Abstract—We test for a change in the volatility of 214 U.S. macroeconomic time series over the period 1959–1999. We find that approximately 80% of these series have experienced a break in unconditional volatility during this period. Even though more than half of the series experienced a break in conditional mean, most of the reduction in volatility appears to be due to changes in conditional volatility. Our results are robust to controlling for business cycle nonlinearity in both mean and variance. Volatility changes are more appropriately characterized as instantaneous breaks than as gradual changes. Nominal variables such as inflation and interest rates experienced multiple volatility breaks and witnessed temporary increases in volatility during the 1970s. On this evidence, we conclude that the increased stability of economic fluctuations is widespread.

I. Introduction

The volatility of U.S. output growth showed a substantial decline in the early 1980s, as uncovered by Kim and Nelson (1999) and McConnell and Perez Quiros (2000). Subsequent research has detected similar volatility reductions in other important macroeconomic variables such as employment, consumption, and income, suggesting that business cycle fluctuations in the United States have dampened considerably over the last two decades.

In this paper, we further investigate the extent of the change in the volatility of economic fluctuations by testing for a change in the volatility of 214 monthly U.S. macroeconomic time series over the period 1959–1999. We find that approximately 80% of these series have experienced a break in unconditional volatility during this period, with most breaks occurring after 1980. We demonstrate that, even though more than half of the series experienced a break in conditional mean, most of the reduction in volatility appears to be due to changes in conditional volatility. We also document that our results are robust to controlling for business cycle nonlinearity in both mean and variance, and that the volatility changes are more appropriately characterized as instantaneous breaks than as gradual changes. Finally, we find that nominal variables such as inflation and interest rates experienced multiple volatility breaks and witnessed temporary increases in volatility during the 1970s. Based upon this evidence, we conclude that the increased stability of economic fluctuations is a widespread phenomenon.

II. Structural Change in Unconditional Volatility

We examine a data set originally compiled by Stock and Watson (1999), consisting of 214 monthly U.S. macroeconomic time series, but we extend the sample period to January 1959–December 1999. The series are conveniently grouped in categories as shown in table 1, with the number of series in each category in parentheses. A detailed description of the data set can be found in Stock and Watson (1999).

We start our analysis by testing for a one-time instantaneous structural change in the unconditional volatility of monthly growth rates of the series, denoted as $y_t$. This is implemented by testing for a break in the mean of the absolute value of the demeaned growth rates. Let $W_T(r,	au)$ denote the heteroskedasticity- and autocorrelation-consistent Wald test of the null hypothesis $H_0: \delta_1 = \delta_2$ in the regression

$$ \sqrt{T} \left| y_t - \bar{\mu} \right| = \delta_1 \{1 - I(t > \tau)\} + \delta_2 I(t > \tau) + \varepsilon_t, $$

$$ t = 1, \ldots, T, $$

where $\bar{\mu}$ denotes the sample mean of $y_t$, $T$ is the sample size, $\tau$ is the specified break date, and $I(A)$ is an indicator function for the event $A$. If $y_t$ follows a normal distribution with mean $\mu$, then $\sqrt{n} \left| y_t - \bar{\mu} \right|$ is an unbiased estimator of the standard deviation of $y_t$.

Our analysis is similar in spirit to independently conducted research by Stock and Watson (2002), examining a data set of 168 quarterly U.S. macroeconomic time series. Their emphasis is more on exploring the different explanations for the reduction in volatility that have been put forward. Here we confine ourselves mainly to documenting the prevalence and robustness of the decline in volatility, although we provide some links to its possible causes. Our results do not provide unequivocal support for a single explanation for the reduction in macroeconomic volatility. The finding that changes in conditional volatility are remarkably similar to changes in unconditional volatility does suggest, however, that a large part of the reduction is due to good luck in the form of a reduction in volatility of exogenous shocks.
method of Hansen (1997) to obtain approximate asymptotic

We require both pre- and postbreak periods to contain at least 15% of the conditional mean in 214 monthly U.S. macroeconomic time series over the period 1959–1999. Columns headed “UV” contain results of tests for change in unconditional volatility. The column headed “CM” concerns results of tests for change in the conditional mean that is, in the parameters in the linear autoregressive model (3). Columns headed “CV” contain results of tests for change in conditional volatility (while allowing for a change in conditional mean). Columns headed “ΔR” contain the number of rejections of the null hypothesis of constant (un)conditional volatility or conditional mean at the 5% nominal significance level, where the procedure of Hansen (1997) is used to obtain approximate asymptotic p-values. Columns headed “Δσ” contain the median percentage change in the (un)conditional standard deviation for those series for which the SupW test statistic is significant. Numbers in parentheses following the series type are the numbers of series tested.

We require both pre- and postbreak periods to contain at least 15% of the available observations, that is, we set \( \tau_1 = \lfloor \pi T \rfloor \) and \( \tau_2 = \lfloor (1 - \pi)T \rfloor + 1 \) with \( \lfloor \cdot \rfloor \) denotes integer part. We use the method of Hansen (1997) to obtain approximate asymptotic p-values and employ a 5% significance level throughout. The value of \( \tau \), that minimizes the sum of squared residuals in equation (1) is taken to be the estimate of the break date, confidence intervals for which are computed using the methods developed by Bai (1997a).

Results from the SupW test are summarized in the first two columns of table 1 and in figure 1. Cross-plots of the break dates against the percentage change in standard deviation, including 90% confidence intervals for both, are shown in figure 2 for selected groups of series. Detailed results for individual series are available upon request.

A significant change in unconditional volatility is detected for 168, or 78.5%, of the series, with a median change in standard deviation equal to \(-32.6\%\). In fact, almost three-quarters of the significant changes concern a reduction in volatility, as can be seen from figure 1A. More than 70% of the volatility changes are dated in the 1980s and the first half of the 1990s, with a particularly large number of breaks occurring in 1984; see figure 1B. The scatter in figure 1C reveals a pronounced negative relationship between the timing and magnitude of the volatility breaks. For example, of the 48 (120) volatility changes dated before (after) January 1980, 38 (8) are positive and 10 (112) are negative. We also find a marked contrast between real variables (production, employment, wages and salaries, construction, trade, inventories, orders, consumption, and miscellaneous) and nominal variables (money and credit, stock prices, dividends and volume, interest rates, exchange rates, producer and consumer prices): Of the 115—out of 131—real series for which a significant volatility break is detected, the change is negative (positive) for 101 (14) series. By contrast, volatility has declined (increased) for 21 (32) of the 53—out of 83—nominal variables with significant volatility changes.

The overall results mask interesting differences occurring across and within groups of series. We highlight some of these below. First, total industrial production growth experienced a decline in standard deviation of more than 40%, where the break is dated in March 1984 with the corresponding 90% confidence interval running from August 1983 to December 1986. This is consistent with the break in volatility of GDP occurring in the first quarter of 1984, as documented by McConnell and Perez-Quiros (2000). Most series in the production category experienced declines in volatility of similar magnitude around the same time. Notable exceptions are production and capacity utilization for utilities, which saw volatility increasing by 70% and 43% in 1980 and 1982, respectively, following the second OPEC oil price shock.

Second, volatility declines are dated in 1984 for production and capacity utilization of durable consumer goods and durable manufacturing, whereas for the analogous series for nondurables these occurred only in 1990. This is in line with the finding of McConnell and Perez-Quiros (2000) that the break in output volatility originates from a reduction in volatility of durable goods production.

Third, the reduction in volatility of inventories is dated in 1986 (for both durable and nondurable manufacturing goods), with the lower limit of the 90% confidence intervals placed at the end of 1984, that is, after the reduction in production volatility. This goes against the explanation put forward by Kahn, McConnell, and Perez-Quiros (2002) that change in inventory management is the driving force behind reductions in output volatility (via reduced volatility of durable goods inventories). Also in contrast with Kahn et al. (2002), we do find a substantial decline in durable goods trade volatility (\(-40\%\)), albeit it is dated in 1990 only. On the other hand, volatility of unfilled orders decreased by 40% in 1979 and 1984 for durable and nondurable manufacturing goods, respectively. This provides somewhat more positive evidence for the hypothesis that reduced output volatility is due to better business practice, especially in the durable goods sector.

Fourth, the main employment and unemployment series experienced a decline in volatility around 1984. We find similar reductions around the same time for all sectors of the economy, in contrast to Warnock and Warnock (2000), who found that only employment in (durable) manufacturing has become more stable. These conflicting results can be attributed to major differences in methodology.

Fifth, the results for the monetary and financial variables also reveal several interesting features. All significant volatility changes in the money and credit series are positive, with break dates varying widely from 1968 until 1991. Results for interest rate series are in line with Watson (1999). Medium- and long-term rates have experienced increases in volatility at the end of the 1960s or 1970s, whereas short-term interest rates, including the federal funds rate and the 3- and 6-month treasury bills, have declines in volatility between 1983 and 1985. This would support the explanation advocated by Clarida, Gali, and Gertler (2000), Kim, Nelson, and Piger (2004), and Herrera and Pesavento (2003) that the reduction in output volatility is due to improved monetary policy. Finally, the volatility changes in consumer

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4 When computing these confidence intervals we take into account the fact that, in the presence of a structural change, the variance of the error term in the test regression (1) is different before and after the break; cf. Stock and Watson (2002). This results in asymmetric confidence intervals, with less uncertainty about the break date in the high- than the low-volatility period.

5 In general, the span of the confidence intervals varies widely, ranging from a few months to more than a decade.
and producer prices clearly fall into two groups: substantial increases in the early 1970s on the one hand, and decreases in the early 1980s. This is in line with the hypothesis of Blanchard and Simon (2001) that falls in inflation volatility after the temporary increases in the 1970s are an important determinant of output volatility reductions.

### III. Structural Change in Conditional Mean and Volatility

The changes in unconditional volatility documented above may be due to changes in the conditional mean or in the conditional variance, or in both. For example, Kim and Nelson (1999) argue that a smaller gap between mean growth rates during expansions and contractions is more important than the decline in the volatility of shocks in explaining the increased stability of U.S. output after 1984. Overwhelming evidence for structural change in the conditional mean dynamics of U.S. macroeconomic variables is provided by Stock and Watson (1996).

To explore this issue, we consider a linear autoregressive (AR) model with a single structural change at time $\tau_m$,

$$
y_t = (\phi_{1o} + \phi_{11}y_{t-1} + \cdots + \phi_{1p}y_{t-p})(1 - I(t > \tau_m))$$

$$+ (\phi_{2o} + \phi_{21}y_{t-1} + \cdots + \phi_{2p}y_{t-p})I(t > \tau_m) + \epsilon_t,
$$

(3)

where $\epsilon_t$ is a martingale difference sequence with time-varying conditional variance $E[\epsilon_t^2|\Omega_{t-1}] = \sigma_t^2$, where

$$\sigma_t = \sigma_1(1 - I(t > \tau_o)) + \sigma_2I(t > \tau_o).
$$

(4)

Note that we allow the break date $\tau_m$ for the conditional mean to be different from the break date $\tau_v$ in conditional volatility. Our testing strategy in this case is to first test for a structural change in the conditional mean, and estimate the parameters in equation (3) using the value of $\tau_m$ that minimizes the sum of squared residuals as the estimate of the break date. We then proceed with testing for a structural change in the conditional standard deviation using the SupW procedure described in the previous section, but instead of the de-meaned growth rates now using $\hat{\epsilon}_t$ as the dependent variable in equation (1), where $\hat{\epsilon}_t$ are the residuals from equation (3).

In total, 59% of the series show evidence of structural change in the conditional mean, as shown in the third column of table 1. A (relatively) large number of changes in mean are found in interest rates, producer and consumer prices, consumption, and production. The histogram of estimated mean break dates shown in figure 3 shows that most breaks are dated in a few particular short episodes: 1973–1974, 1980–1982, and 1984. Obviously, many breaks in conditional mean can be attributed to the OPEC oil price shocks.

Significant conditional volatility breaks are detected for 80% of the series, with a median change in standard deviation of $-33.5\%$; see the final two columns of table 1. This corresponds rather closely with the results from tests for changes in unconditional volatility. The main effect of allowing for a structural change in mean appears to be that for quite a few series the break in volatility is dated somewhat later, in particular in the early 1990s, as shown in figure 4B. The distribution of percentage changes in standard deviation is largely unaffected (see figure 4A), while the negative relationship between timing and magnitude of the volatility break continues to emerge from the scatter in

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**FIGURE 1.—CHARACTERISTICS OF UNCONDITIONAL VOLATILITY BREAKS FOR SERIES FOR WHICH THE SUPW STATISTIC IS SIGNIFICANT AT THE 5% LEVEL (168 SERIES)**

In panel A, series for which the standard deviation more than doubles are collected in the rightmost category. In panel C, series for which the standard deviation more than triples are shown as triangles.
Figure 4C. Comparing the relevant columns in table 1 in fact shows that for most groups the test results for changes in unconditional volatility and for conditional volatility are remarkably similar. Substantial differences are found only for orders and money and credit groups, for which the numbers of significant changes in conditional volatility are considerably higher and lower, respectively.

In sum, even though changes in the conditional mean dynamics appear to be a relevant feature of the majority of U.S. macroeconomic
time series, they do not account at all for the observed changes in volatility. This provides quite strong support for the good luck hypothesis that the reduced output volatility is primarily accounted for by a reduction in the variance of exogenous shocks hitting the economy; cf. Ahmed et al. (2002) and Stock and Watson (2002). In the remainder of this section we summarize results from additional tests, which are performed to examine the robustness of the results discussed above.

A. Nonlinearities in Conditional Mean and Volatility

First we examine whether the observed reductions in volatility may be due to neglected business cycle asymmetry in the (conditional) mean or variance. The volatility of macroeconomic variables typically is higher during recessions than during expansions (Brunner, 1992; French and Sichel, 1993), and mean growth rates and conditional mean dynamics also tend to be quite different during these different business cycle phases (Acemoglu and Scott, 1997; Lundbergh, Teräsvirta, and van Dijk, 2003). Given that after the trough of November 1982 only eight months (August 1990 – March 1991) are labeled “recession” by the NBER as opposed to 59 months before this trough, it may be that the apparent reduction in volatility is simply due to the lack of recessions during the second half of our sample period.

For our data set, we find that 62% and 68% of all series exhibit significant business cycle asymmetry in conditional mean dynamics and in conditional variance, respectively, where we use NBER turning points to define expansions and recessions. A high incidence of nonlinearity occurs in production, employment, trade, orders, consumption, stock prices (volatility only), and interest rates. Allowing for nonlinearity in the conditional mean dynamics (with or without allowing for structural change during expansions) has very little effect on subsequent tests for structural change in conditional volatility. Similarly, allowing for nonlinearity in (un)conditional volatility and testing for structural change in volatility during expansions renders results that are qualitatively identical and quantitatively similar to those discussed before. Results are not shown here, to save space, but are available upon request.

6 We do not allow for structural change in the conditional mean dynamics during contractions, in view of the limited number of recession months during our sample period. For the same reason, we only test for structural change in (un)conditional volatility during the expansions below.
B. Smooth Changes in Conditional Mean and Volatility

There has been some discussion whether the reductions in volatility of U.S. output and other macroeconomic variables are best characterized as instantaneous breaks or as gradual (“smooth”) changes; see Blanchard and Simon (2001) and Stock and Watson (2002). We examine this issue by replacing the indicator function \( I(t > \tau_m) \) in equations (1) and (4) with the logistic function

\[
F(t; \gamma, \tau_m) = \frac{1}{1 + \exp[-\gamma(t - \tau_m)]}, \quad \gamma > 0, \tag{5}
\]

which changes smoothly from 0 to 1 as \( t \) increases, with \( F(\tau_m; \gamma, \tau_m) = 0.5 \), so that \( \tau_m \) represents the midpoint of the change in volatility and hence can still be interpreted as the break date. The parameter \( \gamma \) controls the degree of smoothness in the transition of \( F(t; \gamma, \tau_m) \) from 0 to 1. In particular, as \( \gamma \to \infty \), the logistic function approaches the indicator function \( I(t > \tau_m) \).

When estimating the resulting smooth transition model, we find significant differences between pre- and postchange volatility for 75% and 83% of the series for unconditional and conditional volatility, respectively. For the large majority of series, the estimates are such that volatility declines over time. In general, the estimate of \( \gamma \) in equation (5) is rather large—such that the change of \( F(t; \gamma, \tau_m) \) from 0 to 1 is almost instantaneous. Hence, it appears that the volatility changes are best characterized as discrete breaks rather than as gradual changes; cf. Stock and Watson (2002). Again, detailed results are not shown but are available upon request.

C. Multiple Breaks in Volatility

As a final robustness check, we examine the possibility of multiple breaks in volatility. This is partly motivated by the previous results for producer prices and other nominal variables, where for some series a significant increase early in the sample period is found, and for others a reduction in volatility at a later date is detected. This suggests that the increase in volatility may have been temporary, and that the volatility of these variables has undergone multiple breaks. Further

motivation is given by the observed negative relationship between the timing and magnitude of the volatility break: this pattern would also be observed in the presence of two structural changes where the first break is an increase in volatility and the second a decrease.

We employ the sequential procedure of Bai (1997b) to test for multiple changes in (un)conditional volatility; see also Bai and Perron (1998). We apply this sequential testing procedure both to the absolute value of de-meaned growth rates and to the residuals from an AR(\( p \)) model with multiple structural changes for the conditional mean, to test for multiple changes in unconditional and conditional volatility, respectively. The number and timing of the breaks in the AR parameters are determined by an analogous sequential procedure. As the results are qualitatively similar, we only report results from the procedure for testing for multiple breaks in conditional volatility.

Of the 126 series for which at least one significant change in the conditional mean is found, almost half have experienced multiple breaks, in particular production series, wages, interest rates, and producer and consumer prices; see the first four columns of table 2. A considerable number of money series and producer and consumer price series have experienced two changes in volatility; see the next four columns of table 2. A notable difference is that, on average, volatility of the money series increases at both breaks, whereas volatility of the price series generally shows a hump-shaped pattern, with an increase in volatility at the first break (generally in the early 1970s) followed by a decrease of roughly similar absolute magnitude at the second break (in the early 1980s). To some extent this can be seen from the final four columns of table 2, which show the number of breaks and median percentage change in volatility for breaks dated...
before and after January 1980. For money series, the median percentage changes in volatility is positive for both subperiods, whereas for producer and consumer price series it is positive (negative) for breaks occurring before (after) 1980. More generally, these columns demonstrate the marked difference between breaks occurring before and after January 1980, where early breaks meant an increase in volatility on average, whereas later breaks generally reduced volatility. The large majority of interest rate series experienced three changes in volatility, showing a similar hump-shaped pattern to the producer and consumer price series. Multiple changes also are not uncommon in real series such as construction, orders, and consumption, although most real series show evidence of only a single volatility break.

REFERENCES


