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ABSTRACT

From 1960-1983, the standard deviation of annual growth rates in real GDP in the United States was 2.7%. From 1984-2001, the corresponding standard deviation was 1.6%. This paper investigates this large drop in the cyclical volatility OF real economic.activity. The paper has two objectives. The first is to provide a comprehensive characterization of the decline in volatility using a large number of U.S. economic time series and a variety of methods designed to describe time-varying time series processes. In so doing, the paper reviews the literature on the moderation and attempts to resolve some of its disagreements and discrepancies. The second objective is to provide new evidence on the quantitative importance of various explanations for this "great moderation". Taken together, we estimate that the moderation in volatility is attributable to a combination of improved policy (20-30%), identifiable good luck in the form of productivity and commodity price shocks (20-30%), and other unknown forms of good luck that manifest themselves as smaller reduced-form forecast errors (40-60%).

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1. Introduction

The U.S. economy has entered a period of moderated volatility or quiescence. The long expansion of the 1990s, the mild 2001 recession, and the forecast of a moderate recovery reflect a trend over the past two decades towards moderation of the business cycle and, more generally, reduced volatility in the growth rate of GDP.

This reduction in volatility is evident in the plot of the four-quarter growth rate of real GDP in Figure 1. As is summarized in Table 1, during the 1960s the standard deviation of GDP growth was approximately 2.0 percentage points. This standard deviation rose to 2.7 percentage points in the 1970s and was 2.6 percentage points in the 1980s. But during the 1990s, the standard deviation of four-quarter GDP growth was only 1.5 percentage points.

The first published articles to identify this moderation in volatility are Kim and Nelson (1999) and McConnell and Perez-Quiros (2000), who independently conclude that there was a sharp decline, or break, in the volatility of U.S. GDP growth in the first quarter of 1984. These papers have stimulated a substantial recent literature, much of it unpublished, that characterizes this decline in volatility and searches for its cause[1].

This article has two objectives. The first is to provide a comprehensive characterization of the decline in volatility using a large number of U.S. economic time series and a variety of methods designed to describe time-varying time series processes. In so doing, we review the literature on the moderation and attempt to resolve some of its

[1]See Ahmed, Levin and Wilson (2001), Basistha and Startz (2001), Blanchard and Simon (2001), Boivin and Giannoni (2001), Chauvet and Potter (2001), Herrera and Pesavento (2002), Kahn, McConnel and Perez-Quiros (2001), Kim, Nelson and Piger (2001), Pagan (2001), Primiceri (2002), Ramey and Vine (2001), Sensier and van Dijk (2001), Simon

disagreements and discrepancies. This analysis is presented in Sections 2, 3 and 4. Our empirical analysis and review of the literature leads us to five conclusions:

1. The decline in volatility has occurred broadly across the economy: measures of employment growth, consumption growth, and sectoral output have typically exhibit reductions in standard deviations on the order of 60% to 70%, relative to the 1970s and early 1980s. Fluctuations in wage and price inflation have also moderated considerably.
2. For variables that measure real economic activity, the moderation generally is associated with reductions in the conditional variance in time series models, not with changes in the conditional mean; in the language of autoregressions, the variance reduction is attributable to a smaller error variance, not to changes in the autoregressive coefficients. This conclusion is consistent with the findings of Ahmed, Levin, and Wilson (2002), Blanchard and Simon (2001), Pagan (2001), and Sensier and van Dijk (2001).
3. An important unresolved question in the literature is whether the moderation was a sharp break in the mid-1980s, as initially suggested by Kim and Nelson (1999) and McConnell and Perez-Quiros (2000), or part of an ongoing trend, as suggested by Blanchard and Simon (2001). In our view the evidence better supports the "break" than "trend" characterization; this is particularly true for interest-sensitive sectors of the economy such as consumer durables and residential investment.

(2001), Sims and Zha (2002), and Warnock and Warnock (2001). These papers are discussed below in the context of their particular contribution.

4. Both univariate and multivariate estimates of the break date center on 1984. When we analyze all 168 series for breaks in their conditional variance, approximately 40% have significant breaks in their conditional variance in 1983 – 1985. Our 67% confidence interval for the break date in the conditional variance of four-quarter GDP growth (given past values of GDP growth) is 1982:4 to 1985:3, consistent with Kim and Nelson's (1999) and McConnell and Perez-Quiros' (2000) estimate of 1984:I.
5. This moderation could come from two nonexclusive sources: smaller unforecastable disturbances ("impulses") or changes in how those disturbances propagate through the economy ("propagation"). Although the propagation mechanism (as captured by VAR lag coefficients) appears to have changed over the past four decades, these changes do not account for the magnitude of the observed reduction in volatility. Rather, the observed reduction is associated with a reduction in the magnitude of VAR forecast errors, a finding consistent with the multivariate analyses of Ahmed, Levin and Wilson (2002), Boivin and Giannoni (2002), Primiceri (2002), Simon (2001), and Sims and Zha (2002), although partially at odds with Cogley and Sargent (2002).

The second objective of this article is to provide new evidence on the quantitative importance of various explanations for this "great moderation". These explanations fall into three categories. The first category is changes in the structure of the economy. Candidate structural changes include the shift in output from goods to services (Burns (1960), Moore and Zarnowitz (1986)), information-technology led improvements in inventory management (McConnell and Perez-Quiros (2000), Kahn, McConnell and

Perez-Quiros (2001, 2002)); and innovations in financial markets that facilitate intertemporal smoothing of consumption and investment (Blanchard and Simon (2001)). The second category is improved policy, in particular improved monetary policy (e.g. Taylor (1999b), Cogley and Sargent (2001)), and the third category is “good luck,” that is, reductions in the variance of exogenous structural shocks.

We address these explanations in Section 5. In brief, we conclude that the structural shifts explanations fail to explain the timing and magnitude of the moderation documented in Sections 2 – 4. Structural changes to other parts of the economy, such as inventory management and residential investment, are intriguing possibilities but the evidence is, in our view, either unconvincing or incomplete. Changes in U.S. monetary policy seem to account for some of the moderation, but most of the moderation seems to be attributable to reductions in the volatility of structural shocks. Taken together, we estimate that the moderation in volatility is attributable to a combination of improved policy (20-30%), identifiable good luck in the form of productivity and commodity price shocks (20-30%), and other unknown forms of good luck that manifest themselves as smaller reduced-form forecast errors (40-60%); as discussed in Section 5, these percentages have many caveats.

2. Reductions in Volatility Throughout the Economy

This section documents the widespread reduction in volatility in the 1990s and provides some nonparametric estimates of this reduction for 22 major economic time series. We begin with a brief discussion of the data.

2.1 Data and Transformations

In all, we consider data on 168 quarterly macroeconomic U.S. time series from 1959:1 – 2001:3. The data represent a wide range of macroeconomic activity and are usefully grouped into seven categories: (1) NIPA decompositions of real GDP, (2) money, credit, interest rates and stock prices, (3) housing, (4) industrial production, (5) inventories, orders and sales, (6) employment, and (7) industrial production for other countries. Seasonally adjusted series were used when available.

Most of our analysis uses these quarterly data, transformed to eliminate trends and obvious nonstationarity. Specifically, most real variables were transformed to growth rates (at an annual rate), prices and wages were transformed to changes in inflation rates (at an annual rate), and interest rates were transformed to first differences. For some applications (such as the data description in Section 2.2) we use annual growth rates or differences of the quarterly data. For variable transformed to growth rates, say X_t, this means that the summary statistics are reported for the series $100\times\ln(X_t/X_{t\text{-}4})$. For prices and wages, the corresponding transformation is $100\times[\ln(X_t/X_{t\text{-}4}) - \ln(X_{t\text{-}4}/X_{t\text{-}8})]$, and for interest rates the transformation is $X_t - X_{t\text{-}4}$. Definitions and specific transformations used for each series are listed in Appendix 2.

2.2 Historical Volatility of Major Economic Time Series

Volatility by decade. Table 2 reports the sample standard deviation of 22 leading macroeconomic time series by decade (2000 and 2001 are included in the 1990s). Each decade's standard deviation is presented relative to the full-sample standard deviation, so a value less than one indicates a period of relatively low volatility. All series were less volatile in the 1990s than over the full sample, and all but one series (consumption of nondurables) were less volatile in the 1990s than in the 1980s. On the demand side, the 1990 relative standard deviations ranged from 0.65 (government spending and residential investment) to 0.89 (nonresidential investment). On the production side, the standard deviation during the 1990s, relative to the full sample, range from 0.65 (durable goods production) to 0.87 (services).

This decline in volatility is reflected in other series as well. For example, the relative standard deviation of annual growth of nonagricultural employment in the 1990s was 0.73. The 1990s was also a period of quiescence for inflation: changes in annual price inflation, measured by the GDP deflator, has a relative standard deviation of 0.50. As noted by Kim, Nelson and Piger (2001), Watson (1999), and Basistha and Startz (2001), the situation for interest rates is somewhat more complex. Although the variance of interest rates decreased across the term structure, the decrease was more marked at the short than the long end, that is, the relative volatility of long rates increased.

Estimates of time-varying standard deviations. Figure 2 provides graphical evidence on the decline in volatility for the 22 time series in Table 2. The light line in Figure 2 is a "raw" estimate of the volatility of the series, the absolute value of the deviation of each series (transformed as in Table 2) from its mean. To provide a guide to the numerical importance of the change in the standard deviation, the NIPA series are weighted by their average nominal share in GDP from 1960 – 2001 (the weights are indicated in the figure captions)[2]. For example, for consumption, the light line is the

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[2] Specifically, let $\Delta_4 \ln(GDP_t) = \ln(GDP_t/GDP_{t-4})$ be the four-quarter growth rate of GDP, let X_{jt} denote the level of the j^h of n components of GDP, where imports have a negative sign and where X_{nt} is the quarterly change in inventory investment. Then $\Delta_4 \ln(GDP_t) \approx$

absolute value of the demeaned four-quarter growth in consumption, weighted by the average share of consumption, 0.64. The solid line is a two-sided estimate of the instantaneous time-varying standard deviation of the series, based on a fourth-order autoregression (AR(4)) with time varying parameters and stochastic volatility. This model and associated nonGaussian smoother are conceptually similar (but different in details) to the multivariate approach in Cogley and Sargent (2002) and are discussed further in Appendix 1.

The results in Figure 2 present a varied picture of the decline in volatility. For some series – GDP, total goods production, durable goods consumption and production, total investment, residential investment, construction output, and imports – volatility declines sharply in the mid-1980s. A closer look at the components of investment shows that the overall decline in its volatility is associated with a sharp decline in residential investment in the mid-1980s. For some series, such as consumption of nondurables and government consumption, volatility is essentially unchanged over the sample. The volatility of employment growth seems to have declined in steps, first falling from the 1950s to the 1960s, then falling again in the early 1980s and the early 1990s. The volatility of changes in short-term interest rates fell sharply in the mid-1980s, then continued to fall, whereas long-term rates remain as volatile as they were in the 1970s.

Results for other series. The decline in volatility seen for the 22 series in Table 2 is typical of other macroeconomic time series. Across the 168 series listed in Appendix 2

$s_{1t}\Delta_4 \ln X_{1t} + \ldots + s_{n-1,t}\Delta_4 \ln X_{n-1,t} + (\Delta_4 X_{nt})/GDP_t$, where s_{jt} is the GDP share of the j^{th} component at date t. The first $n - 1$ terms are the share-weighted growth rates of the components, other than inventories, and the final term is the four-quarter difference of the quarterly change in inventories, relative to GDP. If the terms in the expression for (including the 22 in Table 2), the median relative standard deviation in the 1990s is .73, and 78% of the series had a relative standard deviation less than 0.85 in the 1990s. For example, the relative standard deviation of the overall index of industrial production in the 1990s was 0.63; this reduction is also found in the various industrial production sectors, with sectoral relative standard deviations ranging from 0.59 (consumer goods) to 0.77 (utilities). Orders and inventories showed a similar decline in volatility; the average relative standard deviation was 0.68 for these series in the 1990s. As discussed in more detail by Warnock and Warnock (2001), the standard deviation of employment also fell in most sectors (the exceptions being contract construction, FIRE, services, and wholesale and retail trade, where the relative standard deviations are close to one. Although broad measures of inflation show marked declines in volatility, some producer prices showed little decrease or an increase in volatile and the overall index of producer prices has a relative standard deviation close to one.

Finally, as discussed in Blanchard and Simon (2001) and Simon (2001), the decrease in volatility is not unique to the US. The relative standard deviation of industrial production indexes for several other developed countries were low in the 1990s. However some countries (France, Japan, and Germany) also experienced low variability in the 1980s and experienced somewhat more variability in the 1990s.

Implications for recessions and expansions. Because recessions are defined as periods of absolute decline in economic activity, reduced volatility with the same mean growth rate implies fewer and shorter recessions. As discussed further by Kim and Nelson (1999), Blanchard and Simon (2001), Chauvet and Potter (2001), and Pagan

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$\Delta_4\ln(GDP_t)$ were uncorrelated (they are not), then the sum of their variances would equal

(2001), this suggests that the decrease in the variance of GDP has played a major role in the increased length of business cycle expansions over the past two decades.

2.3 Summary

The moderation in volatility in the 1990s is widespread (but not universal) and appears in both nominal and real series. When the NIPA series are weighted by their shares in GDP, the decline in volatility is most pronounced for residential investment, output of durable goods, and output of structures. The decline in volatility appears both in measures of real economic activity and in broad measures of wage and price inflation. For the series with the largest declines in volatility, volatility seems to have fallen distinctly in the mid-1980s, but to draw this conclusion with confidence we need to apply some statistical tests to distinguish distinct breaks from steady, trend declines in volatility, a task taken up in the next section.

3. Dating the Great Moderation

The evidence in Section 2 points towards a widespread decline in volatility throughout the economy. In this section, we consider whether this decline is associated with a single distinct break in the volatility of these series and, if so, when the break occurred. We study the issue of a break in the variance first using univariate methods, and then using multivariate methods. We begin by examining univariate evidence on whether the change in the variance is associated with changes in the conditional mean of the univariate time series process or changes in the conditional variance.

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the variance of $\Delta_4\ln(GDP_t)$.

3.1. Changes in Mean v. Changes in Variance: Univariate Evidence

The changes in the variance evident in Figure 2 could arise from changes in the autoregressive coefficients (that is, changes in the conditional mean of the process, given its past values), changes in the innovation variance (that is, changes in the conditional variance), or both. Said differently, the change in the variance of a series can be associated with changes in its spectral shape, changes in the level of its spectrum, or both. Research on this issue has generally concluded that the changes in variance are associated with changes in conditional variances. This conclusion was reached by Blanchard and Simon (2001) for GDP and by Sensier and van Dijk (2001) using autoregressive models, and by Ahmed, Levin and Wilson (2002) using spectral methods. Kim and Nelson (1999) suggest that both the conditional mean and conditional variance of GDP changed, although Pagan (2001) argues that the changes in the conditional mean function are quantitatively minor. Cogley and Sargent (2002) focus on the inflation process and conclude that although most of the reduction in volatility is associated with reductions in the innovation variance, some seems to be associated with changes in the conditional mean[3].

Tests for time-varying means and variances. We take a closer look at the issue of conditional means vs. conditional variances using a battery of break tests, applied to

[3] Cogley and Sargent (2001, 2002) are especially interested in whether there has been a change in the persistence of inflation. The evidence on this issue seems, however, to be sensitive to the statistical method used: Pivetta and Reis (2001) estimate the largest root in the inflation process to have stably remained near one from 1960 to 2000. Because our focus is volatility, not persistence, we do not pursue this interesting issue further.

time-varying autoregressive models of the 168 series listed in Appendix 2. The tests look for changes in the coefficients in the AR model,

$$y_t = \alpha_t + \phi_t(L)y_{t-1} + \varepsilon_t \qquad (1)$$

where

$$\alpha_t + \phi_t(L) = \begin{cases} \alpha_1 + \phi_1(L), t \le \kappa \\ \alpha_2 + \phi_2(L), t > \kappa \end{cases} \text{ and } \mathrm{var}(\varepsilon_t) = \begin{cases} \sigma_1^2, t \le \tau \\ \sigma_2^2, t > \tau \end{cases},$$

where $\phi_1(L)$ is a lag polynomial (etc.) and κ and τ are break dates in, respectively, the conditional mean and the conditional variance. This formulation allows for the conditional mean and the conditional variance each to break (or not) at potentially different dates.

We use the formulation (1) to test for changes in the AR parameters. First, the heteroskedasticity-robust Quandt (1960) likelihood ratio (QLR) statistic (also referred to as the sup-Wald statistic, see Andrews (1993)) is used to test for a break in the conditional mean. Throughout, QLR statistics are computed for all potential break dates in the central 70% of the sample. We test for a break in the variance at an unknown date τ by computing the QLR statistic for a break in the mean of the absolute value of the residuals from the estimated autoregression (1), where the autoregression allows for a break in the AR parameters at the estimated break date $\hat{\kappa}$ (see Appendix 1). Although the QLR statistic is developed for the single-break model, this test has power against other forms of time variation such as drifting parameters (Stock and Watson (1998)): rejection of the no-break null by the QLR statistic is evidence of time variation, which may or may not be of the single-break form in (1).

Estimated break dates and confidence intervals. In addition to testing for time-varying AR parameters, in the event that the QLR statistic rejects at the 5% level we report OLS estimates of the break dates $\hat{\kappa}$ (AR coefficients) and $\hat{\tau}$ (innovation variance) and 67% confidence intervals computed following Bai (1997).[4]

Results. Results for the 22 series are summarized Table 3. For GDP, the QLR statistic fails to reject the null hypothesis of no break in the coefficients of the conditional mean. In contrast, the null hypothesis of no break in the variance is rejected at the 1% significance level. The break date is estimated to be 1983:2, which is consistent with estimated break dates reported by McConnell Perez-Quintos (2001) and Kim, Nelson and Piger (2001). The 67% confidence interval for the break date is precise, 1982:4 – 1985:3, although (for reasons discussed in footnote 4) the 95% confidence interval is quite wide.

The results for the components of GDP indicate that although several series (such as the components of consumption) reveal significant time variation in the conditional mean coefficients, the estimated break dates and confidence intervals do not coincide with the timing of the reductions in volatility evident in Figure 2. In contrast, for ten of the seventeen NIPA components there are significant changes in the conditional variance, and for eight of those ten series the break in the conditional variance is estimated to be in the mid-1980s. Thus, like Kim, Nelson, and Piger (2001), who use Bayesian methods,

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[4] The break estimator has a non-normal, heavy-tailed distribution, so 95% intervals computed using Bai's (1997) method are so wide as to be uninformative. We therefore deviate from convention and report 67% confidence intervals.

we find breaks in the volatility of many components of GDP, not just durable goods output as suggested by McConnell and Perez-Quiros (2000). Durables consumption, total fixed investment, residential investment, imports, goods production, and employment all exhibit significant breaks in their conditional volatility with break dates estimated in the mid-1980s.

Estimates based on the stochastic volatility model. As another check on this conclusion, we recalculated the estimates of the instantaneous variance based on the stochastic volatility model (the smooth lines in Figure 2), with the restriction that the AR coefficients remain constant at their full-sample OLS estimated values. The resulting estimated instantaneous standard deviations (not reported here) were visually very close to those reported in Figure 2. The most substantial differences in the estimated instantaneous variance was for price inflation, in which changes in the conditional mean coefficients in the 1960s contributed to changes in the estimated standard deviation. These results are consistent with the conclusion drawn from Table 3 that the reduction in the variance of these series is attributable to a reduction in the conditional variance.

Results for other series. Results for additional time series are summarized in Appendix Table A.1. There is evidence of widespread instability in both the conditional mean and the conditional variance. Half of the 168 series show breaks in their conditional mean parameters (consistent with the evidence in Stock and Watson (1996)). Strikingly, the hypothesis of a constant variance is rejected in two-thirds of the series. Sensier and van Dijk (2001) find a similar result in their analysis of 215 U.S. macroeconomic time series. The breaks in the conditional means are mainly concentrated in the 1970's. In contrast, the breaks in the conditional variances are concentrated in the 1980s or, for some series, the early 1990s. Thus, the timing of the reduction in the unconditional variance of these series in the 1980s and 1990s coincides with the estimated breaks in the conditional variance, not with the estimated breaks in the conditional means.

3.2 Is the Moderation a Trend or a Break?

Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) modeled the volatility reduction using Markov switching models; as in the AR model (1) with coefficient breaks, the Markov switching model treats the moderation as a discrete event, which they independently dated as occurring in 1984:1. After examining evidence on rolling standard deviations, however, Blanchard and Simon (2001) argued that the volatility reduction was better viewed as part of a longer trend decline, in which the high volatility of the late 1970s and early 1980s was a temporary aberration.

To elucidate this "trend vs. break" debate, we conduct some additional tests using a model that nests the two hypothesis. Specifically, the QLR test for a change in the standard deviation in Section 3.1 was modified so that the model for the heteroskedasticity includes a time trend as well as the break. That is, the QLR test is based on the regression, $|\hat{\varepsilon}_t| = \gamma_0 + \gamma_1 t + \gamma_2 d_t(\tau) + \eta_t$, where $d_t(\tau)$ is a binary variable that equals 1 if $t \geq \tau$ and equals zero otherwise and η_t is an error term; the modified QLR test looks for breaks for values of τ in the central 70% of the sample.

The results are reported in the final columns of Table 3. For GDP, the coefficient on the time trend is not statistically significantly different from zero, while the hypothesis of no break (maintaining the possibility of a time trend in the standard deviation) is rejected at the 1% significance level. The estimated break date in GDP volatility is 1983:2, the same whether a time trend is included in the specification or not. For GDP, then, this evidence is consistent with the inference drawn from the estimated instantaneous standard deviation plotted in Figure 2: the sharp decline in the volatility of GDP growth in the mid-1980s is best described by a discrete reduction in the variance, rather than as part of a continuing trend towards lower volatility.

The results in Table 2 suggest that the break model is also appropriate for some, but not all, of the components of GDP, specifically nondurables consumption, residential fixed investment, imports, total goods production, production of durable goods, and production of construction. For these series, the estimated break dates fall between 1983:2 and 1987:3. Consumption of durables and production of nondurables, however, seem to be better described by the trend model. A few of the components of GDP, such as exports, are not well described by either model.

These conclusions based on Table 2 are consistent with those based on the smoothed volatility plots in Figure 2: there was a sharp decline, or break, in the volatility of GDP growth and some of its components, most strikingly residential investment, durable goods output, and output of construction, while other components and time series show more complicated patterns of time-varying volatility.

3.3 Multivariate Estimates of Break Dates

In theory, a common break date can be estimated much more precisely when multiple equation methods are used (see Hansen (2001) for a review). In this section, we therefore use two multivariate methods in an attempt to refine the break date confidence intervals of Section 3.1, one based on low-dimensional VARs, the other based on dynamic factor models.

Common breaks in VARs. To estimate common breaks across multiple series, we follow Bai, Lumsdaine, and Stock (1998) and extend the univariate autoregression in (1) to a VAR. The procedure is the same as described in Section 3.1, except that to avoid overfitting the VAR coefficients were kept constant. The hypothesis of no break is tested against the alternative of a common break in the system of equations using the QLR statistic computed using the absolute values of the VAR residuals. We also report the OLS estimator of the break date in the mean absolute residual and the associated 67% confidence interval, computed using the formulas in Bai, Lumsdaine and Stock (1998).

The results for three different VARs are summarized in Table 4. The first VAR decomposes GDP by its end-use components, the second decomposes GDP by its production components, and the third focuses on the more durable components of demand by individuals, consumption of nondurables and durables and residential fixed investment. In each, the hypothesis of a constant variance is rejected at the 1% significance level. The estimated break dates range from 1982:4 to 1984:1, with 67% confidence intervals that are tight and similar to the 67% confidence interval based on the univariate analysis of GDP growth.

Evidence based on factor models. Dynamic factor models provide a complementary way to use information on multiple variables to estimate the volatility break date. Chauvet and Potter (2001) use Bayesian methods to analyze a dynamic factor model of nine measures of economic activity (including GDP, industrial production, consumption, sales, and employment). Their model allow for breaks in the autoregressive coefficients and variance of the single common dynamic factor. They find strong evidence for a break in the variance of the common factor, and the posterior distribution for the break date places almost all the mass in 1983 or 1984.

This analysis can be extended to higher dimensional systems by using the first principal components of the data to estimate the space spanned by the postulated common dynamic factors (Stock and Watson (2001)). Previous empirical work (Stock and Watson (1999, 2001) has shown that the first principal component computed using the series such as those in Appendix 2 captures a large fraction of the variation in those series, and that the first principal component can be thought of as a real activity factor. Like GDP, this factor has a significant break in its conditional variance, with an estimated break date of 1983:3 and a 67% confidence interval of 1983:2 to 1986:3.

3.4 Summary

The results in this section point to instability both in conditional mean functions and in conditional variances. The weight of the evidence, however, suggests that the reductions in volatility evident in Table 1 and Figure 2 are associated with changes in conditional variances (error variances), rather than changes in conditional means (autoregressive coefficients). Analysis of the full set of 168 series listed in Appendix 2 provides evidence of a widespread reduction in volatility, with the reduction generally dated in the mid-1980s. For most series, this conclusion is unchanged when one allows for the possibility that the volatility reduction could be part of a longer trend. Accordingly, we conclude that, for most series the preferred model is one of a distinct reduction in volatility rather than a trend decline.

This view of a sharp moderation rather than a trend decline is particularly appropriate for GDP and some of its more durable components. Following McConnell and Perez-Quiros (2000), much of the literature focuses declines in volatility in the production of durable goods; however like Kim, Nelson and Piger (2001) we find significant reductions in volatility in other series. Our results particularly point to large reductions in the variance of residential fixed investment and output of structures, both of which are highly volatile. The finding of a break in volatility in the mid-1980s is robust, and univariate and multivariate confidence intervals for the break date are tightly centered around 1983 and 1984.

4. Impulse or Propagation?

The univariate analysis of Section 3.1 suggests that most of the moderation in volatility of GDP growth is associated with a reduction in its conditional variance, not changes in its conditional mean. But does this conclusion hold when multiple sources of information are used to compute the conditional mean of output growth? Several recent studies (Ahmed, Levin and Wilson (2002), Boivin and Giannoni (2002a, 2002b), Primiceri (2002), and Simon (2000)) have examined this question using vector autoregressions (VARs), and we adopt this approach here. Specifically, in the context of reduced form VARs, is the observed reduction in volatility associated with a change in the magnitude of the VAR forecast errors (the "impulses"), in the lag dynamics modeled by the VAR ("propagation"), or both?

The counterfactual VAR method. Because the results of Sections 3.2 and 3.3 point to a distinct break in volatility in 1983 or 1984, in this section we impose the Kim and Nelson (1999)/McConnel and Perez-Quiros (2000) break date of 1984:1. Accordingly, we use reduced-form VARs estimated over 1960 – 1983 and 1984 – 2001 to estimate how much of the reduction in the variance of GDP is due to changes in the VAR coefficients and how much is due to changes in the innovation covariance matrix. Each VAR has the form,

$$X_t = \Phi_i(\mathrm{L})X_{t-1} + u_t, \quad \mathrm{Var}(u) = \Sigma_i, \tag{2}$$

where X_t is a vector time series and the subscript i = 1, 2 denotes the first and second subsample (the intercept is omitted in (2) for notational convenience but is included in the estimation). Let B_{ij} be the matrix of coefficients of the j^{th} lag in the matrix lag polynomial $B_i(\mathrm{L}) = [I - \Phi_i(\mathrm{L})\mathrm{L}]^{-1}$. With this notation, the variance of the k^{th} series in X_t in the i^{th} period is,

$$\mathrm{var}(X_{kt}) = \left(\sum_{j=0}^{\infty} B_{ij}\Sigma_i B_{ij}'\right)_{kk} = \sigma_k(\Phi_i, \Sigma_i)^2. \tag{3}$$

By evaluating the expression in (3) for different Φ and Σ, it is possible to compute the counterfactual variance of X_{kt} that would have arisen had either Φ or Σ taken on different values. For example $\sigma_k(\Phi_1, \Sigma_1)$ is the standard deviation of X_{kt} in period 1, and $\sigma_k(\Phi_2, \Sigma_1)$ is the standard deviation of X_{kt} that would have occurred had the lag dynamics been those of the second period and the error covariance matrix been that of the first period. Although these expressions are based on the population parameters, the various counterfactuals can be estimated by replacing the population parameters with sample estimators.

Results. The results are summarized in Table 5 where, for comparability to the previous tables, the quarterly variances have been temporally aggregated to pertain to annual growth rates of quarterly variables. Table 5A presents results for a four-variable VAR(4) benchmark model consisting of GPD growth, the first difference of inflation (measured by the GDP deflator), the Federal Funds rate, and the growth rate of commodity prices. The first two columns provide the sample standard deviations of the various series, and the final four columns provide the VAR-based estimates of the standard deviations for the four possible permutations of estimated lag coefficients and covariance matrices. The columns labeled $\sigma(\hat{\Phi}_1, \hat{\Sigma}_1)$ and $\sigma(\hat{\Phi}_2, \hat{\Sigma}_2)$ respectively contain the VAR-based estimate of the first- and second-period sample standard deviations, which (as they should be) are quite close to the respective sample standard deviations. The columns labeled $\sigma(\hat{\Phi}_1, \hat{\Sigma}_2)$ and $\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$ contain the counterfactual estimates.

First consider the results for GDP. The counterfactual combination of second-period dynamics and first-period shocks (that is, $\sigma(\hat{\Phi}_2, \hat{\Sigma}_1)$) produces an estimated standard deviation of 2.63, essentially the same as the first period standard deviation. In contrast, the first-period dynamics and second-period shocks produce an estimated standard deviation of 1.48, essentially the same as the second period standard deviation. According to these estimates, had the shocks of the 1970s occurred in the 1990s, the 1990s would have been almost as volatile as the 1970s. Similarly, had the shocks of the 1990s occurred in the 1970s, the 1970s would have been almost as quiescent as the 1990s. In short, the changes in the covariance matrix of the unforecastable components of the VARs – the impulses – account for virtually all of the reduction in the observed volatility of output.

Sensitivity analysis and comparison with the literature. The sensitivity of this finding to changes in the model specification or assumptions is investigated in Table 5B. The conclusion from the benchmark model – that it is impulses, not shocks, that are associated with the variance reduction – is robust to most changes reported in that table. For example, similar results obtain when the first period is changed to end in 1978; when log GDP, inflation, and the interest rate are used rather than their first differences; when monthly data are used; and when GDP is replaced with goods output or sales. Dropping the commodity spot price index does not change the results, nor does using an alternative index of sensitive materials prices (a smoothed version of which is used by Christiano, Eichenbaum and Evans (1999)). Curiously, however, replacing the commodity price index by the produce price index for crude materials does change the conclusions somewhat, giving some role to propagation. The weight of this evidence, however, suggests that changes in the propagation mechanism play at best a modest role in explaining the moderation of economic activity.

The substantive conclusions drawn from Table 5 are similar to Primiceri's (2002), Simon's (2000), and (for the same sample periods) Boivin and Giannoni's (2002a, 2002b). Ahmed, Levin, and Wilson (2002) conclude that most of the reduction in variance stems from smaller shocks, but give some weight to changes in the propagation mechanism. The main source of the difference between our results and theirs appears to be that Ahmed, Levin, and Wilson (2002) use as commodity prices the producer price index for crude materials.

Conclusions. The estimates in Table 5 suggest that most, if not all, of the reductions in the variance of the four-quarter growth of GDP are attributable to changes in the covariance matrix of the reduced-form VAR innovations, not to changes in the VAR lag coefficients (the propagation mechanism). These changes in reduced-form VAR innovations could arise either from reductions in the variance of certain structural shocks or from changes in how those shocks impact the economy, notably through changes in the structure of monetary policy. To sort out these possibilities, however, we need to move beyond reduced-form data description and consider structural economic models, a task taken up in the next section.

5. Explanations for the Great Moderation

What accounts for the moderation in the volatility of GDP growth and, more generally, for the empirical evidence documented in Sections 2 –4? In this section, we consider five potential explanations. The first is that the reduction in volatility can be traced to a change in the sectoral composition of output away from durable goods. The second potential explanation, proposed by McConnell and Perez-Quiros (2000), is that the reduction in volatility is due to new and better inventory management practices. The third possibility emphasizes the volatility reduction in residential fixed investment. The fourth candidate explanation is that the structural shocks to the economy are smaller than they once were: we simply have had good luck. Finally, we consider the possibility that the reduction in volatility is, at least in part, attributable to better macroeconomic policy, in particular better policymaking by the Federal Reserve Board.

5.1 Changes in the Sectoral Composition

The services sector is less cyclically sensitive than the manufacturing sector so, as suggested by Burns (1960) and Moore and Zarnowitz (1986), the shift in the U.S. from manufacturing to services should lead to a reduction in the variability of GDP. Blanchard and Simon (2001), McConnell and Perez-Quiros (2000), and Warnock and Warnock (2001)) investigated this hypothesis and concluded that this sectoral shift hypothesis does not explain the reduction in volatility. The essence of Blanchard and Simon's (2001) and McConnell and Perez-Quiros' (2000) argument is summarized in Table 6A. The standard deviation of annual GDP growth fell from 2.7% during 1960 – 1983 to 1.6% during 1984 – 2001; when the output subaggregates of durables, nondurables, services and structures are combined using constant 1965, this resulting standard deviations for the two periods are 3.1% and 1.8%. Thus, autonomously fixing the output shares of the different sectors yields essentially the same decline in the standard deviation of GDP growth as using the actual, changing shares. Mechanically, the reason for this is that the volatility of output in the different sectors has declined across the board. Moreover, the sectors with the greatest volatility – durables and structures – also have output shares that are essentially constant.

The same result is evident if (like Warnock and Warnock (2001)) one looks instead at employment growth: the standard deviation of employment growth falls by approximately one-third whether one uses actual employment shares or constant employment shares. Here, as discussed further by Warnock and Warnock (2001), it is not just that employment is migrating from a more volatility sector to a less volatility sector; rather, the volatility of employment within construction and manufacturing has itself declined.[5] Finally, the structural shift hypothesis has a timing problem: the shift away from manufacturing has taken place gradually over the past four decades, whereas the analysis of Sections 2 – 4 suggests a sharp moderation in volatility in the mid-1980s.

5.2 Changes in Inventory Management

McConnell and Perez-Quiros (2000) proposed that new inventory management methods, such as just-in-time inventory management, are the source of the reduction in volatility in GDP; this argument is elaborated upon by Kahn, McConnell and Perez-Quiros (2001, 2002). The essence of their argument is that the volatility of production in manufacturing fell sharply in the mid-1980s, but the volatility of sales did not; they found a statistically significant break in output variability, especially in durables manufacturing, but not in sales variability. They concluded that changes in inventory management must account for this discrepancy. Moreover, they suggested that the decline in the variance of goods production fully accounts for the statistical significance of the decline in GDP, so that understanding changes in inventory behavior holds the key to understanding the moderation in GDP volatility. Unlike the sectoral shift hypothesis, timing works in favor of this inventory management hypothesis, for new inventory management methods relying heavily on information technology gained popularity during the 1980s.

This bold conjecture – that micro level changes in inventory management could have major macroeconomic consequences – has received a great deal of attention. Our

[5]A caveat on these "accounting identity" calculations is that they ignore general equilibrium effects of a switch to services production. If, for example, increased stability of employment in services results in more stable incomes, then an increase in the share of services could in equilibrium stabilize demand for all products, including goods and

reading of this research suggests, however, that upon closer inspection the inventory management hypothesis does not fare well. The first set of difficulties pertain to the facts themselves. The stylized fact that production volatility has fallen but sales volatility has not is not robust to the method of analysis used or the series considered. Ahmed, Levin, and Wilson (2002) find statistically significant evidence of a break in final sales in 1983:3 using the Bai-Perron (1998) test; Herrera and Pesavento (2002) use the QLR test and find a break in sales in the variance of the growth of output in nondurables manufacturing (in 1983:3) and durables manufacturing (in 1984:1), as well as in many 2-digit sectors; and Kim, Nelson and Piger (2001) find evidence of a decline in volatility of aggregate final sales and in durable goods sales using Bayesian methods.

Our break test results for sales (see Table A.1) are consistent with this more recent literature: we find statistically significant breaks in the variance of total final sales and final sales of durable goods. Like Kim, Nelson, and Piger (2001), we date the break in the variance of durable goods sales in the early 1990s, whereas the break in the variance of production is dated in the mid-1980s. Although the confidence intervals for the break dates in durables production and sales are wide, the 67% confidence interval for the durable sales break date does not include the mid-1980s. Figure 3 presents the estimated instantaneous variances, computed using the nonGaussian smoother described in Appendix 1, for the four-quarter growth in durables production and sales. Both series have a complicated pattern of time-varying volatility, but the decline in volatility in the

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construction. If so, the mechanical calculation in Table 6 could understate the moderating effect of a shift to services.

1980s and 1990s is evident for both series (as is the mismatch in the timing of this decline).[6]

An additional challenge for the inventories theory is that the finding that the variance of production has fallen proportionately more than the variance of sales is sensitive to the frequency of the data considered. As seen in the first columns of Table 7, the standard deviation of the quarterly growth of production in durables manufacturing fell sharply in the latter period, whereas the standard deviation of sales fell proportionately less: the standard deviation of quarterly growth of durable goods sales in the second period is 79% what it was in the first period, while the standard deviation of quarterly growth of durable goods production in the second period was 47% of its first-period value[7]. As the second set of columns show, however, this disproportionate decline disappears when one considers longer frequency fluctuations: when one considers four-quarter growth rather than one-quarter growth, the standard deviations of production and sales fell by essentially the same amount.[8] Indeed, the striking feature of the final column of Table 7A is that the standard deviation of four-quarter growth in sales and production fell by 30% to 40% across all production sectors: durables, nondurables, services, and structures. This suggests that, to the extent that information technology has facilitated using inventories to smooth production, this effect occurs as smoothing across

[6] The variance of final sales of nondurable goods has also experienced a statistically significant decrease, although that decrease appears better characterized by a trend than a distinct break.
[7] The entries in first columns of Table 7 closely match those in Table 4 of Kahn, McConnell, and Perez-Quiros (2002), with the slight differences presumably attributable to different sample periods and different vintages of data.
[8]This is true for other degrees of temporal aggregation. For one-quarter growth, the ratio of the relative standard deviations of durables output to durables sales growth is .79/.47 =

months or across adjacent quarters. At the longer horizons of interest in business cycle analysis, such as the four-quarter growth rates considered in this paper, the declines in volatility of production and sales have been effectively proportional, suggesting no role for improved inventory management for volatility at this horizon.

The inventories hypothesis confronts other difficulties as well. As emphasized by Blinder and Maccini (1991) and Ramey and West (1999), most inventories in manufacturing are raw materials or work-in-progress inventories, which do not play a role in production smoothing (except avoiding raw materials stock-outs). One would expect inventory-sales ratios to decline if information technology has an important impact on aggregate inventories; however, inventory-sales ratios have declined primarily for raw materials and work-in-progress inventories, and in fact have risen for finished goods inventories and for retail and wholesale trade inventories. Information technology may have improved the management of finished goods inventories, but this improvement is not reflected in a lower inventory-sales ratio for finished goods.

Ramey and Vine (2001) offer a different explanation of the relative decline in the variance of production at high frequencies, relative to sales. They suggest that a modest reduction in the variance of sales can be magnified into a large reduction in the variance of production because of nonconvexities in plant-level cost functions. In their example, a small reduction in the variance of auto sales means that sales fluctuations can be met through overtime rather than by (for example) adding temporary shifts, thereby sharply reducing the variance of output and employee-hours.

1.70; for two-quarter growth, it falls to 1.35; for 3-, 4-, 6-, and 8-quarter growth, it is respectively 1.15, 1.04, 1.00, and 1.01.

None of this evidence is decisive. Still, in our view it suggests that the reduction of volatility is too widespread across sectors and across production and sales (especially at longer frequencies) to be consistent with the view that inventory management plays a central role in explaining the economy-wide moderation in volatility.

5.3 Residential Housing

Although residential fixed investment constitutes a small share of GDP, historically it has been highly volatile and procyclical. The estimated instantaneous variance of the four-quarter growth in residential investment is 14.2 percentage points in 1981, but this falls to 6.0 percentage points in 1985. As is evident in Figure 2, even after weighting by its small share in GDP, the share-weighted standard deviation fell during the mid-1980s by approximately the same amount as did the share-weighted standard deviation of durable goods output.

Figure 4 presents estimated instantaneous standard deviations of the four-quarter growth of various series relating to the construction sector (these plots are comparable to those in Figure 2, except that Figure 2 is share-weighted whereas Figure 4 is not). The sharp decline in volatility in the mid-1980s is evident in the residential sector real activity measures of building permits, housing starts, and real private residential construction put in place. In contrast, nonresidential construction does not show any volatility reduction: the variance of real industrial construction is approximately constant, while the variance of real commercial construction is constant then increases slightly during the 1990s. As noted by Warnock and Warnock (2001), employment in total contract construction (which includes residential and nonresidential) also shows a decline in volatility, although it is not as sharp as for the output measures. Intriguingly, the decline in volatility of purchases of residential structures is more distinct for single-unit than multi-unit residences.

There are a variety of potential explanations for this marked decline in volatility in the residential sector. One explanation emphasizes structural changes in the market for home loans. As discussed in detail by McCarthy and Peach (2002) (and alluded to by Blanchard and Simon (2001)), the mortgage market underwent substantial regulatory and institutional changes in the 1970s and 1980s. These changes included the introduction of adjustable rate mortgages, the development of the secondary market for bundled mortgages, and the decline of thrifts and growth of non-thrift lenders. To the extent that these changes reduced or eliminated credit rationing from the mortgage market, so that mortgages became generally available at the stated interest rate for qualified borrowers, they could have worked to reduce the volatility of demand for new housing. According to this explanation, this autonomous decline in the volatility of residential investment in turn spills over into a reduction of volatility of aggregate demand. A difficulty with this explanation, however, is that these institutional developments took time, and the drop in volatility observed in Figure 4 is quite sharp. Moreover, McCarthy and Peach (2002) present evidence that although the impulse response of residential investment to a monetary shock changed in the mid-1980s, the ultimate effect of a monetary shock on residential investment was essentially unchanged; their results are, however, based on a Cholesky-factored VAR and without a structural identification scheme they are hard to interpret. Additional work is needed to ascertain if there is a relation between the developments in the mortgage market and the stabilization of real activity in residential construction.

Other explanations suggest a more passive role for housing, that is, the reduction in housing volatility could be a response to the reduction in general shocks to the economy. For example, if the decision to purchase a home is based in part on expected future income, and if expected future income is less volatile, then home investment would be less volatile. A difficulty with this explanation is that, although the volatility of four-quarter GDP growth has diminished, it is not clear that the volatility of changes in permanent income has fallen. In fact, the variance of consumption of services has been approximately constant (if there is a break in its variance, it is in the early 1970s; see Table 3); to the extent that nondurables consumption is a scaled measure of permanent income then the variance of permanent income did not change in the 1980s. This argument is quantified by Kim, Nelson, and Piger (2001), who in fact conclude that the reduction in the variance of GDP growth is associated with a decrease in the variance of its cyclical, but not long-run, component.

A related candidate explanation emphasizes the role of mortgage rates rather than expected incomes: the reduction in volatility of housing investment reflects reduced volatility of expected real long-term rates. This is consistent with the reduction in the volatility of long and short interest rates in Figure 2, at least relative to the late 1970s and early 1980s. It is also consistent with the reduction in the volatility of durables consumption, durable goods sales, and durable goods production, which in part entail debt financing by consumers. To investigate this hypothesis, however, one would need to develop measures of the expected variance of the ex-ante real mortgage rate, to see how these measures changed during the 1980s, and to integrate this into a model of housing investment, topics that are appropriate for future work.

5.4 Smaller Shocks

The reduced form VAR analysis of Section 4 suggested that most, possibly all, of the decline in the variance of real GDP growth is attributable to changes in the covariance matrix of the VAR innovations. In this section, we attempt to pinpoint some specific structural shocks that have moderated. We consider four types of shocks: money shocks, fiscal shocks, productivity shocks and oil/commodity price shocks.

Money shocks. Over the past fifteen years, there has been considerable research devoted to identifying shocks to monetary policy and to measuring their effects on the macroeconomy. Two well known approaches, both using structural VARs but different identifying assumptions, are Bernanke and Mihov (1998) (BM) and Christiano, Eichenbaum and Evans (1997) (CEE) (see Christiano, Eichenbaum and Evans (1999) for a survey). Using structural VARs we have implemented the BM and CEE identification strategies and computed the implied money shocks in the early (pre '84) and late (post '84) sample periods. Our specifications are the same as used by those authors, although we extend their data sets.[9] Bernanke and Mihov suggest that monetary policy shifted over the sample period, so we include a specification that incorporates this shift.

The standard deviation of the BM and CEE monetary shocks in the 1984-2001 sample period, relative to the standard deviation in the earlier period, are reported in the

[9] In our version of BM we use industrial production instead of their monthly interpolated GDP because their series, and the related series in Bernanke, Gertler and Watson (1998), ends in 1997.

first block of Table 8. Since the money shocks were very volatile during 1979-83, results are shown for early sample periods that include and that exclude 1979-83. The results suggest a marked decrease in the variability of monetary shocks for both CEE and BM identifications. The relative standard deviations over 1984-2001 are roughly 0.50 when the early sample includes 1979-83 and 0.75 when this period is excluded.

Fiscal shocks. Blanchard and Perotti (2001) identify shocks to taxes and government spending using a VAR together with an analysis of the automatic responses of these variables to changes in real income and inflation. The next two rows of Table 8 show results for their shocks.[10] There has been some moderation in both shocks; the standard deviation of tax shocks has fallen by approximately 20%.

Productivity shocks. Standard measures of productivity shocks, such the Solow residual, suffer from measurement problems from variations in capacity utilization, imperfect competition and other sources. While there have been important improvements in methods and models for measuring productivity (for example, see Basu, Fernald and Kimball (1999)), there does not seem to be a widely accepted series on productivity shocks suitable for our purposes. Instead we have relied on a method suggested by Gali (1999) that, like the money and fiscal shocks, is based on a structural VAR. In particular, Gali associates productivity shocks with those components of the VAR that lead to permanent changes in labor productivity. Gali's (1999) productivity shock shows a 25% reduction in its standard deviation in the second sample period.

Oil Price Shocks. The next three rows show results for oil price shocks. The first two rows measure oil shocks by quarterly growth rates in nominal and real price oil prices. Since oil prices were much more variables in the post 1984 sample period, these measures show a large relative standard deviation in the second sample period. Hamilton (1996) argues that oil price effects are asymmetric, and he proposes a measure that is the larger of zero and the percentage difference between the current price and the maximum price during the past year. Using Hamilton's measure, there has been essentially no change in the variability of oil shocks across the two sample periods.

Other commodity price shocks. The final four rows show results for commodity price measures: an aggregate index of commodity prices (the same measure often included in VAR models), an index for food, an index of industrial materials, and an index of sensitive material prices. Results are shown for nominal growth rates (commodity price inflation); the results for real growth rates are essentially identical. These series show a marked reduction in volatility, with standard deviations falling between 20% and 30% in the second sample period relative the first period.

Importance of these reductions. Whether the reductions in the variances of the structural shocks can explain the moderation in GDP depends on the importance of these shocks in determining output growth. The final column of Table 8 reports the fraction of the reduction in the variance of four-quarter GDP growth that is explained by the change in the variance of the shock in that row. For example, the reduction in the variance of the CEE monetary policy shock explains 10% of the reduction in the variance of GDP growth when the first period ends in 1983 (but none of the reduction when the first period ends in 1978). The BM shock explains more of the reduction, at least in some specifications, although that percentage reduction is not directly comparable to the other

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[10] We thank Roberto Perotti for supplying us with the data and computer programs used

rows because it pertains to industrial production. Fiscal policy shocks make a negligible contribution, and oil price shocks either make a negligible contribution (the Hamilton shock) or go the wrong way, because oil price volatility increased in the second period. Productivity and commodity price shocks seem to have made modest contributions, in the neighborhood of 15%, to the reduction in the variance of four-quarter GDP growth.

It is tempting to add up the entries in the final column to produce a composite number, but the result would be misleading. If these are true structural shocks, they should be uncorrelated with each other, but they are not; there is, in fact, considerable disagreement about whether these series are plausible proxies for the structural shocks they purport to estimate (e.g. Rudebusch (1998)). This said, although these shocks appear to explain some of the observed reduction in the volatility, most – perhaps two-thirds – of the reduction in volatility is *not* explained by the reduction in volatility of these shocks.

5.5 Changes in Policy

An important candidate for the moderation in GDP growth is improved monetary policy[11]. Most importantly, the timing is right: empirical studies suggest that monetary policy changed significantly in the Volcker-Greenspan era relative to earlier times. For example, Taylor (1999b), Clarida, Gali and Gertler (2000) and Boivin (2002b) estimate large increases in the inflation response in Taylor-type monetary policy rules for the short

to compute these shocks.

[11] As Taylor (2000) argues, fiscal policy is not a likely candidate. For example, Auerbach and Feenberg (2000) show that fiscal automatic stabilizers in 1995 were roughly at their same level as in the early 1960's, and, if anything were higher in the late

term interest rate. Moreover, developments in financial markets are consistent with a shift in monetary policy. Although short rates are less variable than they were pre-1984, they seem to be more persistent: Watson (1999) reports that the (median unbiased) estimate of the largest AR root for monthly observations of the Federal Funds rate increased from 0.96 in the 1965-1978 sample period to 1.00 in the 1985-1998 sample period.[12] This increase in persistence has a large effect on the variance of expected future values of the Federal Funds rate, and hence on the expectations component of long-term rates. Indeed, while the variance of short rates declined in the second sample period, the variance of long rates, relative to the variance of short rates, increased. Taken together with the evidence on changing Taylor rule coefficients, it appears that the Fed has become more responsive to movements in inflation and output and that these responses have led to increases in the variability of (medium- and long-term) interest rates.

There now are a number of studies examining the extent to which this change in monetary policy – more precisely, this change in the rule approximating monetary policy – caused the reduction of the variance of output growth and/or inflation; see Boivin and Giannoni (2002), Clarida, Gali and Gertler (2000), Cogley and Sargent (2001), Gali, Lopez-Salido, Valles (2002), Primiceri (2002), and Sims and Zha (2002). This is a challenging task: to evaluate the effect of a change in the monetary policy rule, it is necessary to specify a model of the economy that is arguably invariant to the policy shift, that is, to specify a plausible structural model for the economy. The general strategy in this literature has been to combine some structural reasoning with VARs that permit the

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1970's and early 1980's (because of high inflation and the lack of indexation of the tax code).

model to fit the dynamics in the data, but within this general framework the details of the approach differ widely. In this section, we perform these counterfactual policy evaluation calculations using a four-variable structural VAR with GDP growth (y), GDP deflator inflation (π), the one-year Treasury bill rate (R); and commodity prices (PSCCOM, z).

Model specification and identification. The structural VAR identification scheme is based on a structural model with an IS equation, a forward-looking New Keynesian Phillips curve, a forward looking Taylor-type monetary policy rule, and an exogenous process for commodity prices:

$$y_t = \theta r_t + \text{lags} + \varepsilon_{y,t} \quad (4)$$

$$\pi_t = \gamma Y(\delta)_t + \text{lags} + \varepsilon_{\pi,t} \quad (5)$$

$$r_t = \beta_\pi \bar{\pi}_{t+h/t} + \beta_y \bar{y}^{gap}_{t+h/t} + \text{lags} + \varepsilon_{r,t} \quad (6)$$

$$Z_t = \text{lags} + \alpha_y \varepsilon_{y,t} + \alpha_\pi \varepsilon_{\pi,t} + \alpha_r \varepsilon_{r,t} + \varepsilon_{z,t} \quad (7)$$

where $r_t = R_t - \bar{\pi}_{t+k/t}$ is the real interest rate, $\bar{\pi}_{t+k/t}$ is the expected average inflation rate over the next k periods, where k is the term of the interest rate R; $Y(\delta)_t = \sum_{i=0}^{\infty} \delta^i y^{gap}_{t+1/t}$ is the discounted expected future output gap, and $\bar{y}^{gap}_{t+h/t}$ is the expected future average output gap over the next h periods. We have used generic notation "lags" to denote unrestricted lags of variables in each of these equations.

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[12] Similar results, but using different methods, are reported Kim, Nelson and Piger (2001) and Basistha and Startz (2002).

Equation (4) is an IS relation. Equation (5) is a hybrid New Keynesian Phillips curve. If δ, the discount factor used to construct $Y(\delta)_t$, is equal to 0, then this is a traditional formulation of the relation. More recent formulations based on price stickiness (discussed, for example in Gali and Gertler (1999), Goodfriend and King (1997), Rotemberg and Woodford (1997)) express π_t as a function of the output gap (as a proxy for marginal cost) and expected future inflation. Solving this equation forward yields (5) with $\delta = 1$. Allowing forward looking and backward looking price setting yields (5) with δ interpreted as the weight on forward inflation (Gali and Gertler (1999)). Equation (6) is a forward-looking Taylor rule, written in terms of the real interest rate. The parameter h indexes the horizon. For simplicity we use the same interest rate in (4) and (6), although in principle one would like to use long rates in (4) and short rates in (6) [13]. We use the 1-year interest rate as a compromise between a long and short rate. Similarly, in our benchmark specification we use a 1-year horizon in (6), so that $h = 4$, but investigate the robustness of this as well. The commodity price equation (7) plays no structural role in the analysis but, as is conventional, commodity prices are included to help forecast future values of inflation and the output gap. As usual, the ε's are taken to be mutually uncorrelated structural shocks.

Estimation. Our estimation strategy relies on *a-priori* knowledge of the three key parameters θ (the slope of the IS function), γ (the slope of the Phillips relation), and δ (the parameter governing the forward-looking nature of the Phillips relation). Given these parameters, estimation proceeds as follows. First, projecting all variables on lags produces a version of (4) – (7) in which the variables are replaced by reduced form VAR

[13] Both long and short rates could be included by adding a term structure equation as in

residuals. (The forecasts of the output gap and inflation are computed by the VAR, so that innovations in these variables are also functions of the reduced form VAR innovations.) We suppose that the forecast errors associated with trend output are negligible, so we replace innovations in the expected future gap with innovations in expected future output. Then, with θ, δ, and γ given, the errors ε_y and ε_π follow from (4) and (5). These errors are in turn used as instruments to estimate the parameters in the Taylor rule, yielding ε_r. The unknown coefficients in (7) can then be determined by OLS. We assume that the parameters θ, δ, and γ remain constant over the entire sample period, but we allow the parameter of the Taylor rule to change. We also allow the coefficients in the *Z* equations to changes.

There is considerable disagreement about the values of the parameters θ, γ, and δ in the literature (see Rudebusch (2002) for a review). In our benchmark model, we set $\theta = -0.2$, $\gamma = 0.3$ and $\delta = 0.5$. When simulating small quantitative models, a larger value for θ is sometimes used (e.g. $\theta = -1$), but large values of θ are difficult to reconcile with IS slope estimates computed by traditional methods (which often find values of $\theta = -.1$ or smaller). The value $\gamma = 0.3$ was used by Clarida, Gali, Gerter (2000) in their simulations of the effects of changes in monetary policy on output and inflation variability. Traditional estimates of the Phillips curve (for example, Staiger, Stock and Watson (2001)), suggest values of γ around 0.1. The value of δ has also been the subject of controversy. Backward looking models (such as Rudebusch and Svensson (1999)) set $\delta = 0$, Gali and Gertler (2001) estimate δ to be approximately 0.6, and many models are simulated with $\delta = 1.0$.

Bernanke, Gertler and Watson (1998).

Table 9 summarizes the results for these benchmark parameter values. Results are presented for the 1960-1978 and 1984-2001 sample periods. The estimated Taylor rule coefficients (Table 9(A)) are consistent with what others have found. The inflation response in the first period is negative (remember that we specify the Taylor rule using the real interest rate) and the output coefficient is small. In the second period both the inflation and output coefficients are significantly higher.

Armed with these estimated parameters, we can use the structural VAR to compute the implied variability of output growth, changes in inflation, and interest rates. The calculations are analogous to those carried in Section 4, except now the VAR is characterized by three sets of parameters: Φ, the VAR distributed lag coefficients (just as in Section 4); Ω, the covariance matrix of the structural shocks (ε_y, ε_π, ε_r, ε_z); and A, the structural coefficients (θ, γ, δ, β_π, β_y, α_y, α_π, α_r) that link the structural and reduced form errors. We present results for the triples $\sigma(\Phi_i, \Omega_j, A_k)$, for $i, j, k = 1, 2$ corresponding to the two sample periods.

The results are shown in Table 9(B). Using (Φ_1, Ω_1, A_1), the standard deviation of the four-quarter growth rate of GDP is 2.54%. Using (Φ_2, Ω_2, A_2) the corresponding value 1.41%. These are close the estimates of the standard deviation of output growth computed directly from the sample moments of GDP. How much of the change in the variability of output can be attributed to shocks (Ω), and how much to policy (A)? The standard deviation of output using (Φ_1, Ω_2, A_1) is 1.59; using (Φ_1, Ω_1, A_2), it is 2.41. These results suggest that 14% of the decrease in variance in output growth is associated with changes in the monetary policy coefficients.[14] Said differently, most of the reduction in variability in output stems from smaller shocks, not to changes in the monetary policy coefficients.

The results for other sets of parameter values are shown in Table 9(C). To save space, this table only reports the estimated Taylor rule coefficients for each sub-sample and the implied variability of output growth for the four counter-factual simulations. Looking across these results, the estimated effect of the change in monetary policy is larger when the IS curve is more elastic (θ is more negative); when the output gap receives more weight in the Phillips curve (γ is larger); and when the New Keynesian Phillips curve is more forward looking (δ is larger).

One notable special case is when $\theta = 0$, so that monetary policy has no effect on output growth within the period; this corresponds to a common VAR identifying restriction (see the discussion in Christiano, Eichenbaum and Evans (1999)). This assumption implies that the change in monetary policy had little to do with the decline in output growth volatility (the estimated contribution to the decline for $\theta = 0$, $\gamma = 0.3$, and $\delta = 0.5$ is approximately 7%). For most of the parameter combinations examined in Table 9(C), however, the estimated contribution of the change in monetary policy to the reduction in the variance of four-quarter GDP growth falls in the range of 20% to 30%. Estimates with very large contributions are associated with implausibly large coefficients on inflation in the estimated second-period Taylor rule (inflation responses of 4 or more).

[14] The total decrease in the variability of output suggested by the VAR is $2.54^2 - 1.41^2$. The decrease associated with the change in A is $2.54^2 - 2.41^2$. The ratio is .14.

Other sensitivity checks. We performed a number of other sensitivity checks. These included reducing the horizon in the Taylor rule to one quarter; dropping the commodity price index from the VAR; replacing the commodity price index with the estimated first factor constructed from the series listed in Appendix 2 (as suggested by Bernanke and Boivin's (2000) factor-augmented VARs); and carrying out the counterfactuals holding the parameters α fixed at their period 1 values. The results from these models are similar to results from the specifications reported in Table 9 and, to save space, are not reported.

Summary. Even within the stylized model of equations (4) – (7), there is considerable uncertainty about whether the widely-perceived shift in monetary policy in the 1980s produced the moderation of output volatility. For the benchmark parameter values, and for other values that produce estimates of monetary reaction functions consistent with those discussed elsewhere in the literature, our calculations attribute perhaps 20% to 30% of the reduction in the variance of four-quarter GDP growth to improved monetary policy.

6. Conclusions and Remaining Questions

There is strong evidence of a decline in the volatility of economic activity, both as measured by broad aggregates and by a wide variety of other series that track specific facets of economic activity. For real GDP growth, the decline is, we think, best characterized as a sharp drop in the mid-1980s. This sharp decline, or break, in the volatility in real GDP growth is mirrored by declines in the variance of the four-quarter growth rates of consumption and production of durable goods, in residential fixed investment, and in the production of structures. Not all series, however, have exhibited this sharp drop in volatility, and for some series the decline in their variance is better characterized as a trend or, possibly, an episodic return to the relative quiescence of the 1960s.

Our search for the causes of this great moderation has not been completely successful, nor does one find a compelling case in the literature for a single cause of this moderation. On the positive side, we find some role for improved monetary policy; our estimates suggest that the Fed's more aggressive response to inflation since the mid-1980s has contributed perhaps 20% to 30% of the decline in output volatility. In addition, we find some role for identifiable shocks, such as less volatile productivity shocks and commodity price shocks, in reducing the variance of output growth. But this leaves much – perhaps half – of the decline in volatility unaccounted for. The shift away from manufacturing and towards services does not seem to explain the moderation; nor do improvements in inventory management arising from information technology seem to us to be a source of the reductions in volatility of four-quarter GDP growth, although improved inventory management could help to smooth production within the month or quarter. Our reduced-form evidence suggests that this reduction in volatility is associated with an increase in the precision of forecasts of output growth (and of other macroeconomic variables), but to a considerable extent we have not identified the specific source of the reduced forecast errors.

These results provide some clues for future work. Among the components of GDP, the clearest concomitant declines appear in durable goods (both consumption and production), in output of structures, and in residential investment. The declines in volatility appear in a variety of measures of residential (but not nonresidential) construction, and further investigation of the role of the housing sector in the moderation is warranted.

To the extent that improved policy gets some of the credit, then one can expect at least some of the moderation to continue as long as the policy regime is maintained. But because most of the reduction seems to be due to good luck in the form of smaller economic disturbances, we are left with the unsettling conclusion that the quiescence of the past fifteen years could well be a hiatus before a return to more turbulent economic times.

Appendix 1: Time Series Methods

This appendix describes the stochastic volatility model used to compute the smoothed estimates in Figures 2 – 4 and the variance break tests in Tables 3 and A.1.

Stochastic volatility model. The smoothed instantaneous standard deviations were estimated using a stochastic volatility model with time-varying autoregressive coefficients. Specifically, let y_t follow the time-varying AR process,

$$y_t = \sum_{j=1}^{p} \alpha_{jt} y_{t-j} + \sigma_t \varepsilon_t,$$

$$\alpha_{jt} = \alpha_{jt-1} + c_j \eta_{jt}$$

$$\ln \sigma_t^2 = \ln \sigma_{t-1}^2 + \zeta_t,$$

where ε_t, $\eta_{1t}, \ldots, \eta_{pt}$ are i.i.d. $N(0,1)$ and independently distributed, and where ζ_t is distributed independently of the other shocks. To allow for large jumps in the instantaneous innovation variance σ_t^2 (and thereby capture a possible break in the variance), we use a mixture of normals model for ζ_t, specifically, ζ_t is distributed $N(0, \tau_1^2)$ with probability q and $N(0, \tau_2^2)$ with probability $1 - q$. The series y_t is standardized before the computations, and we set $c_t = 7/T$, a value consistent with previous estimates of parameter drift in autoregressions. For these calculations, we set $\tau_1 = .04$, $\tau_2 = .2$, $q = .95$, and $p = 4$.

The nonGaussian smoother for the time-varying parameters is computed using Markov chain Monte Carlo (MCMC) methods. Let Y denote $y_1, \ldots, y_T$, let A denote $\{\alpha_{jt}, j = 1, \ldots, p, t = 1, \ldots, T)$, and let S denote $\sigma_1, \ldots, \sigma_T$. The MCMC algorithm iterates between the three conditional distributions of $Y|A, S$; of $A|Y, S$; and of $S|A, Y$. The first two of these conditional distributions are normal, given the stated assumptions. The third distribution, however, is nonnormal, and as suggested by Shephard (1994) is computed by approximating the distribution of $\ln \varepsilon_t^2$ (which is the distribution of the logarithm of a chi-squared random variable with one degree of freedom) by a mixture of normals distribution; the means and variances of the mixture (and the mixture weights) were chosen to match the first four moments of the log χ_1^2 distribution. Initial conditions were set using a flat prior, and a diffuse conjugate prior was used for the parameter values.

Given the smoothed parameter values, the estimated instantaneous autocovariances of y_t are computed using $\sigma_{t|T}^2$ and $a_{jt|T}$, the conditional means of σ_t^2 and α_{jt} given $y_1,\ldots, y_T$. The smoothed instantaneous variance of four-quarter growth rates were computed by temporal aggregation of the instantaneous autocovariance function.

Variance break tests. To test for a break in the unconditional variance (the first column of Table A.1), the absolute value of the demeaned series (e.g., the absolute value of demeaned four-quarter growth in GDP) was regressed against a constant and a binary variable $1(t \geq \tau)$ for the break date. The QLR statistic is the squared heteroskedasticity- and autocorrelation-robust t-statistic on the break indicator, maximized over τ in the central 70% of the sample.

The tests for a break in the conditional variance were computed as follows. Let $\varepsilon_t(\kappa)$ denote the errors in the autoregression in (1), where the AR coefficients break at date κ; and let $\hat{\varepsilon}_t(\kappa)$ denote the OLS residuals estimated with a break in the AR coefficients at date κ. Under the null hypothesis that there is no break in the variance,

$E|\varepsilon_t(\kappa)|$ is constant; under the alternative hypothesis that there is a break at date τ, $E|\varepsilon_t(\kappa)|$ $= \sigma_1 + \lambda 1(t \geq \tau)$, where σ_1 is the first-period standard deviation and λ is the difference between the standard deviations before and after the break. We therefore test for a break by computing the QLR statistic in the regression of $|\hat{\varepsilon}_t(\hat{\kappa})|$ against a constant and the binary variable $1(t \geq \tau)$, using homoskedastic standard errors (which are valid under the null), where $\hat{\kappa}$ is the least squares estimator of the break date in the AR coefficients. Table 3 also reports results for a trend-augmented version of this regression, in which $|\hat{\varepsilon}_t(\hat{\kappa})|$ was regressed against a constant, $1(t \geq \tau)$, and the time trend t, as well as the p-value for the test that the coefficient on t is zero in the regression in which $\tau = \hat{\tau}$. Critical values for the QLR statistic (the squared t-statistic on $1(t \geq \tau)$, maximized over τ) in this trend-augmented regression were computed by Monte Carlo simulation. In all cases, the search over τ was conducted in the central 70% of the sample.

Confidence intervals for the conditional variance break date were computed using the least squares estimator from the regression of $|\hat{\varepsilon}_t(\hat{\kappa})|$ against a constant and $1(t \geq \tau)$. If there is a break, the variance of the error term in this regression differs before and after the break, requiring a modification to Bai's (1997) limiting distribution for the least squares break date estimator. This modification entails scaling the distribution differently on either side of the break, by the appropriate estimated variance. The confidence interval for the break date is then obtained by inverting the test of the break date, based on this distribution. This results in asymmetric confidence intervals that express greater uncertainty about the break date in the low than the high volatility period. The same method applies to the unconditional variance break date, except the dependent variable is the absolute value of the demeaned series and HAC standard errors are used as discussed in Bai (1997).

Appendix 2: Data

This appendix lists the time series used in the empirical analysis. The series were either taken directly from the DRI-McGraw Hill Basic Economics database, in which case the original mnemonics are used, or they were produced by authors' calculations based on data from that database, in which case the authors' calculations and original DRI/McGraw series mnemonics are summarized in the data description field. Following the series name is a transformation code and a short data description. The transformations are (1) level of the series; (2) first difference; (3) second difference; (4) logarithm of the series; (5) first difference of the logarithm; (6) second difference of the logarithm. The following abbreviations appear in the data descriptions: SA = seasonally adjusted; NSA = not seasonally adjusted; SAAR = seasonally adjusted at an annual rate; FRB = Federal Reserve Board; AC = Authors' calculations.

Series Name	Transformation code	Description
		NIPA Components
GDPQ	5	Gross domestic product (chained)
GOQ	5	Gross domestic product - goods
GOSQ	5	Final sales of goods
GODQ	5	Gross domestic product - durable goods
GODSQ	5	Final sales of durables
GONQX	5	Gross domestic product - nondurables
GONSQX	5	Final sales of nondurables
GOOSQ	5	Gross domestic product - services
GOCQ	5	Gross domestic product - structures
GCQ	5	Personal consumption expenditures (chained) - total
GCDQ	5	Personal consumption expenditures (chained) - durables
GCNQ	5	Personal consumption expenditures (chained) - nondurables
GCSQ	5	Personal consumption expenditures (chained) - services
GPIQ	5	Investment, total (chained)
GIFQ	5	Fixed investment, total (chained)
GINQ	5	Fixed investment, nonresidential (chained)
GIRQ	5	Fixed investment, residential (chained)
GEXQ	5	Exports of goods & services (chained)
GIMQ	5	Imports of goods & services (chained)
GGEQ	5	Government consumption expenditures & gross investment (chained)
DGV_GDP	1	Change in Nominal Inventory Investment divided by Nominal GDP (AC)
GGFENQ	5	National defense cons. Expenditures & gross investment (chained)
GMCANQ	5	Personal cons expend (chained) - new cars (bil 1996$,saar)
GMCDQ	5	Pers consumption expend (chained) - total durables (bil 1996$,saar)
GMCNQ	5	Personal consumption expend (chained) - nondurables (bil 92$,saar)
GMCQ	5	Personal consumption expend (chained) - total (bil 92$,saar)
GMCSQ	5	Personal consumption expend (chained) - services (bil 92$,saar)

GMPYQ	5	Personal income (chained) (series #52) (bil 92$,saar)
GMYXPQ	5	Personal income less transfer payments (chained) (#51) (bil 92$,saar)
		Money, Credit, Interest Rates and Stock Prices
CONCRED	6	Consumer credit
FM1	6	Money stock: m1(curr,trav.cks,dem dep,other ck'able dep)(bil$,sa)
FM2	6	Money stock:m2(m1+o'nite rps,euro$,g/p&b/d mmmfs&sav&sm time dep(bil$,
FM2DQ	5	Money supply - m2 in 1992 dollars (bci)
FM3	6	Money stock: m3(m2+lg time dep,term rp's&inst only mmmfs)(bil$,sa)
FMFBA	6	Monetary base, adj for reserve requirement changes(mil$,sa)
FMRRA	6	Depository inst reserves:total,adj for reserve req chgs(mil$,sa)
FSDXP	5	S&p's composite common stock: dividend yield (% per annum)
FSNCOM	5	Nyse common stock price index: composite (12/31/65=50)
FSPCAP	5	S&p's common stock price index: capital goods (1941-43=10)
FSPCOM	5	S&p's common stock price index: composite (1941-43=10)
FSPIN	5	S&p's common stock price index: industrials (1941-43=10)
FSPXE	5	S&p's composite common stock: price-earnings ratio (%,nsa)
FYAAAC	2	Bond yield: moody's aaa corporate (% per annum)
FYBAAC	2	Bond yield: moody's baa corporate (% per annum)
FYFF	2	Interest rate: federal funds (effective) (% per annum,nsa)
FYFHA	2	Secondary market yields on fha mortgages (% per annum)
FYGM3	2	Interest rate: u.s.treasury bills,sec mkt,3-mo.(% per ann,nsa)
FYGT1	2	Interest rate: u.s.treasury const maturities,1-yr.(% per ann,nsa)
FYGT10	2	Interest rate: u.s.treasury const maturities,10-yr.(% per ann,nsa)
		Housing
HSBR	5	Housing authorized: total new priv housing units (thous.,saar)
HSFR	5	Housing starts:nonfarm(1947-58);total farm&nonfarm(1959-)(thous.,sa
HSMW	5	Housing starts:midwest(thous.u.)s.a.
HSNE	5	Housing starts:northeast (thous.u.)s.a.
HSSOU	5	Housing starts:south (thous.u.)s.a.
HSWST	5	Housing starts:west (thous.u.)s.a.
		Industrial production
IP	5	Industrial production: total index (1992=100,sa)
IPC	5	Industrial production: consumer goods (1992=100,sa)
IPCD	5	Industrial production: durable consumer goods (1992=100,sa)
IPCN	5	Industrial production: nondurable condsumer goods (1992=100,sa)
IPD	5	Industrial production: durable manufacturing (1992=100,sa)
IPE	5	Industrial production: business equipment (1992=100,sa)
IPF	5	Industrial production: final products (1992=100,sa)
IPI	5	Industrial production: intermediate products (1992=100,sa)
IPM	5	Industrial production: materials (1992=100,sa)
IPMD	5	Industrial production: durable goods materials (1992=100,sa)
IPMFG	5	Industrial production: manufacturing (1992=100,sa)
IPMIN	5	Industrial production: mining (1992=100,sa)
IPMND	5	Industrial production: nondurable goods materials (1992=100,sa)
IPN	5	Industrial production: nondurable manufacturing (1992=100,sa)
IPP	5	Industrial production: products, total (1992=100,sa)
IPUT	5	Industrial production: utilities (1992-=100,sa)
IPXMCA	1	Capacity util rate: manufacturing,total(% of capacity,sa)(frb)
		Inventories, Orders and Sales
IVMFDQ	5	Inventories, business durables (mil of chained 1996 dollars, sa)
IVMFGQ	5	Inventories, business, mfg (mil of chained 1996 dollars, sa)
IVMFNQ	5	Inventories, business, nondurables (mil of chained 1996 dollars, sa)
IVMTQ	5	Mfg & trade inventories:total (mil of chained 1996)(sa)
IVRRQ	5	Mfg & trade inv:retail trade (mil of chained 1996 dollars)(sa)
IVWRQ	5	Mfg & trade inv:merchant wholesalers (mil of chained 1996 dollars)(sa)
IVSRMQ	5	Ratio for mfg & trade:mfg;inventory/sales (1996$)(s.a.)
IVSRQ	5	Ratio for mfg & trade: inventory/sales (chained 1996 dollars, sa)
IVSRRQ	5	Ratio for mfg & trade:retail trade;inventory/sales(1996$)(s.a.)
IVSRWQ	5	Ratio for mfg & trade:wholesaler;inventory/sales(1996$)(s.a.)
GVSQ	1	(Change in inventories)/sales - goods (ac)
GVDSQ	1	(Change in inventories)/sales - durable goods (ac) (ac)
GVNSQ	1	(Change in inventories)/sales - nondurable goods

MDOQ	5	New orders, durable goods industries, 1992 dollars (bci)
MOCMQ	5	New orders (net) - consumer goods & materials, 1992 dollars (bci)
MPCONQ	5	Contracts & orders for plant & equipment in 1992 dollars (bci)
MSDQ	5	Mfg & trade:mfg; durable goods (mil of chained 1996 dollars)(sa)
MSMQ	5	Sales, business - manufacturing (chained)
MSMTQ	5	Mfg & trade: total (mil of chained 1996 dollars)(sa)
MSNQ	5	Mfg & trade:mfg;nondurable goods (mil of chained 1996 dollars)(sa)
MSONDQ	5	New orders, nondefense capital goods, in 1992 dollars (bci)
RTNQ	5	Retail trade:nondurable goods (mil of 1996 dollars)(sa)
WTDQ	5	Merch wholesalers:durable goods total (mil of chained 1996 dollars)(sa)
WTNQ	5	Merch wholesalers:nondurable goods (mil of chained 1996 dollars)(sa)
WTQ	5	Merch wholesalers: total (mil of chained 1996 dollars)(sa)
		Employment
LHEL	5	Index of help-wanted advertising in newspapers (1967=100;sa)
LHELX	5	Employment: ratio; help-wanted ads:no. Unemployed clf
LHEM	5	Civilian labor force: employed, total (thous.,sa)
LHNAG	5	Civilian labor force: employed, nonagric.industries (thous.,sa)
LHU14	5	Unemploy.by duration: persons unempl.5 to 14 wks (thous.,sa)
LHU15	5	Unemploy.by duration: persons unempl.15 wks + (thous.,sa)
LHU26	5	Unemploy.by duration: persons unempl.15 to 26 wks (thous.,sa)
LHU5	5	Unemploy.by duration: persons unempl.less than 5 wks (thous.,sa)
LHU680	5	Unemploy.by duration: average(mean)duration in weeks (sa)
LHUR	2	Unemployment rate: all workers, 16 years & over (%,sa)
LP	5	Employees on nonag payrolls: total, private (thous,sa)
LPCC	5	Employees on nonag. Payrolls: contract construction (thous.,sa)
LPED	5	Employees on nonag. Payrolls: durable goods (thous.,sa)
LPEM	5	Employees on nonag. Payrolls: manufacturing (thous.,sa)
LPEN	5	Employees on nonag. Payrolls: nondurable goods (thous.,sa)
LPFR	5	Employees on nonag. Payrolls: finance,insur.&real estate (thous.,sa
LPGD	5	Employees on nonag. Payrolls: goods-producing (thous.,sa)
LPGOV	5	Employees on nonag. Payrolls: government (thous.,sa)
LPHRM	5	Avg. Weekly hrs. Of production wkrs.: manufacturing (sa)
LPMOSA	5	Avg. Weekly hrs. Of prod. Wkrs.: mfg.,overtime hrs. (sa)
LPNAG	5	Employees on nonag. Payrolls: total (thous.,sa)
LPS	5	Employees on nonag. Payrolls: services (thous.,sa)
LPSP	5	Employees on nonag. Payrolls: service-producing (thous.,sa)
LPT	5	Employees on nonag. Payrolls: wholesale & retail trade (thous.,sa)
		NAPM indexes
PMCP	1	Napm commodity prices index (percent)
PMDEL	1	Napm vendor deliveries index (percent)
PMEMP	1	Napm employment index (percent)
PMI	1	Purchasing managers' index (sa)
PMNO	1	Napm new orders index (percent)
PMNV	1	Napm inventories index (percent)
PMP	1	Napm production index (percent)
		Wages and Prices
R_LEHCC	2	Ln(lehcc/gdpd)
LEHCC	6	Avg hr earnings of constr wkrs: construction ($,sa)
R_LEHM	2	Ln(lehm/gdpd)
LEHM	6	Avg hr earnings of prod wkrs: manufacturing ($,sa)
GDPD	6	Gross domestic product:implicit price deflator(index,92=100)(t7.1)
GDC	6	Implicit pr deflator: personal consumption expenditures
PUNEW	6	Cpi-u: all items (82-84=100,sa)
PUXF	6	Cpi-u: all items less food (82-84=100,sa)
PUXHS	6	Cpi-u: all items less shelter (82-84=100,sa)
PUXM	6	Cpi-u: all items less midical care (82-84=100,sa)
PW	6	Producer price index: all commodities (82=100,nsa)
PSCCOM	6	Spot market price index:bls & crb: all commodities(67=100,nsa)
R_PSCCOM	2	Ln(psccom/gdpd) (ac)
PSM99Q	6	Index of sensitive materials prices (1990=100)(bci-99a)
R_PSM99Q	2	Ln(psm99q/gdpd) (ac)
PU83	6	Cpi-u: apparel & upkeep (82-84=100,sa)
R_PU83	2	Ln(pu83/gdpd) (ac)
PU84	6	Cpi-u: transportation (82-84=100,sa)

R_PU84	2	Ln(pu84/gdpd) (ac)
PU85	6	Cpi-u: medical care (82-84=100,sa)
R_PU85	2	Ln(pu85/gdpd) (ac)
PUC	6	Cpi-u: commodities (82-84=100,sa)
R_PUC	2	Ln(puc/gdpd) (ac)
PUCD	6	Cpi-u: durables (82-84=100,sa)
R_PUCD	2	Ln(pucd/gdpd) (ac)
PUS	6	Cpi-u: services (82-84=100,sa)
R_PUS	2	Ln(pus/gdpd) (ac)
PW561	6	Producer price index: crude petroleum (82=100,nsa)
R_PW561	2	Ln(pw561/gdpd) (ac)
PWFCSA	6	Producer price index:finished consumer goods (82=100,sa)
R_PWFCSA	2	Ln(pwfcsa/gdpd) (ac)
PWFSA	6	Producer price index: finished goods (82=100,sa)
R_PWFSA	2	Ln(pwfsa/gdpd) (ac)
		Industrial Production in Other Countries
IPCAN	5	Industrial production: canada (1990=100,sa)
IPFR	5	Industrial production: france (1987=100,sa)
IPIT	5	Industrial production: italy (1987=100,sa)
IPJP	5	Industrial production : japan (1990=100,sa)
IPOECD	5	Industrial production - oecd, european countries (1990=100,sa)
IPUK	5	Industrial production: united kingdom (1987=100,sa)
IPWG	5	Industrial production: west germany (1990=100,sa)
		Additional Series Shown in Figure 4
GFIRSQ	5	Purchases of residential structures - 1-unit
GFIRMQ	5	Purchases of residential structures - two or more units
CONFRC	5	Construct.put in place:priv residential bldg 87$(mil$,saar
CONCC	5	Construct.put in place:commercial bldgs 1987$(mil$,saar)
CONIC	5	Construct.put in place:industrial bldg 1987$(mil$,saar)

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Table 1
Summary Statistics for Four-Quarter Growth in Real GDP, 1960 – 2001

Sample Period	Mean (%)	Standard deviation (%)
1960 - 2001	3.3	2.3
Statistics by decade		
1960 - 1969	4.3	2.0
1970 - 1979	3.2	2.7
1980 - 1989	2.9	2.6
1990 – 2001	3.0	1.5

Notes: Summary statistics are shown for $100\times\ln(GDP_t / GDP_{t-4})$, where GDP_t is the quarterly value of real GDP.

Table 2
Standard Deviations, by Decade, of Annual Growth Rates or Changes of 22 Macroeconomic Time Series

Series	Standard Deviation 1960-2001	Standard Deviation, relative to 1960 - 2001			
		1960-1969	1970-1979	1980-1989	1990-2001
GDP	0.023	0.98	1.18	1.14	0.67
consumption	0.019	0.97	1.17	1.07	0.78
consumption – durables	0.066	0.87	1.18	1.13	0.79
consumption – nondurables	0.018	1.06	1.22	0.81	0.87
consumption – services	0.012	1.07	0.84	1.20	0.88
investment (total)	0.104	0.82	1.15	1.22	0.77
fixed investment – total	0.067	0.77	1.29	1.04	0.84
nonresidential	0.067	0.87	1.17	1.06	0.89
residential	0.134	0.78	1.25	1.23	0.65
Δinventory investment/GDP	0.006	1.12	0.92	1.22	0.71
exports	0.064	1.07	1.13	1.12	0.66
imports	0.072	0.87	1.24	1.14	0.70
government spending	0.025	1.40	1.00	0.85	0.65
Production					
goods (total)	0.036	0.97	1.13	1.13	0.76
nondurable goods	0.073	1.00	1.14	1.16	0.68
durable goods	0.025	0.92	1.16	1.22	0.65
services	0.011	1.41	0.52	1.01	0.87
structures	0.062	0.73	1.33	1.11	0.73
nonagricultural employment	0.017	0.94	1.21	1.09	0.73
price inflation (GDP deflator)	0.004	0.69	1.51	1.06	0.50
90-day T-bill rate	1.704	0.51	1.10	1.43	0.75
10-year T-bond rate	1.223	0.43	0.65	1.67	0.82

Notes: NIPA series are annual growth rates, except for the change in inventory investment, which is the annual difference of the quarterly change in inventories as a fraction of GDP. Inflation is the four-quarter change in the annual inflation rate, and interest rates are in four-quarter changes.

Table 3
Tests for Changes in Autoregressive Parameters

	Conditional Mean			Conditional Variance: break only			Conditional Variance: trend and break		
Series	***p*-value**	**break date**	**67% confidence interval**	***p*-value**	**break date**	**67% confidence interval**	***p*-value: trend**	***p*-value: break**	**break date**
GDP	0.98	.	. - .	0.00	1983:2	1982:4 - 1985:3	0.63	0.00	1983:2
consumption	0.55	.	. - .	0.00	1992:1	1991:3 - 1994:1	0.00	0.11	.
consumption – durables	0.04	1987:3	1987:1 - 1988:1	0.00	1987:3	1987:2 - 1990:2	0.68	0.03	1987:3
consumption – nondurables	0.00	1991:4	1991:2 - 1992:2	0.08	.	. - .	0.96	0.80	.
consumption – services	0.00	1969:4	1969:2 - 1970:2	0.18	.	. - .	0.03	0.00	1971:3
investment (total)	0.05	.	. - .	0.13	.	. - .	0.06	0.25	.
fixed investment – total	0.69	.	. - .	0.01	1983:3	1983:1 - 1986:4	0.65	0.07	.
nonresidential	0.47	.	. - .	0.70	.	. - .	0.69	0.60	.
residential	0.10	.	. - .	0.00	1983:2	1983:1 - 1985:2	0.08	0.00	1983:2
Δinventory investment/GDP	0.91	.	. - .	0.04	1988:1	1987:3 - 1992:2	0.00	0.10	.
exports	0.09	.	. - .	0.00	1975:4	1975:2 - 1978:2	0.95	0.75	.
imports	0.00	1972:4	1972:2 - 1973:2	0.00	1986:2	1986:1 - 1988:1	0.96	0.05	1986:2
government spending	0.06	.	. - .	0.45	.	. - .	0.33	0.65	.
Production									
goods (total)	0.92	.	. - .	0.00	1983:4	1983:2 - 1986:4	0.54	0.03	1983:3
nondurable goods	0.09	.	. - .	0.00	1983:4	1983:3 - 1987:1	0.00	0.29	.
durable goods	0.77	.	. - .	0.02	1985:2	1984:3 - 1989:1	0.33	0.02	1985:2
services	0.00	1968:3	1968:1 - 1969:1	0.98	.	. - .	0.69	0.92	.
structures	0.02	1991:3	1991:1 - 1992:1	0.02	1984:2	1983:4 - 1988:1	0.42	0.03	1984:2
nonagricultural employment	0.03	1981:2	1980:4 - 1981:4	0.00	1983:2	1982:4 - 1985:3	0.00	0.02	1973:3
price inflation (GDP deflator)	0.00	1973:2	1972:4 - 1973:4	0.11	.	. - .	0.00	0.00	1971:2
90-day T-bill rate	0.00	1981:1	1980:3 - 1981:3	0.01	1984:4	1984:2 - 1988:1	0.00	0.00	1984:4
10-year T-bond rate	0.02	1981:1	1980:3 - 1981:3	0.00	1979:3	1972:2 - 1980:1	0.02	0.00	1979:3

Notes: The test results are based on the QLR test for changes in the coefficients of an AR(4). The first column shows the *p*-value for the QLR test break test statistic. The second column shows the least squares estimate of the break date (when the QLR statistic is significant at the 5% level), and the final column shows the 67% confidence interval for the break date. The results in the "Conditional Mean Coefficients" columns correspond to the parameters α and ϕ in Equation (1). The results in the "Conditional Variance" columns refer to the variance of ε_t in Equation (1), either with or without a time trend in the QLR regression. The tests are described in more detail in Appendix 1 .

Table 4
Estimates of Common Break Dates of Variances of VAR residuals

Variables	**# vbles**	**QLR *p*-value**	**break date**	**67% confidence interval**
consumption, investment, exports, imports, government spending	5	0.01	1982:4	1981:1 – 1984:3
output of: durables, nondurables, services, and structures	4	0.00	1984:1	1982:3 – 1985:3
consumption of durables, consumption of nondurables, residential fixed investment	3	0.00	1983:2	1982:1 – 1984:3

Notes: The estimated break dates and confidence intervals are computed using the methods in Bai, Lumsdaine, and Stock (1998).

Table 5
Implied Standard Deviations of Four-Quarter GDP Growth From Subsample VARs

$$X_t = \Phi(L)X_{t-1} + u_t,\ \ \text{Var}(u_t) = \Sigma$$

First Sample Period: 1960-1983 (Estimated Parameters $\hat{\Phi}_1(L)$ and $\hat{\Sigma}_1$)
Second Sample Period: 1984-2001 (Estimated Parameters $\hat{\Phi}_2(L)$ and $\hat{\Sigma}_2$)

A. Four-variable benchmark specification (VAR(4) with GDP growth, change in inflation, federal funds rate, and the growth rate of real commodity prices)

Variable	**Sample standard deviation**		**Standard deviation of four-quarter GDP growth implied by the VAR**			
	1960-1983	**1984-2001**	$\sigma(\hat{\Phi}_1,\hat{\Sigma}_1)$	$\sigma(\hat{\Phi}_2,\hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_1,\hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_2,\hat{\Sigma}_1)$
GDP growth	2.71	1.59	2.76	1.43	1.48	2.63
Inflation	1.49	0.59	1.52	0.57	0.95	0.92
Federal funds rate	2.64	1.47	2.67	1.48	1.35	3.03

B. Sensitivity Analysis: Alternative Specifications

Deviation from Benchmark Specification	$\sigma(\hat{\Phi}_1,\hat{\Sigma}_1)$	$\sigma(\hat{\Phi}_2,\hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_1,\hat{\Sigma}_2)$	$\sigma(\hat{\Phi}_2,\hat{\Sigma}_1)$
First period is 1960-1978	2.52	1.43	1.46	2.58
VAR(6)	2.78	1.37	1.59	2.45
levels instead of first differences	2.65	1.61	1.43	2.87
1-year Treasury bill rate instead of FF rate	2.72	1.41	1.42	2.73
alternative commodity price index (PPI for Crude Materials)	2.76	1.46	2.13	2.60
alternative commodity price index (Index of Sensitive Mat. Prices)	2.74	1.44	1.68	2.50
commodity prices dropped	2.76	1.47	1.34	2.68
GDP replaced with goods output	3.94	2.68	2.55	4.08
GDP replaced with goods sales	3.00	2.23	2.25	3.00
monthly data (using IP and CPI)	5.50	3.13	3.25	5.53

Note: Entries are various estimates of the square root of the variance of the four-quarter growth in GDP. In the base VAR specification, commodity prices are an index of spot prices, all commodities (PSCCOM). The alternative commodity prices indexes are PWCMSA and PSM99Q.

Table 6
The Effect of Changing Sectoral Composition on the Variance of GDP and Aggregate Employment

A. GDP

	Standard Deviation		Shares	
Sector	**1960-1983**	**1984-2001**	**1960**	**2001**
GDP (Actual)	.027	.016		
GDP (1965 Shares)	.031	.018		
Durables	.084	.053	.18	.18
Nondurables	.030	.018	.31	.19
Services	.012	.008	.39	.53
Structures	.072	.048	.11	.09

B. Aggregate Employment

	Standard Deviation		Shares	
Sector	**1960-1983**	**1984-2001**	**1960**	**2001**
Total (Actual)	.020	.013		
Total (1965 Shares)	.022	.014		
Mining	.075	.059	.013	.004
Construction	.053	.045	.054	.051
Durable Man.	.056	.028	.174	.085
Nondurable Man.	.026	.014	.136	.056
Trans. & Util.	.023	.014	.074	.053
Trade	.017	.017	.210	.230
FIRE	.013	.020	.049	.057
Services	.011	.012	.136	.307
Government	.019	.008	.154	.157

Notes: The first row of each table shows the standard deviation of the four quarter changes in the aggregate series. The next row shows the standard deviation of the 1965-share weighted share of four quarter changes in the disaggregated series shown in the other rows of the table.

Table 7
Standard Deviations of Growth of Production, Sales, and Inventories

Series	One-quarter growth			Four-quarter growth		
	$s_{1960\text{-}1983}$	$s_{1984\text{-}2001}$	$\frac{s_{1984\text{-}2001}}{s_{1960\text{-}1983}}$	$s_{1960\text{-}1983}$	$s_{1984\text{-}2001}$	$\frac{s_{1984\text{-}2001}}{s_{1960\text{-}1983}}$
GDP	4.32	2.18	.51	2.71	1.59	.59
Total Goods						
Production	7.78	4.58	.59	4.12	2.87	.70
Sales	5.14	3.93	.76	3.05	2.01	.66
ΔI/Sales	6.22	4.50	.72	2.09	1.95	.94
Durable Goods						
Production	17.25	8.06	.47	8.46	5.28	.62
Sales	9.86	7.83	.79	5.67	3.67	.65
ΔI/Sales	12.10	8.17	.68	4.15	3.15	.76
Nondurable Goods						
Production	7.41	4.69	.63	2.96	1.81	.61
Sales	4.50	2.88	.64	2.35	1.41	.60
ΔI/Sales	6.55	3.97	.61	1.89	1.59	.84
Services production	1.71	1.38	.81	1.18	0.80	.68
Structures production	11.80	6.71	.57	7.16	4.79	.67

Notes: $s_{1960\text{-}1983}$ denotes the standard deviation computed using the 1960 to 1983 data, etc. One-quarter growth rates are computed as $400\times\ln(X_t / X_{t-1})$, where X_t is sales (etc.), except for $\Delta I/Sales$, which is computed as 400 times its quarterly first difference ($100\times\Delta X_t$). Four-quarter growth rates are computed as $100\times \ln(X_t / X_{t-1})$, except for $\Delta I/Sales$, which is computed as 100 times its fourth difference ($100\times(X_t - X_{t-4})$).

Table 8
Changes in the Standard Deviation of Various Macroeconomic Shocks

Shock	**Period 1**	**Period 2**	$\frac{s_{\text{period 2}}}{s_{\text{period 1}}}$	**Relative contribution to GDP variance reduction**
Monetary policy				
Christiano-Eichenbaum-Evans	60:1-83:4	84:1-01:3	0.50	0.10
Christiano-Eichenbaum-Evans	60:1-78:4	84:1-01:3	0.76	0.00
Bernanke-Mihov-1 (monthly)	66:1-83:4	84:1-01:3	0.57	0.23*
Bernanke-Mihov-1 (monthly)	66:1-78:12	84:1-01:9	0.75	0.27*
Bernanke-Mihov-2 (monthly)	66:1-83:12	84:1-01:9	0.39	0.16*
Bernanke-Mihov-2 (monthly)	66:1-78:4	84:1-01:9	0.62	0.05*
Fiscal policy				
Taxes (Blanchard-Perotti)	60:1-83:4	84:1-97:4	0.83	0.02
Spending (Blanchard-Perotti)	60:1-83:4	84:1-97:4	0.94	0.03
Productivity				
Gali	60:1-83:4	84:1-01:3	0.75	0.15
Oil prices				
nominal price	60:1-83:4	84:1-01:3	2.80	-0.12
Real price	60:1-83:4	84:1-01:3	2.98	-0.15
Hamilton	60:1-83:4	84:1-01:3	1.09	0.05
Commodity prices				
All	60:1-83:4	84:1-01:3	0.73	0.18
Food	60:1-83:4	84:1-01:3	0.75	0.07
Industrial materials prices	60:1-83:4	84:1-01:3	0.78	0.13
Sensitive materials prices	60:1-83:4	84:1-01:3	0.78	0.14

Notes: Standard deviations were computed for each of the shocks listed in the first column over the sample periods listed in the 2nd and 3rd columns. The relative standard deviation shown in the third column is the period 2 standard deviation divide by the period 1 standard deviation. The final column shows the fraction of the reduction in output variance associated with the change in shock variance. For the quarterly series the output series is the annual growth rate of annual GDP. For the monthly series (*) the output series is the annual growth rate of the index of industrial production. Bernanke-Mihov-1 corresponds to shocks estimated in the Bernanke-Mihov model with constant coefficients over the full sample period. Bernanke-Mihov-2 shocks allow the coefficients to differ in the two sample periods. See the text for description of the shocks.

Table 9
Implied Standard Deviation From Sample-Specific Structural VARs

$$AX_t = A\Phi(\mathrm{L})X_{t-1} + \varepsilon_t, \ \ \mathrm{var}(\varepsilon_t) = \Omega$$

Estimated parameters: $\hat{\Phi}_1(\mathrm{L})$, $\hat{A}_1$, and Ω_1 (period 1) and $\hat{\Phi}_2(\mathrm{L})$, $\hat{A}_2$, and Ω_2 (period 2)

A. Estimated Taylor Rule Coefficients, Benchmark Specification

$\theta = -0.2$, $\delta = 0.5$, $\gamma = 0.3$

	β_π	β_y
Sample Period 1	-0.25 (0.18)	0.16 (0.18)
Sample Period 2	0.75 (0.31)	0.62 (0.18)

B. Implied Standard Deviations of Four-Quarter GDP Growth, Benchmark Specification

Variable	Sample standard deviation		Standard deviations implied by VAR									
			VAR with $\Phi = \Phi_1$					VAR with $\Phi = \Phi_2$				
	1960-1978	1984-2001	Ω_1, A_1	Ω_1, A_2	Ω_2 A_1	Ω_2 A_2	Fract Var_1	Ω_1, A_1	Ω_1, A_2	Ω_2 A_1	Ω_2 A_2	Fract Var_2
GDP	2.49	1.60	2.54	2.41	1.59	1.50	0.17	2.68	2.30	1.67	1.41	0.22
Inflation	1.37	0.59	1.40	1.32	0.96	0,92	0.14	0.85	0.74	0.63	0.56	0.05
FF rate	1.29	1.51	1.33	1.57	1.07	1.05	1.13	1.89	2.20	1.45	1.49	0.19

C. Sensitivity Analysis: Alternative Parameter Values

IS and Phiillips curve coefficients			Estimated Taylor rule coefficients				Standard deviations implied by VAR					
			Period 1		Period 2		VAR with $\Phi = \Phi_1$			VAR with $\Phi = \Phi_2$		
θ	γ	δ	β_π	β_y	β_π	β_y	Ω_1, A_2	Ω_2, A_1	Fract Var_1	Ω_1, A_2	Ω_2, A_1	Fract Var_2
-0.20	0.30	0.50	-0.25	0.16	0.75	0.63	2.41	1.59	0.17	2.30	1.67	0.22
-0.20	0.30	0.90	-0.00	0.06	4.15	0.25	1.86	2.88	0.81	1.87	2.56	1.25
-0.20	0.30	0.10	-0.40	0.22	0.21	0.69	2.41	1.61	0.17	2.32	1.65	0.20
-0.20	0.10	0.50	-0.45	0.24	0.19	0.69	2.39	1.63	0.20	2.30	1.65	0.21
-0.20	0.60	0.50	0.12	0.01	1.55	0.54	2.38	1.62	0.21	2.28	1.67	0.22
-0.10	0.30	0.50	-0.45	0.17	0.39	0.57	2.45	1.58	0.11	2.39	1.58	0.14
-0.50	0.30	0.50	0.87	0.14	1.91	0.81	2.19	1.77	0.44	2.19	1.77	0.32
-0.20	0.10	0.90	-0.11	0.10	2.14	0.47	1.98	1.94	0.69	1.96	1.83	0.37
-0.20	0.30	0.75	-0.04	0.07	1.97	0.49	2.20	1.76	0.44	2.10	1.79	0.33
-0.20	0.10	0.75	-0.29	0.18	0.72	0.63	2.35	1.63	0.26	2.24	1.68	0.24
-0.50	0.10	0.75	0.19	0.31	1.62	0.84	2.19	1.80	0.45	2.02	2.01	0.57
0.00	0.30	0.50	-0.61	0.17	0.05	0.51	2.49	1.59	0.07	2.49	1.51	0.08

Notes: The identifying restrictions for the structural VAR are summarized in equations (4) – (7) in the text. The two sample periods are 1960-1978 and 1984-2001.
Fract Var_1 is the ratio, $[\sigma^2(\Phi_1,\Omega_1,A_1)-\sigma^2(\Phi_1,\Omega_1,A_2)]/[\sigma_1^2-\sigma_2^2]$ and *Fract* Var_2 = $[\sigma^2(\Phi_2,\Omega_2,A_1)-\sigma^2(\Phi_2,\Omega_2,A_2)]/[\sigma_1^2-\sigma_2^2]$.

Table A.1
Break Results for Univariate Autoregressions for Selected Macroeconomic Time Series

Series	Variance			Conditional Mean			Conditional Variance: break only			Conditional Variance: trend and break		
	p-value	break date	67% confidence interval	*p*-value	break date	67% confidence interval	*p*-value	break date	67% confidence interval	*p*-value: trend	*p*-value: break	break date
gdpq	0.00	1984:2	1983:3 - 1987:1	0.98	.	. - .	0.00	1983:2	1982:4 - 1985:3	0.65	0.00	1983:2
gcq	0.00	1993:1	1992:3 - 1996:2	0.55	.	. - .	0.00	1992:1	1991:3 - 1994:1	0.00	0.12	.
gcdq	0.00	1991:1	1990:4 - 1994:1	0.04	1987:3	1987:1 - 1988:1	0.00	1987:3	1987:2 - 1990:2	0.69	0.02	1987:3
gcnq	0.38	.	. - .	0.00	1991:4	1991:2 - 1992:2	0.08	.	. - .	0.96	0.79	.
gcsq	0.03	1993:2	1992:2 - 1998:4	0.00	1969:4	1969:2 - 1970:2	0.18	.	. - .	0.03	0.00	1971:3
gpiq	0.07	.	. - .	0.05	.	. - .	0.13	.	. - .	0.06	0.26	.
gifq	0.02	1984:2	1982:4 - 1989:3	0.69	.	. - .	0.01	1983:3	1983:1 - 1986:4	0.66	0.07	.
ginq	0.84	.	. - .	0.47	.	. - .	0.70	.	. - .	0.69	0.61	.
girq	0.01	1983:3	1982:4 - 1989:1	0.10	.	. - .	0.00	1983:2	1983:1 - 1985:2	0.08	0.00	1983:2
dgv_gdp	0.26	.	. - .	0.91	.	. - .	0.04	1988:1	1987:3 - 1992:2	0.00	0.10	.
gexq	0.03	1973:1	1972:4 - 1978:1	0.09	.	. - .	0.00	1975:4	1975:2 - 1978:2	0.95	0.75	.
gimq	0.00	1985:3	1985:1 - 1990:2	0.00	1972:4	1972:2 - 1973:2	0.00	1986:2	1986:1 - 1988:1	0.96	0.05	1986:2
ggeq	0.65	.	. - .	0.06	.	. - .	0.45	.	. - .	0.33	0.66	.
goq	0.01	1984:2	1983:2 - 1989:3	0.92	.	. - .	0.00	1983:4	1983:2 - 1986:4	0.54	0.02	1983:4
godq	0.04	1984:1	1983:4 - 1992:2	0.09	.	. - .	0.00	1983:4	1983:3 - 1987:1	0.00	0.30	.
gonqx	0.12	.	. - .	0.77	.	. - .	0.02	1985:2	1984:3 - 1989:1	0.34	0.02	1985:2
goosq	0.00	1967:1	1965:3 - 1968:1	0.00	1968:3	1968:1 - 1969:1	0.98	.	. - .	0.69	0.93	.
gocq	0.01	1984:2	1983:1 - 1988:3	0.02	1991:3	1991:1 - 1992:1	0.02	1984:2	1983:4 - 1988:1	0.43	0.03	1984:2
lpnag	0.03	1984:4	1981:1 - 1987:3	0.03	1981:2	1980:4 - 1981:4	0.00	1983:2	1982:4 - 1985:3	0.00	0.01	1973:3
gdpd	0.37	.	. - .	0.00	1973:2	1972:4 - 1973:4	0.11	.	. - .	0.00	0.00	1971:2
fygm3	0.71	.	. - .	0.00	1981:1	1980:3 - 1981:3	0.01	1984:4	1984:2 - 1988:1	0.00	0.00	1984:4
fygt10	0.01	1979:3	1975:4 - 1981:1	0.02	1981:1	1980:3 - 1981:3	0.00	1979:3	1972:2 - 1980:1	0.02	0.00	1979:3
ggfenq	0.49	.	. - .	0.00	1972:2	1971:4 - 1972:4	0.00	1987:4	1984:2 - 1989:4	0.00	0.04	1974:3
gosq	0.03	1993:4	1993:2 - 2000:1	0.50	.	. - .	0.39	.	. - .	0.10	0.21	.
godsq	0.00	1991:1	1990:4 - 1997:1	0.06	.	. - .	0.05	.	. - .	0.55	0.06	.
gonsqx	0.00	1986:2	1984:1 - 1988:2	0.46	.	. - .	0.01	1986:2	1985:3 - 1989:3	0.02	0.64	.
concred	0.01	1995:1	1994:4 - 2001:3	0.29	.	. - .	0.19	.	. - .	0.30	0.05	1970:1
fm1	0.02	1979:1	1971:3 - 1979:2	0.03	1980:4	1980:2 - 1981:2	0.00	1979:3	1971:2 - 1980:3	0.00	0.67	.
fm2	0.01	1993:2	1992:4 - 1998:2	0.16	.	. - .	0.27	.	. - .	0.14	0.13	.
fm2dq	0.05	.	. - .	0.00	1975:2	1974:4 - 1975:4	0.16	.	. - .	0.04	0.00	1989:3
fm3	1.00	.	. - .	0.20	.	. - .	0.11	.	. - .	0.38	0.05	1971:2
fmfba	0.88	.	. - .	0.03	1981:2	1980:4 - 1981:4	0.07	.	. - .	0.06	0.88	.
fmrra	0.04	1978:3	1974:4 - 1982:1	0.02	1972:3	1972:1 - 1973:1	0.00	1978:3	1974:1 - 1979:4	0.99	0.37	.

fsdxp	0.63	.	. - .	0.01	1979:1	1978:3 - 1979:3	0.21	.	. - .	0.35	0.07	.
fsncom	0.32	.	. - .	0.02	1975:3	1975:1 - 1976:1	0.42	.	. - .	0.25	0.13	.
fspcap	0.57	.	. - .	0.10	.	. - .	0.60	.	. - .	0.18	0.15	.
fspcom	0.73	.	. - .	0.00	1978:4	1978:2 - 1979:2	0.45	.	. - .	0.66	0.35	.
fspin	0.91	.	. - .	0.00	1995:1	1994:3 - 1995:3	0.10	.	. - .	0.34	0.04	1991:1
fspxe	0.41	.	. - .	0.02	1978:4	1978:2 - 1979:2	0.77	.	. - .	0.61	0.56	.
fyaaac	0.02	1979:3	1974:1 - 1980:2	0.01	1981:3	1981:1 - 1982:1	0.00	1979:2	1972:1 - 1979:4	0.00	0.00	1979:2
fybaac	0.02	1979:3	1974:1 - 1980:2	0.02	1980:4	1980:2 - 1981:2	0.00	1979:3	1973:1 - 1980:2	0.00	0.00	1989:1
fyff	0.53	.	. - .	0.07	.	. - .	0.00	1984:4	1984:3 - 1987:3	0.00	0.00	1984:4
fyfha	0.04	1979:3	1973:4 - 1980:4	0.11	.	. - .	0.00	1979:3	1974:3 - 1980:1	0.06	0.00	1979:3
fygt1	0.01	1966:4	1965:4 - 1967:1	0.00	1981:1	1980:3 - 1981:3	0.05	1984:4	1984:2 - 1989:3	0.00	0.00	1984:4
gmcanq	0.00	1991:1	1990:4 - 1994:4	0.08	.	. - .	0.03	1991:3	1991:2 - 1994:4	0.00	0.06	.
gmcdq	0.00	1991:1	1990:4 - 1994:1	0.04	1987:3	1987:1 - 1988:1	0.00	1987:3	1987:2 - 1990:1	0.72	0.03	1987:3
gmcnq	0.38	.	. - .	0.00	1991:4	1991:2 - 1992:2	0.09	.	. - .	0.96	0.78	.
gmcq	0.00	1993:1	1992:3 - 1996:2	0.61	.	. - .	0.00	1992:1	1991:3 - 1994:1	0.00	0.12	.
gmcsq	0.03	1993:2	1992:2 - 1998:4	0.00	1969:4	1969:2 - 1970:2	0.18	.	. - .	0.03	0.00	1971:3
gmpyq	0.03	1995:2	1994:2 - 1999:4	0.00	1981:3	1981:1 - 1982:1	0.03	1995:1	1994:3 - 1997:3	0.00	0.00	1972:2
gmyxpq	0.12	.	. - .	0.33	.	. - .	0.13	.	. - .	0.00	0.00	1970:3
hsbr	0.13	.	. - .	0.01	1992:3	1992:1 - 1993:1	0.04	1984:3	1983:4 - 1988:4	0.09	0.00	1984:3
hsfr	0.08	.	. - .	0.00	1991:1	1990:3 - 1991:3	0.00	1984:3	1983:4 - 1987:2	0.28	0.00	1984:3
hsmw	0.18	.	. - .	0.71	.	. - .	0.00	1984:1	1983:3 - 1986:4	0.26	0.00	1984:1
hsne	0.00	1992:2	1992:1 - 1997:2	0.08	.	. - .	0.02	1986:1	1985:2 - 1989:4	0.02	0.20	.
hssou	0.15	.	. - .	0.02	1995:2	1994:4 - 1995:4	0.16	.	. - .	0.05	0.00	1983:1
hswst	0.01	1985:1	1983:2 - 1989:3	0.00	1991:1	1990:3 - 1991:3	0.00	1985:1	1984:3 - 1987:1	0.00	0.00	1966:2
ip	0.00	1984:1	1983:3 - 1988:4	0.01	1992:1	1991:3 - 1992:3	0.00	1983:3	1983:2 - 1985:3	0.00	0.00	1973:4
ipc	0.01	1983:3	1983:2 - 1989:3	0.36	.	. - .	0.00	1984:1	1983:3 - 1986:3	0.00	0.13	.
ipcd	0.06	.	. - .	0.76	.	. - .	0.02	1983:3	1983:1 - 1987:3	0.02	0.30	.
ipcn	0.23	.	. - .	0.00	1978:2	1977:4 - 1978:4	0.20	.	. - .	0.01	0.07	.
ipd	0.04	1984:1	1983:3 - 1992:1	0.04	1993:3	1993:1 - 1994:1	0.00	1984:1	1983:3 - 1987:1	0.65	0.04	1983:3
ipe	0.05	.	. - .	0.74	.	. - .	0.16	.	. - .	0.07	0.24	.
ipf	0.00	1984:2	1983:3 - 1988:3	0.56	.	. - .	0.00	1983:3	1983:1 - 1985:4	0.79	0.03	1983:3
ipi	0.58	.	. - .	0.92	.	. - .	0.00	1983:3	1982:3 - 1986:3	0.00	0.00	1973:3
ipm	0.00	1984:1	1983:4 - 1989:1	0.00	1993:3	1993:1 - 1994:1	0.00	1983:3	1983:1 - 1985:3	0.74	0.01	1983:3
ipmd	0.01	1984:1	1983:3 - 1989:4	0.10	.	. - .	0.00	1983:1	1982:4 - 1985:1	0.96	0.07	.
ipmfg	0.01	1984:1	1983:3 - 1989:3	0.02	1992:1	1991:3 - 1992:3	0.00	1984:1	1983:4 - 1986:1	0.00	0.01	1973:4
ipmin	0.01	1986:3	1986:2 - 1993:3	0.01	1982:2	1981:4 - 1982:4	0.10	.	. - .	0.03	0.08	.
ipmnd	0.60	.	. - .	0.01	1974:1	1973:3 - 1974:3	0.27	.	. - .	0.04	0.00	1974:3
ipn	0.28	.	. - .	0.00	1978:2	1977:4 - 1978:4	0.00	1983:3	1983:1 - 1986:4	0.00	0.00	1974:3
ipp	0.02	1984:1	1982:3 - 1989:1	0.01	1994:3	1994:1 - 1995:1	0.00	1983:3	1983:1 - 1985:4	0.00	0.00	1973:4
iput	0.00	1980:4	1977:2 - 1982:1	0.00	1972:4	1972:2 - 1973:2	0.00	1978:4	1973:4 - 1980:1	0.00	0.04	1990:2
ipxmca	0.00	1983:4	1983:3 - 1988:3	0.31	.	. - .	0.00	1983:1	1982:3 - 1985:2	0.00	0.08	.
ivmfdq	0.00	1993:1	1992:3 - 1997:1	0.02	1967:2	1966:4 - 1967:4	0.00	1967:2	1966:4 - 1969:1	0.00	0.06	.
ivmfgq	0.10	.	. - .	0.02	1975:1	1974:3 - 1975:3	0.43	.	. - .	0.15	0.20	.
ivmfnq	0.01	1985:3	1985:1 - 1992:1	0.03	1984:3	1984:1 - 1985:1	0.25	.	. - .	0.23	0.05	1985:3

ivmtq	0.33	.	. - .	0.24	.	. - .	0.74	.	. - .	0.35	0.49	.
ivrrq	0.01	1987:2	1986:3 - 1992:3	0.27	.	. - .	0.14	.	. - .	0.18	0.73	.
ivwrq	0.01	1984:4	1983:4 - 1989:2	0.21	.	. - .	0.00	1983:2	1982:2 - 1985:3	0.00	0.13	.
ivsrmq	0.05	1984:3	1984:2 - 1993:4	0.57	.	. - .	0.00	1983:4	1983:2 - 1986:3	0.08	0.00	1983:4
ivsrq	0.06	.	. - .	0.68	.	. - .	0.00	1983:4	1983:2 - 1986:3	0.00	0.00	1972:3
ivsrrq	0.89	.	. - .	0.23	.	. - .	0.42	.	. - .	0.21	0.09	.
ivsrwq	0.01	1984:4	1984:2 - 1990:4	0.69	.	. - .	0.00	1984:2	1983:2 - 1986:3	0.92	0.12	.
gvsq	0.28	.	. - .	0.09	.	. - .	0.53	.	. - .	0.16	0.29	.
gvdsq	0.00	1992:4	1992:3 - 1998:2	0.47	.	. - .	0.08	.	. - .	0.02	0.26	.
gvnsq	0.37	.	. - .	0.00	1974:3	1974:1 - 1975:1	0.08	.	. - .	0.02	0.00	1985:4
mdoq	0.03	1984:2	1983:4 - 1991:2	0.95	.	. - .	0.02	1984:2	1983:4 - 1988:2	0.18	0.00	1984:2
mocmq	0.01	1984:2	1983:3 - 1990:1	0.44	.	. - .	0.00	1983:3	1983:1 - 1986:2	0.12	0.00	1983:3
mpconq	0.07	.	. - .	0.04	1973:3	1973:1 - 1974:1	0.20	.	. - .	0.04	0.00	1966:3
msdq	0.05	1983:4	1983:3 - 1992:3	0.81	.	. - .	0.01	1983:4	1983:2 - 1987:2	0.17	0.00	1983:4
msmq	0.00	1983:4	1983:2 - 1987:1	0.75	.	. - .	0.00	1983:4	1983:2 - 1985:4	0.16	0.00	1983:4
msmtq	0.01	1984:1	1983:3 - 1990:2	0.30	.	. - .	0.00	1983:4	1983:2 - 1986:2	0.59	0.01	1983:4
msnq	0.02	1983:2	1983:1 - 1990:4	0.24	.	. - .	0.00	1983:2	1982:4 - 1985:4	0.09	0.00	1983:2
msondq	1.00	.	. - .	0.33	.	. - .	0.55	.	. - .	0.63	0.41	.
lhel	0.45	.	. - .	0.00	1995:2	1994:4 - 1995:4	0.00	1983:2	1982:4 - 1986:2	0.02	0.00	1983:2
lhelx	0.03	1984:2	1982:3 - 1989:2	0.08	.	. - .	0.00	1983:4	1983:1 - 1986:4	0.25	0.00	1983:4
lhem	0.28	.	. - .	0.43	.	. - .	0.00	1984:4	1983:4 - 1987:4	0.00	0.00	1974:3
lhnag	0.24	.	. - .	0.23	.	. - .	0.00	1984:4	1983:4 - 1987:3	0.00	0.00	1972:4
lhu14	0.00	1984:2	1983:4 - 1989:3	0.97	.	. - .	0.00	1982:2	1981:4 - 1985:1	0.00	0.46	.
lhu15	0.02	1984:3	1983:4 - 1990:2	0.00	1982:2	1981:4 - 1982:4	0.00	1977:2	1976:3 - 1980:2	0.92	0.27	.
lhu26	0.07	.	. - .	0.00	1983:3	1983:1 - 1984:1	0.00	1983:2	1982:1 - 1986:2	0.19	0.00	1982:1
lhu5	0.07	.	. - .	0.11	.	. - .	0.06	.	. - .	0.02	0.28	.
lhu680	0.03	1985:1	1983:2 - 1990:1	0.00	1994:2	1993:4 - 1994:4	0.16	.	. - .	0.99	0.72	.
lhur	0.25	.	. - .	0.50	.	. - .	0.01	1983:4	1983:2 - 1987:2	0.00	0.00	1972:4
lp	0.01	1984:4	1982:4 - 1988:2	0.01	1981:3	1981:1 - 1982:1	0.00	1982:1	1981:4 - 1984:1	0.00	0.01	1970:1
lpcc	0.38	.	. - .	0.01	1966:3	1966:1 - 1967:1	0.00	1984:1	1983:3 - 1986:3	0.00	0.00	1974:1
lped	0.00	1984:3	1983:1 - 1987:4	0.34	.	. - .	0.00	1983:3	1983:2 - 1985:4	0.00	0.06	.
lpem	0.00	1984:2	1983:3 - 1987:2	0.08	.	. - .	0.00	1983:1	1982:4 - 1984:4	0.00	0.00	1969:3
lpen	0.07	.	. - .	0.02	1995:1	1994:3 - 1995:3	0.00	1984:2	1983:4 - 1986:2	0.65	0.00	1984:2
lpfr	0.00	1966:4	1965:3 - 1967:1	0.00	1987:2	1986:4 - 1987:4	0.38	.	. - .	0.17	0.07	.
lpgd	0.00	1984:2	1983:2 - 1987:4	0.24	.	. - .	0.00	1982:1	1981:4 - 1984:1	0.00	0.00	1970:1
lpgov	1.00	.	. - .	0.49	.	. - .	0.79	.	. - .	0.43	0.37	.
lphrm	0.02	1983:4	1983:3 - 1990:4	0.04	1995:1	1994:3 - 1995:3	0.00	1983:3	1982:4 - 1986:4	0.00	0.02	1973:4
lpmosa	0.00	1984:1	1983:4 - 1988:3	0.61	.	. - .	0.00	1983:3	1983:1 - 1985:3	0.76	0.01	1983:3
lps	1.00	.	. - .	0.27	.	. - .	0.05	1978:2	1976:4 - 1982:4	0.00	0.00	1970:1
lpsp	1.00	.	. - .	0.41	.	. - .	0.17	.	. - .	0.03	0.26	.
lpt	0.04	1992:4	1991:3 - 1998:2	0.28	.	. - .	0.00	1991:1	1990:3 - 1993:2	0.00	0.00	1974:4
pmcp	0.04	1972:3	1967:3 - 1974:3	0.01	1980:4	1980:2 - 1981:2	0.16	.	. - .	0.45	0.12	.
pmdel	0.38	.	. - .	0.00	1994:4	1994:2 - 1995:2	0.00	1981:4	1981:3 - 1983:2	0.96	0.22	.
pmemp	0.17	.	. - .	0.01	1981:1	1980:3 - 1981:3	0.01	1983:1	1982:3 - 1986:3	0.02	0.73	.

pmi	0.10	.	. - .	0.00	1994:4	1994:2 - 1995:2	0.00	1984:4	1984:2 - 1987:4	0.72	0.06	.
pmno	0.17	.	. - .	0.00	1994:4	1994:2 - 1995:2	0.19	.	. - .	0.02	0.06	.
pmnv	0.02	1984:2	1983:3 - 1990:3	0.00	1979:3	1979:1 - 1980:1	0.00	1977:1	1976:3 - 1978:2	0.72	0.25	.
pmp	0.18	.	. - .	0.00	1994:4	1994:2 - 1995:2	0.07	.	. - .	0.00	0.00	1970:3
r_lehcc	0.00	1992:1	1991:2 - 1993:3	0.00	1973:1	1972:3 - 1973:3	0.41	.	. - .	0.19	0.10	.
lehcc	0.03	1991:2	1989:4 - 1996:2	0.05	1969:2	1968:4 - 1969:4	0.08	.	. - .	0.00	0.00	1972:1
r_lehm	0.03	1980:1	1978:2 - 1985:2	0.00	1972:1	1971:3 - 1972:3	0.00	1983:1	1981:3 - 1986:1	0.57	0.04	1983:1
lehm	0.02	1975:1	1974:4 - 1980:2	0.01	1974:2	1973:4 - 1974:4	0.02	1975:1	1974:3 - 1978:4	0.98	0.62	.
gdc	0.05	.	. - .	0.02	1973:2	1972:4 - 1973:4	0.03	1970:3	1965:4 - 1972:4	0.06	0.00	1970:3
punew	0.12	.	. - .	0.00	1966:1	1965:3 - 1966:3	0.01	1970:2	1960:1 - 1970:4	0.00	0.00	1991:2
puxf	0.10	.	. - .	0.00	1975:2	1974:4 - 1975:4	0.02	1991:2	1990:4 - 1994:3	0.03	0.00	1991:2
puxhs	0.23	.	. - .	0.08	.	. - .	0.01	1972:4	1960:1 - 1973:2	0.00	0.00	1991:3
puxm	0.09	.	. - .	0.00	1980:1	1979:3 - 1980:3	0.03	1991:2	1990:4 - 1994:4	0.08	0.00	1991:2
pw	0.27	.	. - .	0.01	1974:4	1974:2 - 1975:2	0.00	1972:4	1965:1 - 1973:4	0.24	0.00	1972:4
psccom	0.05	1972:4	1962:2 - 1973:1	0.21	.	. - .	0.04	1971:4	1962:1 - 1973:2	0.04	0.00	1971:4
r_psccom	0.03	1971:4	1962:4 - 1972:1	0.13	.	. - .	0.02	1971:4	1963:4 - 1973:2	0.00	0.00	1971:4
psm99q	0.04	1973:4	1964:2 - 1974:1	0.01	1974:4	1974:2 - 1975:2	0.11	.	. - .	0.10	0.00	1973:4
r_psm99q	0.05	1971:4	1961:1 - 1972:1	0.01	1974:1	1973:3 - 1974:3	0.23	.	. - .	0.04	0.00	1973:4
pu83	0.00	1972:2	1970:4 - 1972:3	0.00	1987:2	1986:4 - 1987:4	0.00	1972:2	1963:1 - 1972:3	0.00	0.04	1990:2
r_pu83	0.07	.	. - .	0.00	1968:3	1968:1 - 1969:1	0.00	1973:2	1969:2 - 1974:1	0.00	0.00	1990:1
pu84	0.05	1979:1	1970:1 - 1979:2	0.47	.	. - .	0.00	1978:2	1968:4 - 1979:2	0.00	0.00	1991:4
r_pu84	0.00	1970:3	1965:1 - 1970:4	0.03	1969:2	1968:4 - 1969:4	0.02	1973:2	1962:3 - 1974:2	0.00	0.13	.
pu85	0.05	.	. - .	0.55	.	. - .	0.00	1984:2	1984:1 - 1986:4	0.00	0.00	1966:2
r_pu85	0.00	1992:4	1992:3 - 1997:3	0.12	.	. - .	0.00	1983:2	1982:4 - 1985:4	0.00	0.00	1971:3
puc	0.04	1972:4	1962:3 - 1973:1	0.00	1972:3	1972:1 - 1973:1	0.02	1972:4	1962:4 - 1974:1	0.00	0.00	1992:1
r_puc	0.00	1972:4	1966:2 - 1973:1	0.00	1970:3	1970:1 - 1971:1	0.02	1972:4	1961:1 - 1973:4	0.02	0.07	.
pucd	0.11	.	. - .	0.00	1978:2	1977:4 - 1978:4	0.00	1991:1	1990:3 - 1993:3	0.00	0.00	1969:2
r_pucd	0.14	.	. - .	0.07	.	. - .	0.10	.	. - .	0.19	0.02	1985:3
pus	0.15	.	. - .	0.52	.	. - .	0.00	1983:4	1983:3 - 1987:1	0.00	0.00	1983:4
r_pus	0.01	1986:2	1986:1 - 1987:1	0.01	1980:2	1979:4 - 1980:4	0.00	1986:2	1986:1 - 1988:2	0.00	0.00	1983:3
pw561	0.00	1985:4	1984:4 - 1986:3	0.03	1974:1	1973:3 - 1974:3	0.00	1985:4	1980:4 - 1986:1	0.72	0.07	.
r_pw561	0.00	1985:4	1984:2 - 1986:3	0.00	1974:1	1973:3 - 1974:3	0.00	1985:4	1981:2 - 1986:1	0.73	0.06	.
pwfcsa	0.53	.	. - .	0.76	.	. - .	0.02	1972:4	1964:4 - 1974:2	0.17	0.00	1972:4
r_pwfcsa	0.10	.	. - .	0.41	.	. - .	0.02	1972:4	1964:1 - 1974:2	0.22	0.00	1972:4
pwfsa	0.41	.	. - .	0.88	.	. - .	0.02	1972:4	1965:2 - 1974:3	0.08	0.00	1972:4
r_pwfsa	0.11	.	. - .	0.64	.	. - .	0.02	1972:2	1967:1 - 1974:2	0.26	0.00	1972:2
rtnq	0.73	.	. - .	0.00	1973:4	1973:2 - 1974:2	0.12	.	. - .	0.10	0.71	.
wtdq	0.03	1984:2	1984:1 - 1992:2	0.81	.	. - .	0.00	1982:2	1981:2 - 1985:2	0.22	0.00	1982:2
wtnq	0.19	.	. - .	0.31	.	. - .	0.04	1986:3	1985:3 - 1990:3	0.01	0.07	.
wtq	0.01	1984:2	1984:1 - 1991:3	0.08	.	. - .	0.00	1982:3	1982:1 - 1985:1	0.00	0.02	1972:3
ipcan	0.00	1991:1	1990:4 - 1996:1	0.04	1974:1	1973:3 - 1974:3	0.07	.	. - .	0.83	0.19	.
ipfr	0.04	1980:4	1980:3 - 1988:2	0.03	1974:2	1973:4 - 1974:4	0.15	.	. - .	0.61	0.21	.
ipit	0.01	1983:3	1983:2 - 1990:3	0.00	1973:2	1972:4 - 1973:4	0.01	1983:3	1983:1 - 1987:1	0.00	0.00	1969:2
ipjp	0.24	.	. - .	0.00	1973:1	1972:3 - 1973:3	0.15	.	. - .	0.01	0.00	1976:2

ipoecd	0.05	1984:3	1983:3 - 1991:1	0.01	1972:2	1971:4 - 1972:4	0.00	1984:3	1984:1 - 1987:2	0.00	0.15	.
ipuk	0.10	.	. - .	0.00	1974:3	1974:1 - 1975:1	0.02	1985:3	1985:2 - 1989:2	0.00	0.00	1971:4
ipwg	0.32	.	. - .	0.27	.	. - .	0.30	.	. - .	0.98	0.96	.

Notes: The first column reports tests of the hypothesis that the variance of the series is constant, against the alternative of a single break. For the remaining columns, see the notes to Table 3. The break test methods are described in Appendix 1.

Figure 1: Annual Growth Rates in GDP

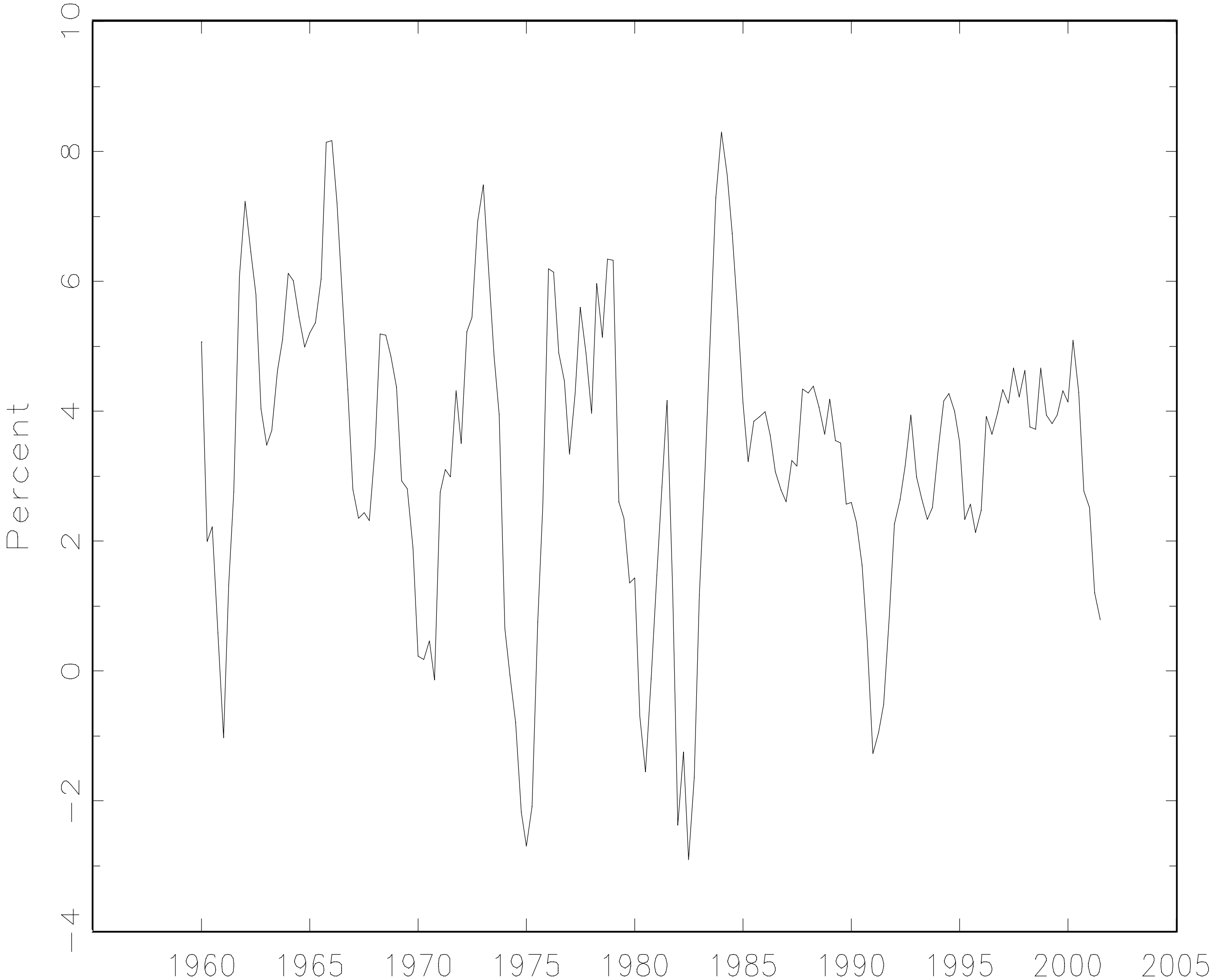


Figure 2. Time Varying Standard Deviations

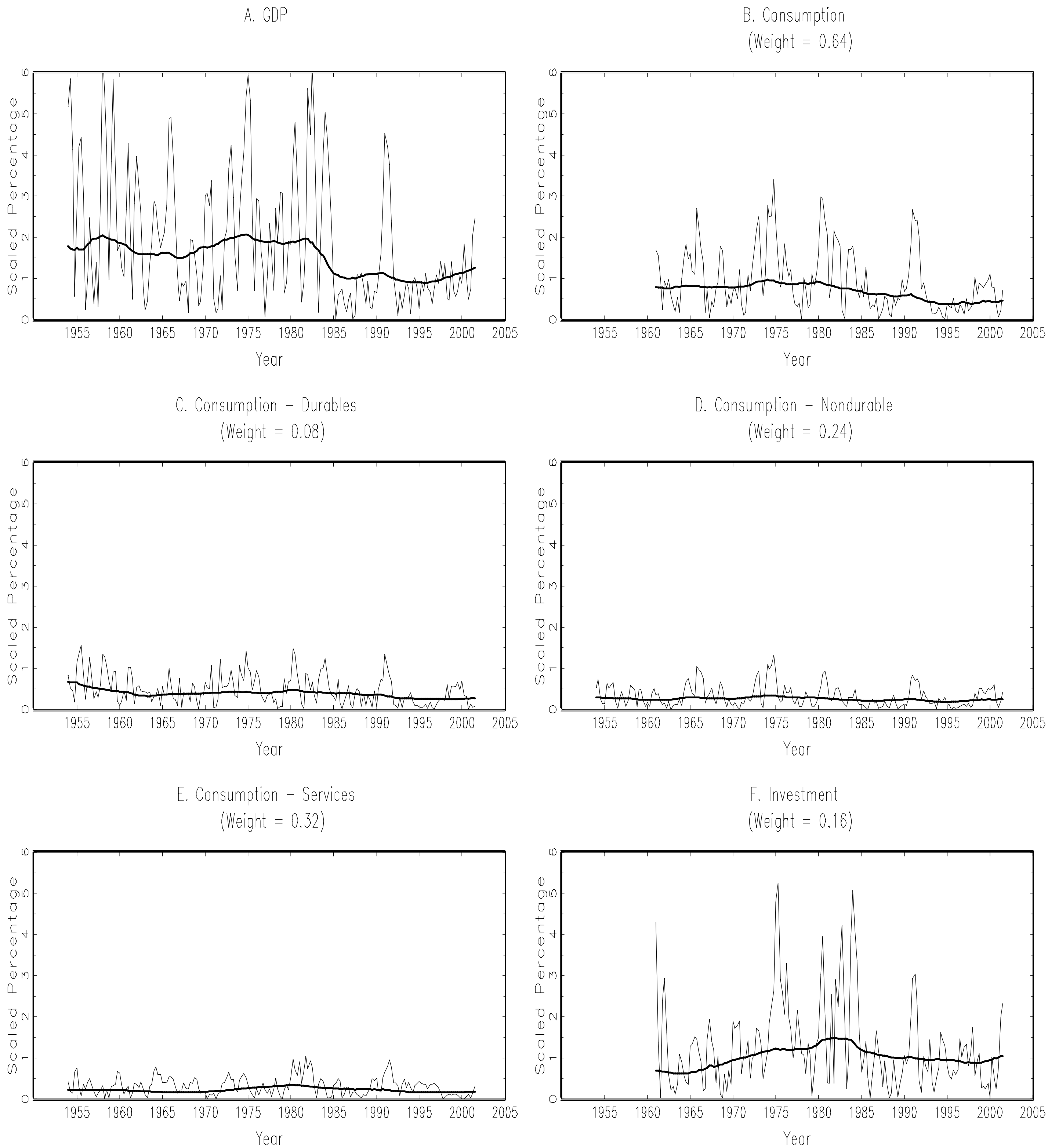
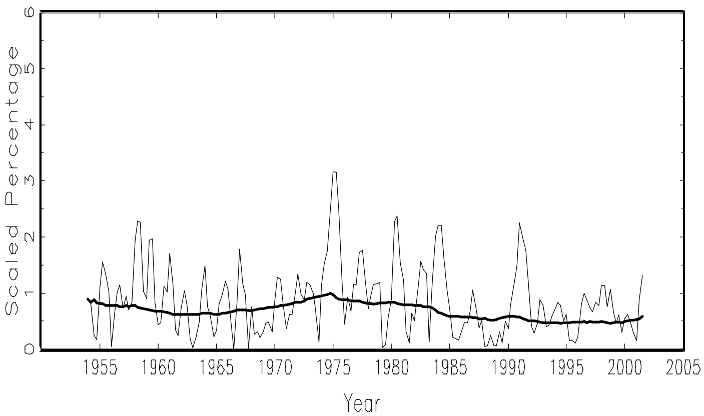
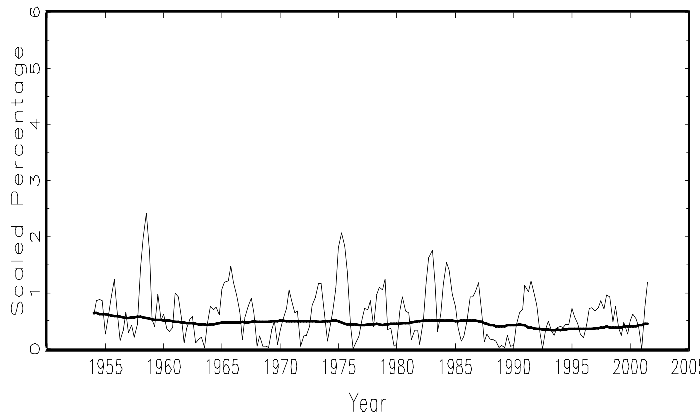


Figure 2. Time Varying Standard Deviations
(Continued)

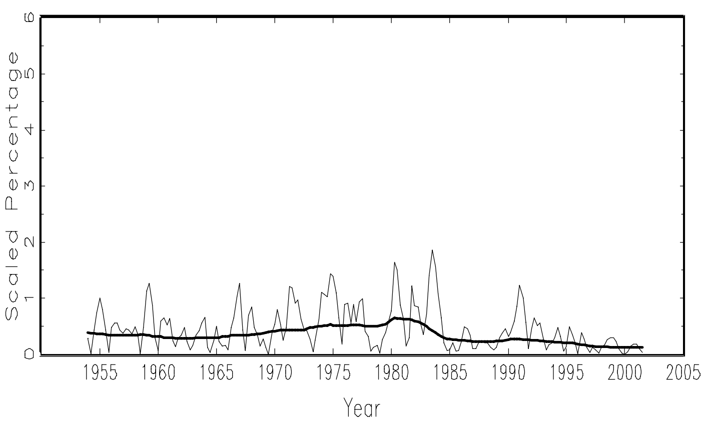
G. Fixed Investment – Total
(Weight = 0.16)



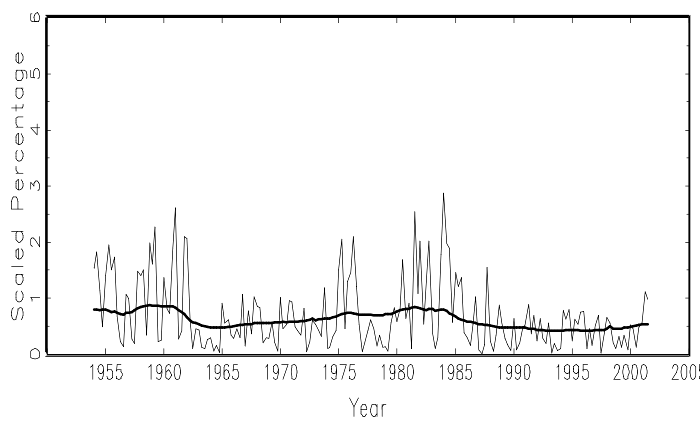
H. Fixed Investment – Nonresidential
(Weight = 0.11)



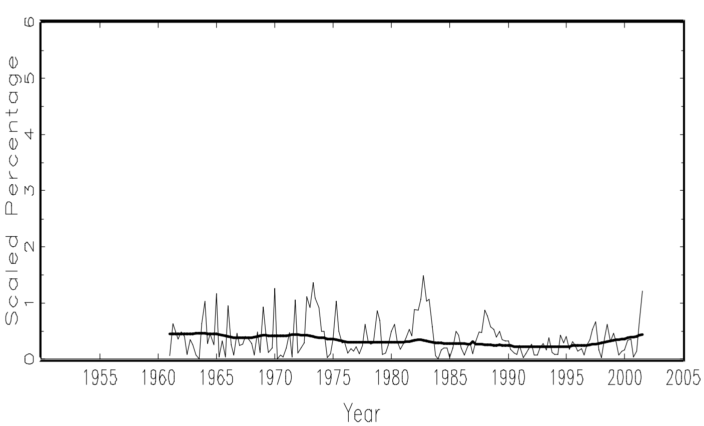
I. Fixed Investment – Residential
(Weight = 0.04)



J. Change in Inventory Investment/GDP



K. Exports
(Weight = 0.08)



L. Imports
(Weight = 0.09)

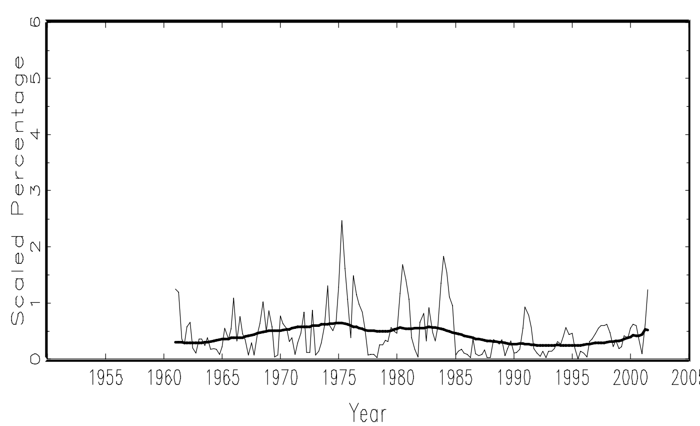
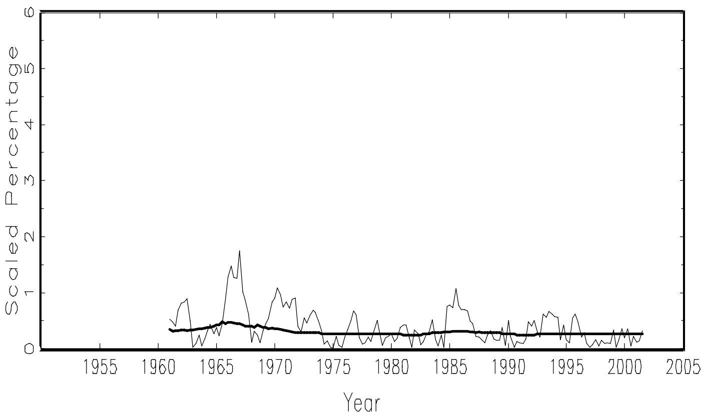
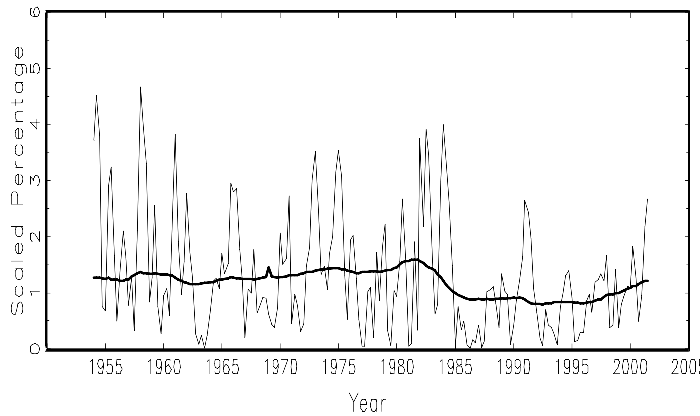


Figure 2. Time Varying Standard Deviations
(Continued)

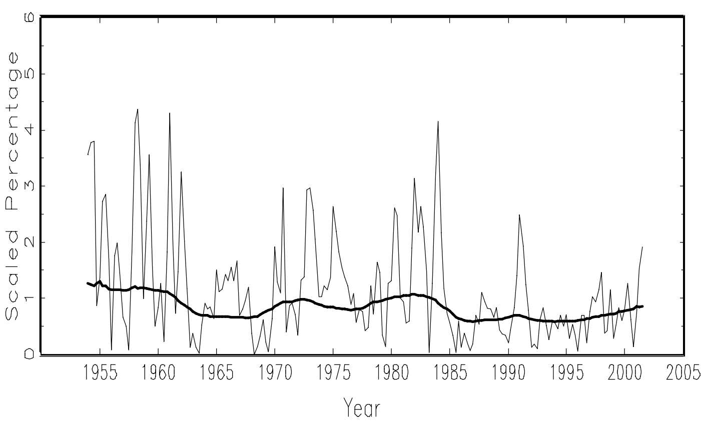
M. Government Spending
(Weight = 0.21)



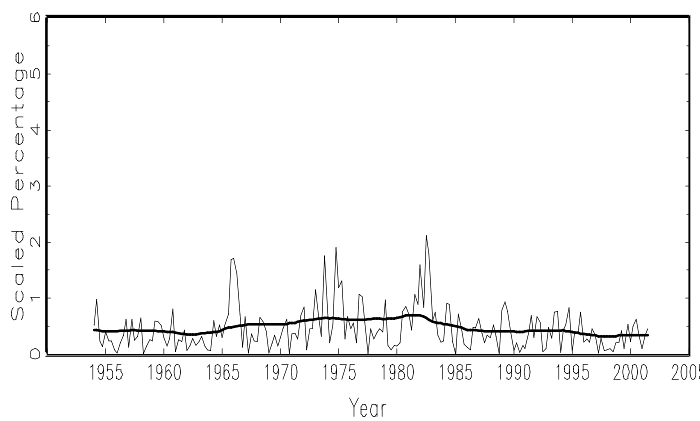
N. Goods Production - Total
(Weight = 0.42)



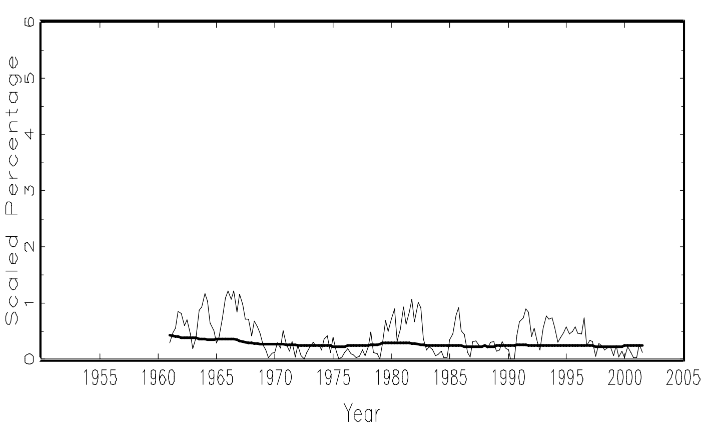
O. Goods Production - Durables
(Weight = 0.18)



P. Goods Production - Nondurables
(Weight = 0.24)



Q. Production - Services
(Weight = 0.47)



R. Production - Construction
(Weight = 0.10)

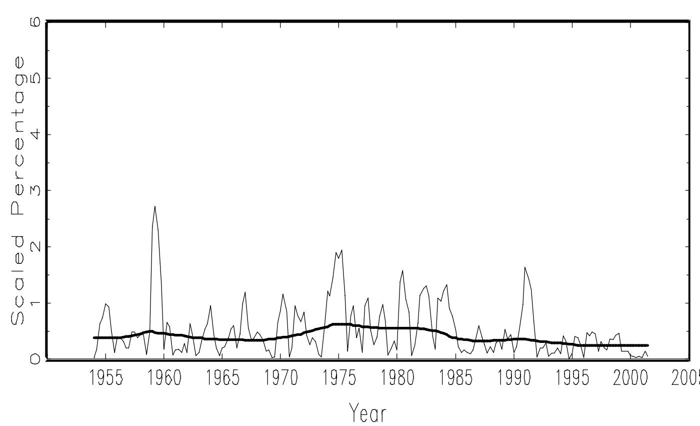
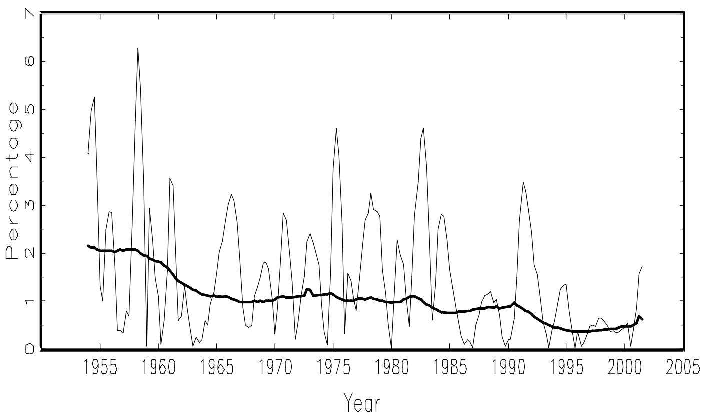
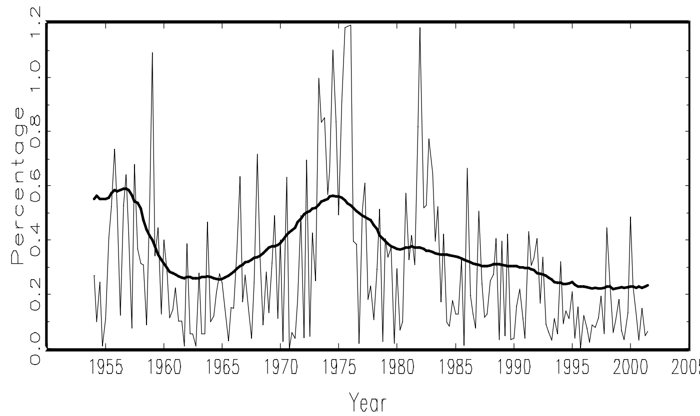


Figure 2. Time Varying Standard Deviations
(Continued)

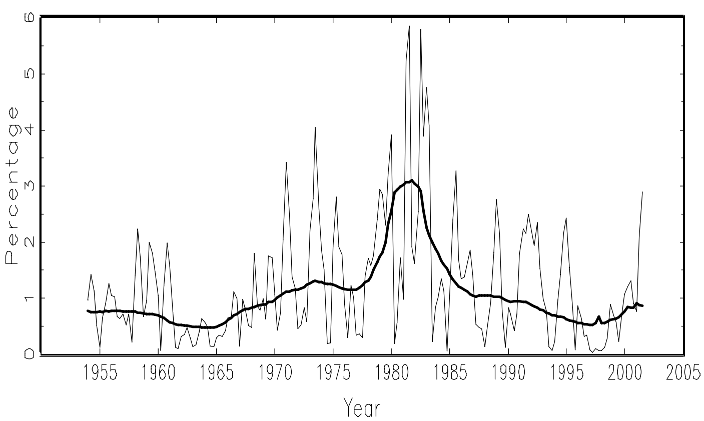
S. NonAgricultural Employment



T. Price Inflation (GDP Deflator)



U. 90-day T-bill Rate



V. 10-Year T-bond Rate

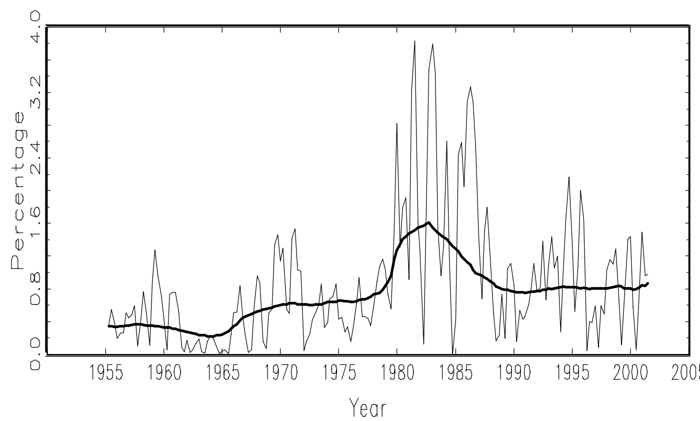


Figure 3. Durable Goods Production and Sales
Time Varying Standard Deviations

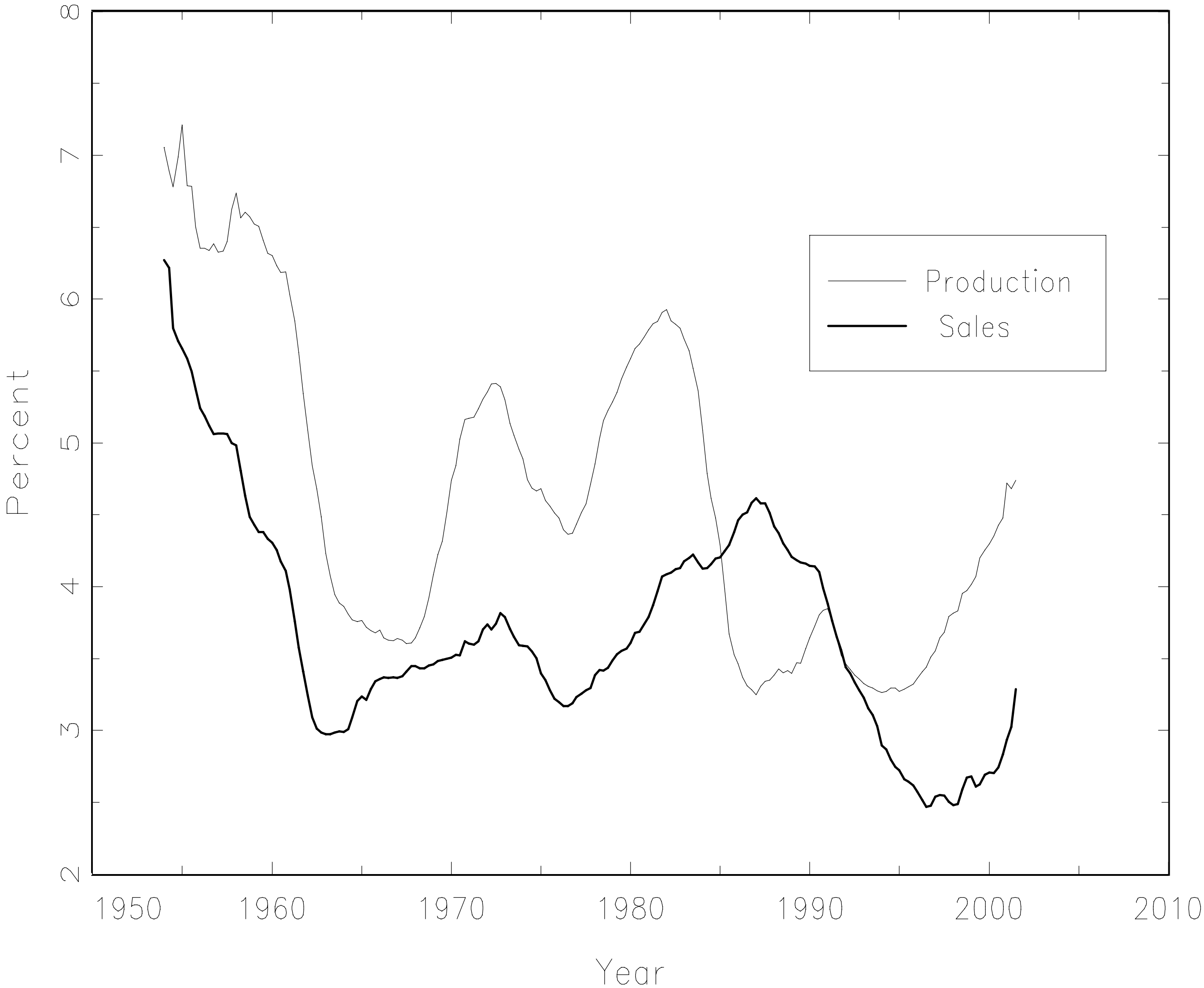


Figure 4. Time Varying Standard Deviations