Greater Moderations♦

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Abstract

We decompose a 219 year sample of U.S. real output data into permanent and transitory shocks. We find reductions in volatility of output growth and inflation, starting in the mid 1980s, consistent with the "Great Moderation" noted by many others. More importantly, we find periods of even more substantial reduction in volatilities. Output growth and inflation volatilities fell by 60% and 76%, respectively, from shortly after World War II until the mid 1960s. We label this period the Postwar Moderation. Also, the largest reduction in inflation volatility occurred during the Classical Gold Standard period. Results from our empirical model suggest that aggregate supply shocks account for most of the changes in output growth volatility while aggregate demand shocks account for most of the changes in inflation volatility. The timing of the Postwar Moderation, which began almost immediately after passage of the Employment Act of 1946, suggests that policy played a crucial role in this period's impressive decline in volatilities.

JEL Classification: *E30, E31, E65*

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1. Introduction

Economic activity in the U.S. is not well-characterized by constant or smooth volatility. There is, in fact, abundant evidence of a substantial decline in the volatility of most U.S. macroeconomic aggregates beginning in the mid 1980s. Stock and Watson (2002) document a decrease in the standard deviation of real GDP growth and inflation of roughly 30% and 50%, respectively. Most explanations of this reduced volatility fall under two main categories: better monetary policy[1], or simply better luck. [2] If the Great Moderation can be attributed to better policy, then this would provide affirmation of the course of action policymakers have followed. But, if the volatility reduction of the mid 1980s is primarily a result of good luck, then as Summers (2005) puts it, "policy makers should recognize that good luck may not last indefinitely and they should prepare for a turn for the worse."

To address some of these issues, we use a structural vector autoregression (SVAR) model that allows for time-varying parameters. We apply it to U.S. data on real output growth and inflation spanning over two centuries. Our primary objective is to examine how the behavior of these two variables may have changed over time. We also examine the contributions of permanent and transitory shocks to changes in volatilities, which may provide structural interpretations to our findings.

2. The Model

Our model is similar to those of Cogley and Sargent (2005), Primiceri (2005) and Gali et.al. (2009). Consider the following VAR process

$$\theta_t(\mathrm{L})\mathrm{x}_t=\mathrm{e}_t \tag{2.1}$$

[1] See Clarida et al. (2000)
[2] See Justiniano and Primiceri (2008)

where x_t is an n-vector of variables; $\theta_t(L)=I - \theta_{1t}L - ... - \theta_{pt}L^p$ is a p-th order lag polynomial, each θ is a matrix of time-varying coefficients[3], and e_t is an n-vector of mean-zero VAR innovations with the time-varying covariance matrix R_t. Let θ_t represent the stacked vector of all coefficients in $\theta_t(L)$, and assume it evolves according to

$$\theta_t=\theta_{t-1}+u_t \tag{2.2}$$

where $u_t \sim iid(0,Q)$ is a Gaussian white noise process. The model in (2.1) and (2.2) is estimated with Bayesian techniques using Cogley and Sargent's (2005) method.

Our model defines $x_t=\left(\Delta y_t \ \Delta p_t\right)'$ where y_t is the logarithm of real output, p_t is the logarithm of the price level and both variables are first differenced. The "structural" shocks, $\varepsilon_t = \left(\varepsilon_t^P \ \varepsilon_t^T\right)'$, are identified by the assumption that a transitory shock does not affect the long run level of output while a permanent shock can:

$$\lim_{k\to\infty}\frac{\partial x_{t+k}}{\partial \varepsilon_t} = M_t = \begin{pmatrix} m_{11,t} & 0 \\ m_{21,t} & m_{22,t} \end{pmatrix}. \tag{2.3}$$

We allow all the effects of shocks to be time varying, except for the long-run effect of the transitory shock on output. M_t is calculated in the same way as Blanchard and Quah (1989), except for two important differences: first, we allow for time variation in the coefficients and the covariance matrix; second, inflation[4] is used in place of the unemployment rate that Blanchard and Quah (1989) used as the second variable in their model.

Letting x_{it} represent each variable, our model yields:

$$x_{it} = \sum_{k=0}^{\infty}[s_{2,2}(\Theta_t^k)\theta_t(1)^{-1}M_t]_{i,P}\varepsilon_{t-k}^P + \sum_{k=0}^{\infty}[s_{2,2}(\Theta_t^k)\theta_t(1)^{-1}M_t]_{i,T}\varepsilon_{t-k}^T \quad for\ x_{it} = \Delta y_t, \Delta p_t \tag{2.4}$$

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[3] Constants are omitted from these equations for convenience, but are included in estimation and allowed to be time varying in similar fashion to the autoregressive coefficients.

[4] Following Keating and Nye (1998), for example.

where $\theta_t(1)$ is the sum of coefficients matrix for the VAR in equation (2.1), Θ_t is the matrix of autoregressive coefficients from the companion form of that VAR, $s_{2,2}$ is a selector function that picks the upper left 2-by-2 matrix from Θ_t^k and M_t is the long-run effect of the identified shocks on the variables. From (2.4) we determine how the time-varying unconditional variance of x_{it} is decomposed into the contribution of each shock to the variance of each variable:

$$\mathrm{var}_t(x_{it}) = \sum_{k=0}^{\infty}[s_{2,2}(\Theta_t^k)\theta_t(1)^{-1}M_t]^2_{i,P} + \sum_{k=0}^{\infty}[s_{2,2}(\Theta_t^k)\theta_t(1)^{-1}M_t]^2_{i,T} \qquad for\ x_{it} = \left(\Delta y_t, \Delta p_t\right) \quad (2.5)$$

3. The Data

Annual measures of nominal and real gross national product for the U.S. were obtained from Mitchell (2003) for the period from 1790 to 1929 and from the St. Louis Federal Reserve Database (FRED) for the 1929 -2009 period. We collected real output from 1790 to 1889 in 1929 prices, from 1889 to 1929 in 1958 prices, and from 1929 to 2009 in chain-weighted 2005 prices. Figure 1 reports real output growth rates obtained by splicing across the various changes in base year. In contrast to a constant parameter model, the splicing of lower quality nineteenth century data with higher quality postwar series should not cause a significant bias in the postwar subsample estimates. Changes in data quality are handled by changing coefficients and shock variances. Output levels, in nominal and real terms, were calculated by chaining growth rates for each output series, using 2005 as the base year. The price level follows naturally from the ratio of nominal to real output, and annual inflation rates are plotted in Figure 2.

There is substantial overlap in the series derived from our two sources. We experimented with alternative dates for splicing the different source data and obtained remarkably similar findings.

4. Empirical Results

The standard deviations of output growth and inflation are calculated with our time-varying VAR and plotted in Figure 3. Equation (2.5) enables us to decompose the variance of each variable at each period into the sum of the variances contingent on each shock, as is shown by Figures 4 and 5. The solid line in Figure 3 shows the estimates of output growth volatility over the sample. Persistent and wide swings in volatility occur until about 1880. From World War I to shortly after World War II ended, output volatility is higher than at any other period in the sample. Subsequently, output volatility began to fall dramatically until the mid-1960s. During this postwar moderation, output's standard deviation fell by roughly 60 percent. Volatility stabilized for some time, and then in the early 1980s it began falling again. This most recent decline is known as the Great Moderation, but it pales in comparison to the decline in output volatility during the period that we label the Postwar Moderation. Figure 4 illustrates how changes in output volatility are closely associated with the permanent shocks. Since, the Blanchard and Quah (1989) model associates permanent shocks with aggregate supply and temporary shocks with aggregate demand, these results suggest that aggregate supply shocks account for most of the changes in output growth volatility.

The dashed line in Figure 3 illustrates inflation volatility. Throughout most of the 19th century, it exhibits wide fluctuations and a relatively high average level. It spiked at the end of the Civil War and in the early 1880s, but afterwards inflation volatility fell dramatically, hitting a low just before the Panic of 1907. This is the largest decline in inflation volatility levels for our U.S. sample, and it occurs during the Classical Gold Standard period. Volatility rose with The Panic of 1907 and then even faster during World War I. Following World War II, inflation volatility fell more in percentage terms than in any other period. By the mid 1960s it had fallen by roughly 76%. Then it started to rise, slowly at first, but more rapidly by the mid-1970s. In the early 1980s, inflation volatility started falling and reached its historic low in the 1990s. Since then, it has increased a small amount and lies in the narrow range between the all time low from the 1990s and the low level it reached in the mid-1960s. Figure 5 shows that variation in inflation volatility is largely explained by the transitory shocks to output. Thus Blanchard and Quah's (1989) model suggests that aggregate demand shocks account for most of the fluctuation in inflation volatility.

5. Conclusions

We provide evidence of substantially greater moderations in volatilities of output growth and inflation. During the Postwar Moderation, running from shortly after World War II until the mid-1960s, the volatility for each of these variables experienced a much greater decline in percentage terms than during the Great Moderation. While there is some concern that the Great Moderation may have ended[5], there is no sign yet that the gains from the Postwar Moderation are in jeopardy of being lost.

Combining Mitchell's relatively low quality measures of output with NIPA data may raise concern that time variation in measurement error variance accounts for our results. If these results were obtained from a single source, this hypothesis would be difficult to refute. However, very similar results are obtained when different output series are used, different base years are spliced together to form a long time series for real output and different dates for splicing are employed. Furthermore, the results are robust to the use of improved historical

[5] See Clark (2009)

measures of US output and data from seven other countries.[6] Thus a preponderance of evidence contradicts a random measurement error explanation.

We find that two of the most substantial declines in inflation volatility occurred when the U.S. had a fixed exchange rate policy. Output variability increased somewhat during the Classical Gold Standard whereas during the Breton Woods regime it fell in percentage terms by more than any other time in our sample. The fact that output volatility behaved so differently suggests something was fundamentally different about these two periods. In contrast to the period before the Great Depression, stabilization has become a major component of policy discussions and procedures implemented throughout the post-World War II period. For example, passage of the Employment Act of 1946 occurs just before the volatilities of output growth and inflation began their rapid descents. That timing suggests the Federal government's intent "to promote maximum employment, production and purchasing power" (15 USC, §1021) led it to adopt policies that played a major role in the Postwar Moderation.

While fixed exchange rate systems are associated with the largest reductions in volatility, our results show that standard errors of inflation and output growth have been at or near historic lows for the last two decades, a time when U.S. exchange rates were permitted to float. While we are unable to definitively determine why the economy has been relatively more stable in recent years, policy seems to be a contributing factor. Compared to earlier periods, U.S. monetary policy has become more proactive to inflationary pressure and to signals that the economy is headed toward recession.

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6 In on-going research, we obtain similar results using Romer's (1989) series in place of Mitchell's data. The same is true for Keating and Valcarcel (2011) who instead use the Balke and Gordon (1989) series. The Romer (1989) and Balke and Gordon (1989) series were developed to improve upon the historical series of Mitchell and others. But, it is interesting that essentially the same results obtain for the US whether the older, more error-prone series of Mitchell or either of the improved series is used. On-going research also finds similar results for the United Kingdom, Sweden, Italy, Finland, Denmark, Canada and Australia.

Volatilities for output growth and inflation both declined during the Great Moderation and the Postwar Moderation. Our finding that changes in volatility for each variable are primarily driven by a different type of structural disturbance seems at odds with the good luck hypothesis. "Good luck" would require a coordinated decline in variances of the two different structural shocks, but they are uncorrelated by construction. Also, the fact that these moderations coincide with actual policy changes—that can, in the context of many economic models, help stabilize an economy—argues against that hypothesis.

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The Employment Act, Act of Feb. 20, 1946, ch. 33, section 2, 60 Stat. 23, 15 USC, §1021

Figure 1: U.S. Real GNP Growth: 1791-2009

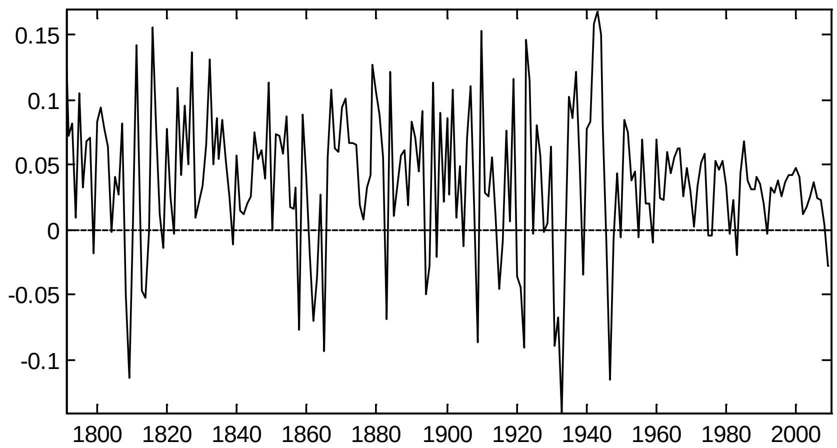

Figure 2: U.S. Inflation Rate: 1791-2009

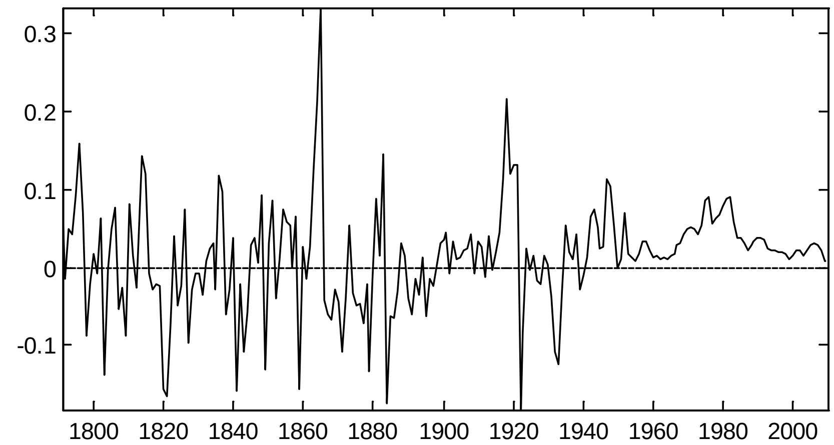

Figure 3: Time Varying Standard Deviations: 1822-2009

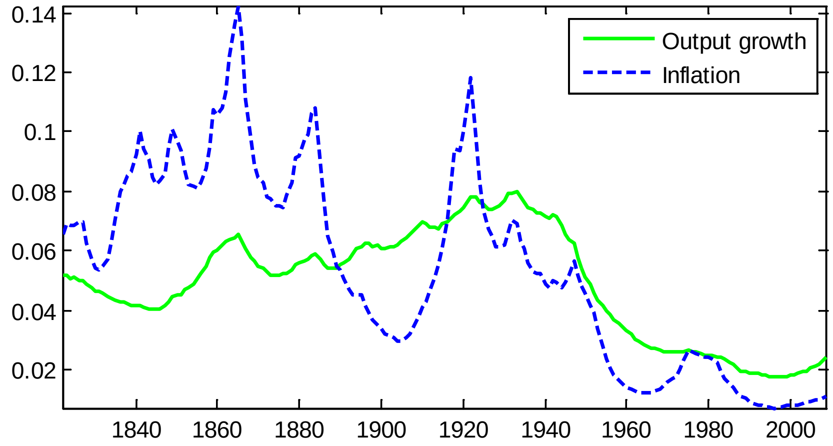

Figure 4: Conditional Standard Deviations for U.S. Real GNP growth: 1822-2009

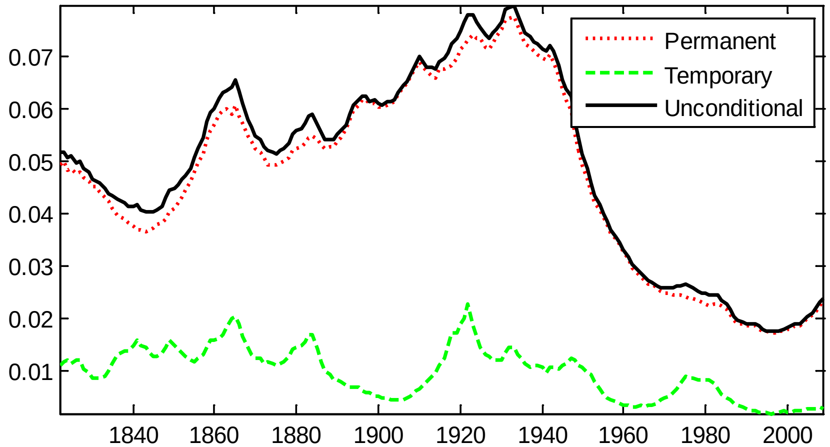

Figure 5: Conditional Standard Deviations for U.S. Inflation: 1822-2009