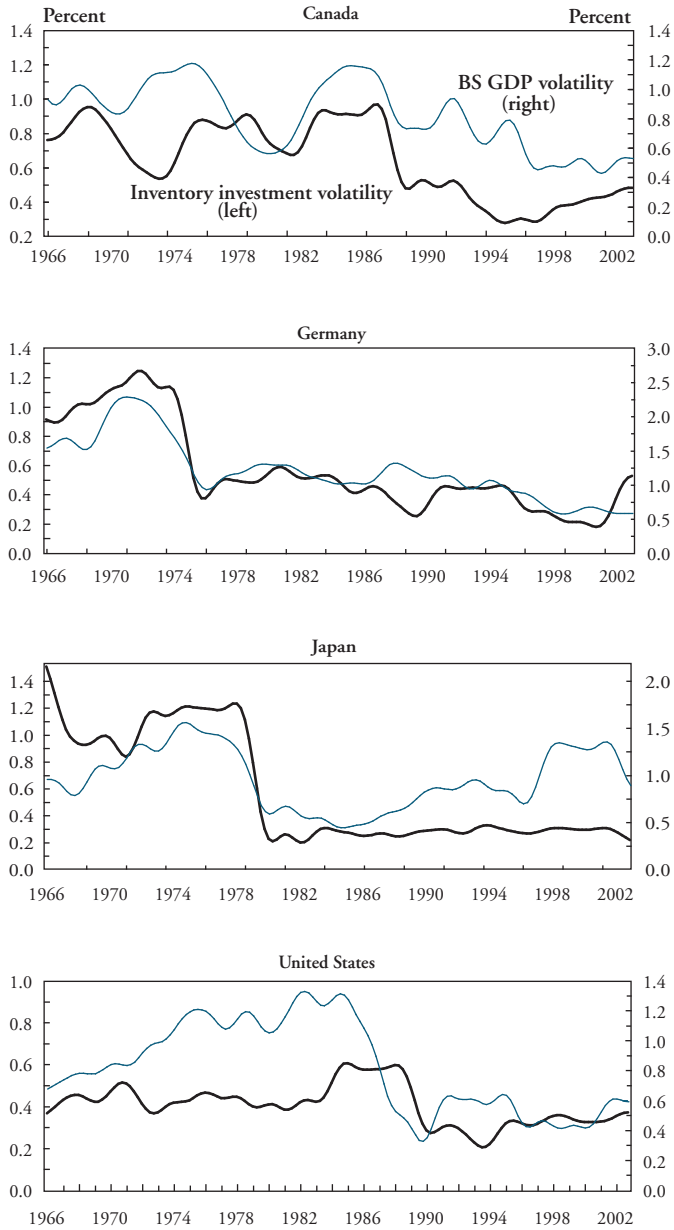
VOLATILITY OF GDP GROWTH AND INVENTORY INVESTMENT VOLATILITY



Source: Author's calculations

Chart 7

VOLATILITY OF GDP GROWTH AND INVENTORY INVESTMENT VOLATILITY (continued)



Source: Author's calculations

Table 4

## INVENTORY VOLATILITY AND GDP VOLATILITY

	Australia	Canada	France	Germany	Italy	Japan	United Kingdom	United States
Could lower inventory volatility explain The Great Moderation?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Correlation with GDP volatility	<b>.92</b>	<b>.65</b>	<b>.48</b>	<b>.91</b>	<b>.86</b>	<b>.59</b>	<b>.83</b>	<b>.50</b>

Note: Entries in bold are statistically significant at 10 percent

*Inventory management*

Cross-country evidence is consistent with a link between changing patterns of inventory investment and GDP volatility. Inventory volatility tended to decline with or before the lower GDP volatility typically associated with The Great Moderation (Chart 7; Table 4).<sup>20</sup> Further, while explanations related to monetary policy or oil prices were generally unsuccessful at explaining relatively high levels of GDP volatility in the 1960s and early 1970s, an explanation based on inventory volatility appears plausible. The volatility of inventory investment tended to be relatively high in the 1960s and early 1970s, consistent with the pattern of GDP volatility.

The behavior of inventory investment discussed here is consistent with the findings of other researchers. Van Dijk and others documented an international drop in the volatility of production—but not in sales. Further evidence supports the key role of inventories in Australia. The ratio of inventories to output in the Australian distribution and manufacturing sectors behaved in a very similar way to that documented by Kahn and others for the United States. In Australia from 1980 to 1996, improved flexibility in inventory management and the resulting decline in the labor intensities of many aspects of goods distribution helped the ratio of inventories to GDP in wholesale and retail trade to fall 43 percent (Johnston and others).

Overall, evidence suggests that new inventory management techniques have been important, not just in the United States, but internationally. The strong, positive correlation between GDP volatility and the volatility of inventory investment in all eight countries is signifi-

cant, and the size of this effect is similar across countries. In addition, for most countries these correlations are at least as strong as those relating GDP volatility to inflation behavior.

#### IV. CONCLUSION

This article has shown that The Great Moderation has indeed been a common feature in much of the industrialized world. GDP volatility fell by about half in all of the G7 countries and Australia. However, the timing of the decline in GDP volatility was not synchronized. Consequently, the data presented here cast doubt on the idea that common global shocks, such as oil price shocks, played a primary role.

In contrast, variations across countries in the onset of The Great Moderation appear to coincide with national differences in the timing of more moderate and stable inflation and of reduced inventory volatility. Thus, the combination of improved monetary policy, which helped lower and stabilize inflation, and better inventory management techniques may have contributed importantly to lower GDP volatility. The empirical evidence, however, does not favor a single explanation. The possible interaction of all three factors—monetary policy, inflation, and inventory investment—appears to be an interesting direction for future work in this area.

## ENDNOTES

<sup>1</sup>Similar results are obtained with a measure of volatility based on the predictability of per capital real GDP growth (Stock and Watson).

<sup>2</sup>In Smith and Summers, the volatility of GDP growth switches randomly between high and low values. In this sort of model, The Great Moderation can be interpreted as taking place when the probability of the volatility being high drops below 50 percent.

<sup>3</sup>As shown in the charts, the BS measures of volatility have been smoothed to remove “noisy” quarter-to-quarter fluctuations. The smoothing method applied was the bandpass filter of Christiano and Fitzgerald. Specifically, the component representing fluctuations of frequency less than eight quarters was removed from the five-year standard deviations.

<sup>4</sup>Blanchard and Simon were apparently the first to study the moderation of volatility in countries other than the United States. Mills and Wang, Smith and Summers, and Stock and Watson (2003), extended the study of The Great Moderation to the other G-7 countries (Smith and Summers also add Australia). Van Dijk and others conducted statistical tests for structural breaks in the volatility of a wide range of macroeconomic variables for each of the G-7 countries.

<sup>5</sup>This view differs from the traditional description of a monetary policy tradeoff between output variability and inflation variability. The tradeoff description suggests reduced output variability could be attained at a cost of higher inflation variability. However, such a description is inconsistent with the observed joint improvement in output and inflation outcomes.

<sup>6</sup>For example, interest on savings is fully taxed as income, even though part of the interest represents compensation for inflation (Reserve Bank of Australia). Higher inflation, therefore, results in heavier taxation of interest income.

<sup>7</sup>Cecchetti and others suggest that it is important to consider effects of policy on both output and inflation. Assuming that policymakers act to stabilize both inflation and output, Cecchetti and others find that more efficient monetary policy accounts for the bulk of the observed improvement in macroeconomic performance since 1991. A more efficient policy is one resulting in less output volatility for any level of inflation volatility, or one resulting in less inflation volatility for any level of output volatility. Cecchetti and others assume that the central bank minimizes a social loss function that is a weighted average of output volatility and inflation volatility. If the weight on inflation volatility is zero (only output volatility is important), then their model gives results very similar to Stock and Watson (2003): more efficient monetary policy explains only about 18 percent of the drop in output volatility for the United States (Stock and Watson estimate 10 percent.) Furthermore, the gain in macroeconomic performance (the reduced social loss) in this case is only 5 percent. On the other hand, using a weight of 0.8 on inflation volatility and 0.2 on output volatility, they find that macroeconomic performance improves (social loss is reduced) by 11 percent, and improved policy explains 45 percent of this gain.

<sup>8</sup>The level and volatility of inflation were both computed in the same way as GDP volatility, over rolling five-year periods, and were smoothed using the Christiano-Fitzgerald bandpass filter as described in endnote 3.



<sup>9</sup>Rogoff also credits the “increased level of competition—in both product and labor markets—that has resulted from the interplay of increased globalization, deregulation, and a decreased role for governments in many countries” as contributing to the reduction in global inflation.

<sup>10</sup>McConnell and Perez-Quiros trace the source of the drop in U.S. output volatility to structural breaks in the absolute value of inventory investment’s share of durable goods production. In other words, their conclusion is that movements in inventories, whether positive or negative, have become a smaller fraction of the production of durable goods. Kahn and others note that while the volatility of production has fallen, there is no evidence of a change in the volatility of sales.

<sup>11</sup>Kahn and others present evidence of a clear change in the relationship between durable goods inventories and final sales since 1984. Using a simple vector autoregression, they show that past values of inventories predict current sales better in the period since 1984 than in earlier years. In addition, they use Kalman filter techniques to estimate a target value of firms’ inventory-to-sales ratio. After remaining roughly constant from 1953 through 1980, this ratio declined by about 43 percent from 1980 to 2000. Furthermore, the deviations from the target value have had a much smaller variance since 1984.

<sup>12</sup>Irvine and Schuh also argue that important structural changes in the behavior of inventories within certain sectors (such as automobile sales and production) are masked by the use of aggregate data.

<sup>13</sup>Siems discusses supply chain management and its role in influencing the volatility of production relative to sales and also provides examples of innovations undertaken by specific companies. Also see Irvine and Schuh, and Kahn and others.

<sup>14</sup>The inflation-adjusted national currency indexes of crude oil import costs serve as a measure of oil prices. The International Energy Agency computes these indexes, beginning in the first quarter of 1980. They are extended back to 1971 by first expressing the price of West Texas Intermediate crude oil in the national currency of each country, indexing these prices so that their average value in 2000 is equal to 100, taking quarterly averages, then deflating by each country’s GDP deflator (the CPI for France and Japan). The growth rates of these indexes are then used to back-cast the IEA’s indexes. The indexes are then transformed as described in Hamilton to produce the oil shock data.

<sup>15</sup>The Blanchard-Simon measure of GDP volatility will appear to dampen any effect of oil price shocks because of the five-year averaging. For this reason, the estimated probability of being in the high-volatility state is shown in Chart 4, as well as in Chart 5. The Blanchard-Simon measure is shown for compatibility with the other charts.

<sup>16</sup>For this exercise, The Great Moderation is identified as having taken place in the quarter listed in the final column of Table 1.

<sup>17</sup>The inflation rate is measured as the average inflation rate over the previous 20 quarters and smoothed using the Christiano-Fitzgerald band-pass filter as described in endnote 3.

<sup>18</sup>The analysis in this article is therefore only partially supportive of the results of Cecchetti and others. The fact that their data begin in 1983 means that the increase in inflation volatility in the earlier years is left unexplained. In the framework of Cecchetti and others, greater inflation volatility represents less

efficient, and therefore less desirable, monetary policy. Why policy would have changed from “better” in the 1960s to “worse” in the 1970s is an open question. Meltzer and Romer address this debate.

<sup>19</sup>It is important to stress that the table entries only show correlation (whether the two series move together), not causation (whether movements in one influence movements in the other). Also, if the series being studied contain strong trends, they will appear to be significantly correlated even if there is no true relationship. Statistical significance is measured at the 10 percent level.

<sup>20</sup>The chart shows the standard deviation of the absolute value of inventory investment as a share of GDP. The standard deviation is calculated using rolling five-year periods and smoothed. Both the change in inventories and GDP are in nominal terms for this chart.

For U.S. data, the chart suggests that the timing of the drop in the volatility of inventory investment may not have preceded the drop in GDP volatility. However, this apparent contradiction in the timing may be because of the use of data on total inventories. As noted by Irvine and Schuh, the use of more detailed data might result in a clearer causal role for inventories in reducing output volatility. Furthermore, volatility as shown in the charts is an approximation and likely measured with error. Consequently, the exact timing of the volatility reductions is subject to uncertainty.

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