ELSEVIER

Journal of Economics and Business 58 (2006) 392–406

Journal of Economics & Business

Why are postwar cycles smoother? Impulses or propagation?

Georgios Karras, Jin Man Lee, Houston Stokes *

Department of Economics (MC 144), University of Illinois at Chicago, 601 S. Morgan Street, Rm 2103, Chicago, IL 60607-7121, United States

Abstract

This paper asks whether the remarkable decrease in business-cycle variability after the end of World War II has been the result of a more stable structure (the propagation mechanism) or less volatile shocks (the impulses). Using data from the pre-World War I, interwar, and post-World War II periods, for the US, Australia, Italy, Sweden, and the UK, our evidence suggests that the reduced volatility is mostly the result of calmer shocks, and less the consequence of a more stable structure. In the US, for example, we calculate that milder shocks have been responsible for around 80% of the reduction in output variability between interwar and postwar periods, while a more stable structure is responsible for the remaining 20%.

JEL classification: C32; E32

Keywords: Business cycles; VAR models

1. Introduction

One of the biggest improvements in macroeconomic performance since the end of World War II has been the extraordinary decrease in business-cycle volatility, in comparison with both the interwar and pre-World War I periods (see Fig. 1 for a simple visual confirmation of this for the US). Indeed, Lucas (2003) has argued that in this sense macroeconomics "has succeeded." But why has the postwar business cycle been smoother in most of the economies examined? The goal of the present paper is to distinguish between two competing explanations: one that credits a supposedly more stable structure and one that holds responsible the shocks that originate in a less volatile environment.

Business-cycle variability has been the subject of intense study, and a sizable literature has investigated whether, and to what extent, postwar fluctuations have been milder than those of either

* Corresponding author.
E-mail addresses: gkarras@uic.edu (G. Karras), jmlee@uic.edu (J.M. Lee), hhstokes@uic.edu (H. Stokes).

0148-6195/$ – see front matter
doi:10.1016/j.jeconbus.2006.06.001

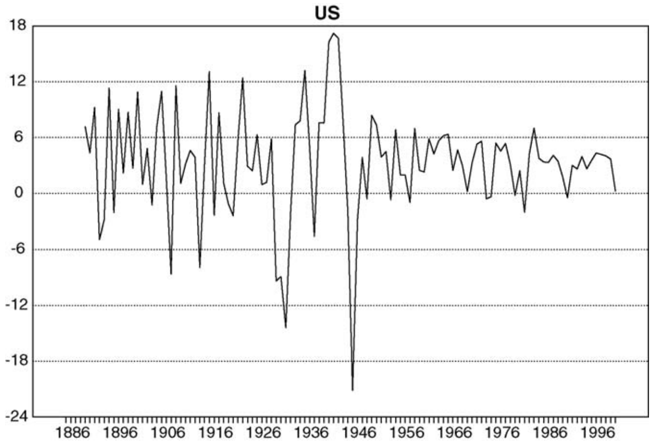

Fig. 1. Difference of log US real GDP.

the interwar period or the period before World War I. Much of the early work focused on the US and found that postwar cycles were much less severe than prewar ones (DeLong & Summers, 1986). This point of view was challenged by a number of skeptical studies which argued that the decrease in business-cycle severity had been grossly exaggerated and that the postwar experience was only marginally, if at all, milder. Romer (1989, 1991) was the most forceful proponent of this view for the US, but Sheffrin (1988) made similar arguments for a number of European countries. More recently, however, the consensus has once again consolidated behind the proposition that, for the majority of the countries for which historical data are available, the business cycle of the post-World War II period has been milder than that of the pre-World War I period, which in turn was less severe than the interwar period's (see Backus & Kehoe, 1992).[1]

While the question of whether, and how much, business-cycle volatility has changed over time is of great interest and will doubtless continue to be investigated, the present paper looks at business-cycle variability from a different perspective. Instead of focusing on the measurement of cyclical volatility, our goal is to shed some light on its causes. In particular, using an innovative technique developed by James (1993), extended by Simon (2001), and recently employed by Stock and Watson (2002, 2003), we will try to ascertain whether the decrease in postwar output volatility has been the result of a more stable structure (the propagation mechanism) or less violent shocks (the impulses).

Using real GDP data from the US, UK, Italy, Australia, and Sweden, our evidence suggests that the reduced volatility is more the result of calmer shocks, and less due to a more stable structure. We show that if the postwar structure had been combined with the prewar or interwar shocks, postwar cyclical activity would have been almost as volatile as during the prewar or interwar period. On the contrary, if either the prewar or interwar structures had been combined with the postwar shocks, prewar and interwar cycles would have been almost as calm as the postwar period actually was.

At the same time, there is evidence that the US postwar structure has been statistically significantly more stable than the structure of the previous two periods. Thus, combining either

[1] A related, and expanding, literature investigates whether the postwar business cycle has further moderated since the mid-1980s, and why. Stock and Watson (2003) survey this literature and provide a number of tests for the G7 countries.

the prewar or interwar shocks with the postwar structure would have (statistically significantly) reduced prewar and interwar variance, though not to postwar levels. We conclude that both US shocks and structure have improved in the postwar period, but that the shocks have contributed much more to the overall decrease in volatility.

Quantitatively, in the US we find that milder shocks are responsible for around 80% of the reduction in output variance between interwar and postwar periods, while a more stable structure is responsible for the remaining 20%. Interestingly, in each of the other four economies examined, the contribution of the structure is negative, so that the shocks account for more than 100% of the decreased output volatility.

The rest of the paper is organized as follows. Section 2 discusses the econometric methodology and the sources of the data used in the estimation. Section 3 presents the empirical results and implements a number of robustness checks. Section 4 discusses the findings and some policy implications, and concludes.

2. Methodology and data sources

We begin this section with a brief description of the "counterfactual VAR" method of James (1993), Simon (2001), and Stock and Watson (2002). We start by estimating reduced-form VARs for several countries for the three periods of interest.[2] *Prewar*, the period before World War I, is up to 1914. The starting point of this period varies by country as it depends on the availability of historical data. The second period, *interwar*, includes 1918–1939, the period between the two world wars. Third, *postwar*, the period since the end of World War II, covers 1945–2000. The economies examined are the United States, the United Kingdom, Italy, Australia, and Sweden. Fig. 1, a graph of the annual growth rate of real GDP in the US, shows how apparent are the differences in business-cycle variability among the three periods. Fig. 2 paints a similar picture for the other four countries.

Suppose the VARs can be written as

$$x_t = A_i(L)x_{t-1} + u_t \tag{1}$$

where x is the vector of the k variables included in the VAR ($k \geq 1$), i is indexing over the three time periods ($i = 1, 2, 3$), the As are matrices of polynomials in the lag operator L, and u is the error term with variance Σ_i in period i.

Next, define $B_i(L) = [I - A_i(L)L]^{-1}$, and let B_{ij} be the jth lag of B_i. Then, the variance of the kth series of x in the ith period is given by

$$var(x_{kt}) = \left(\sum_{j=0}^{\infty} B_{ij}\Sigma_i B'_{ij}\right)_{kk} = \sigma_k(A_i, \Sigma_i)^2. \tag{2}$$

As Stock and Watson (2002) point out, the terms in (2) can be evaluated for different *A*s and *G*s, making it possible to compute "counterfactual" values for the variances, i.e., values that would have been the result of different combinations of *A*s and *G*s than the ones actually observed.

[2] We are not pursuing a structural VAR approach in this paper because our interest is not to identify specific shocks but the contribution of shocks as a whole. The cost of the reduced-form approach is that it does not enable us to tell whether the individual shocks are 'fiscal', 'monetary', 'supply-side', etc. – but the benefit is that our findings are not sensitive to any particular structural identification assumptions.

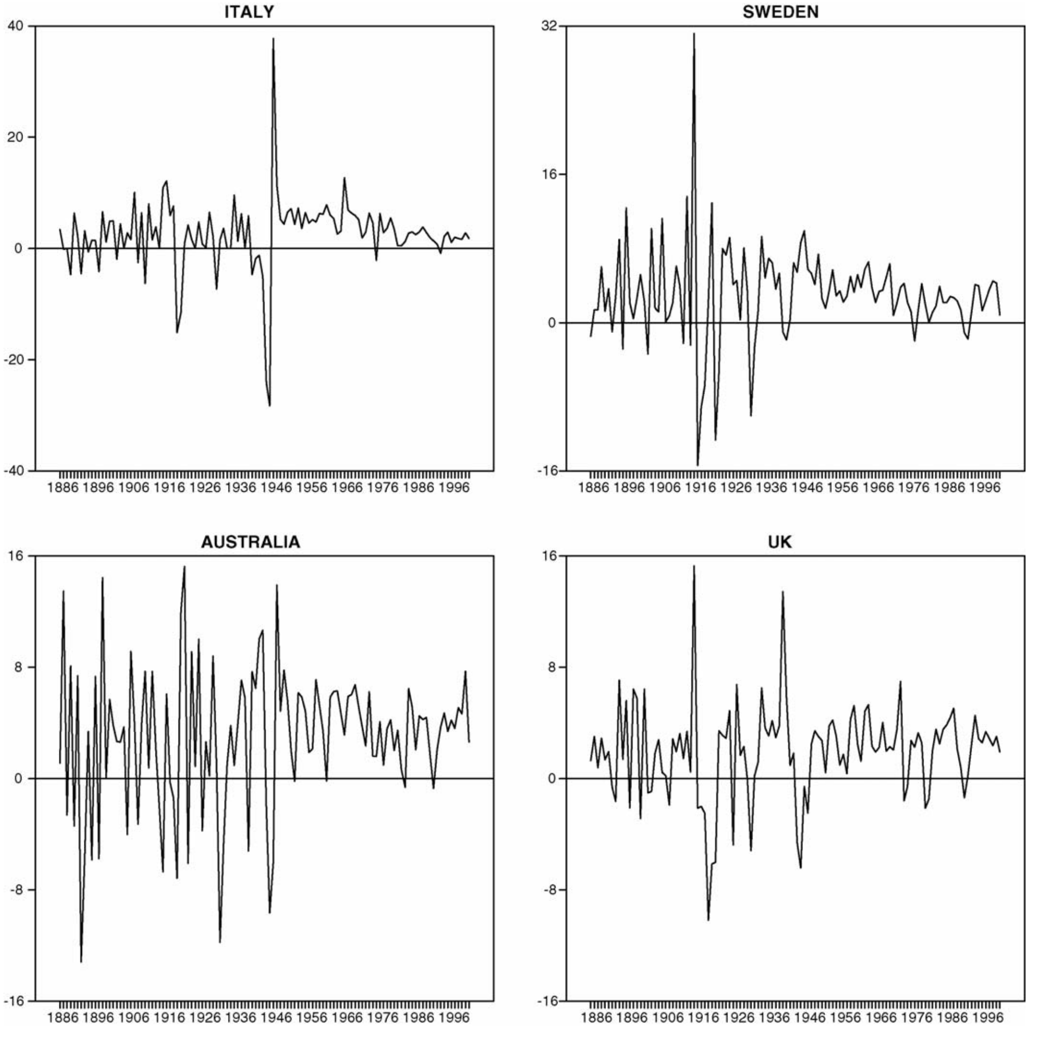

Fig. 2. Difference of log real GDP.

To illustrate, assume that the growth rate of real GDP is the first variable in the VAR ($k = 1$). We will use $\sigma_{11} = \sigma_1(A_1, \Sigma_1)$ and $\sigma_{33} = \sigma_1(A_3, \Sigma_3)$, for example, to denote the "factual" variances of the growth rate in the prewar and postwar periods, respectively. But Eq. (2) can also be used to estimate $\sigma_{13} = \sigma_1(A_1, \Sigma_3)$ as the "counterfactual" variance that would have obtained if the structure of the prewar period had been combined with the shocks of the postwar period. Similarly, $\sigma_{31} = \sigma_1(A_3, \Sigma_1)$ can be computed as another "counterfactual" variance, the one that would have occurred under the structure of the postwar period combined with the shocks of the prewar period. Comparing the variances will reveal how much of the increased variability is due to a change in the structure and how much is due to the shocks.

We are also interested in several of the differences between pairs of these variances and we develop a method to evaluate their statistical significance. For example, testing whether $|\sigma_{11} - \sigma_{21}| = 0$, is equivalent to testing whether $\sigma_{11} = \sigma_1(A_1, \Sigma_1)$ is equal to $\sigma_{21} = \sigma_1(A_2, \Sigma_1)$; or, in other words, whether the change in the structure that occurred between the prewar and interwar periods had a statistically significant effect on the variability of real GDP. Similarly, testing whether amounts to testing whether $\sigma_{11} = \sigma_1(A_1, \Sigma_2)$ are equal; or, in other words, whether the change in the shocks which took place between the prewar and interwar periods had a statistically significant effect on the output volatility. Similar tests can compare the prewar and postwar periods, as well as the interwar to the postwar period.

Since the distribution of these statistics is unknown, both bootstrapping and Monte Carlo methods are used to obtain critical values. The original implementation of the bootstrapping algorithm to time-dependent data assumed errors that are independent and identically distributed (Effron, 1979). However, if heteroskedasticity or serial correlation exist, the randomly generated resampled data set will not preserve these properties, which will lead to inconsistent estimators. One of the proposed remedies is to use the parametric method of bootstrapping, which has been extended by Stine (1987) to an AR(p) model and by Runkle (1987) to VAR(p) model. This methodology has been applied by Inoue and Kilian (2002) to generate the confidence intervals of VAR(∞) parameters. Our work, using their methods, takes the following steps. First, an AR or VAR process of order p,

$$x_t = \beta_0 + \beta_1 x_{t-1} + \ldots + \beta_p x_{t-p} + \varepsilon_{p,t}$$

is estimated with least squares (LS) to obtain the LS estimate $\hat{\beta}(p) = (\hat{\beta}_0, \hat{\beta}_1, \ldots \hat{\beta}_p)$. p is selected to remove autocorrelation and cross-correlation of the residuals. Second, including k initial observations $T+k+p$ bootstrap innovations ε_t^* where $T=p+1, \ldots, t$ are generated by random sampling with replacement from the regression residuals. Third, we generate a sequence of pseudo-data of length $T+k+p$ from the recursion $x_t^* = \hat{\beta}_0 + \hat{\beta}_1 x_{t-1}^* + \ldots + \hat{\beta}_p x_{1-p}^* + \varepsilon_{tt}^*$ using the vector of the initial observations $x_0^* = (x_1^*, \ldots, x_p^*)$ as starting values to preserve the scale of x_t. Fourth, factual and counterfactual variances of x_t^* were calculated after removing k initial observations. The second, third, and fourth steps are repeated for the desired number of iterations in order to build the empirical distribution of the statistics.

Following Kilian (1997), we have used $p=12$ to avoid the consequences of bootstrapping an under-parameterized model. We report the critical values based on 1000 iterations.[3] The Monte Carlo critical values are obtained using similar steps, except that the residual on the second step is replaced by $T+k+p$ independent and identically distributed random innovations μ_{t+k+P} adjusted to the same variances of the estimated residuals from the first step. An advantage of the Monte Carlo method is that the disturbance is free of serial correlation and heteroskedasticity.

All data are annual and are obtained from Liesner (1990) and the IMFs International Financial Statistics. Our strategy has been to use Liesner for the historical data and update using the IFS. The series cover the periods 1886–1914 (prewar, with the exception of the US for which it is 1890–1914), 1920–1939 (interwar), and 1950–2001 (postwar).

3. Empirical evidence

3.1. A simple model for the US

We begin by estimating the simplest model possible: a univariate version of Eq. (1) for the log-difference of the US real GDP. Panel A of Table 1 reports the factual and counterfactual estimated

[3] Hundred initial observations have been generated to obtain stable model.

Table 1
US

Actual		
Prewar	Interwar	Postwar
$\sigma_1^2 = 33.59$	$\sigma_2^2 = 51.74$	$\sigma_3^2 = 5.14$

A. Univariate model

Factual		
$\sigma_{11} = \sigma_1(\mathrm{A}_1, \Sigma_1)$	$\sigma_{22} = \sigma_1(\mathrm{A}_2, \Sigma_2)$	$\sigma_{33} = \sigma_1(\mathrm{A}_3, \Sigma_3)$
33.48	52.06	5.13

Counterfactual					
$\sigma_{12} = \sigma_1(A_1, \Sigma_2)$	$\sigma_{13} = \sigma_1(A_1, \Sigma_3)$	$\sigma_{21} = \sigma_1(A_2, \Sigma_1)$	$\sigma_{23} = \sigma_1(A_2, \Sigma_3)$	$\sigma_{31} = \sigma_1(A_3, \Sigma_1)$	$\sigma_{32} = \sigma_1(A_3, \Sigma_2)$
49.52	5.98	36.26	6.29	29.61	42.52

Differences of Counterfactual Variances by structure ($\lvert\sigma_{ii} - \sigma_{ji}\rvert$)					
$\lvert\sigma_{11} - \sigma_{21}\rvert$	$\lvert\sigma_{11} - \sigma_{31}\rvert$	$\lvert\sigma_{22} - \sigma_{12}\rvert$	$\lvert\sigma_{22} - \sigma_{32}\rvert$	$\lvert\sigma_{33} - \sigma_{13}\rvert$	$\lvert\sigma_{33} - \sigma_{23}\rvert$
1.77	4.87**	2.55	9.54**	0.84	1.15

Differences of Counterfactual Variances by shock ($\lvert\sigma_{ii} - \sigma_{ij}\rvert$)					
$\lvert\sigma_{11} - \sigma_{12}\rvert$	$\lvert\sigma_{11} - \sigma_{13}\rvert$	$\lvert\sigma_{22} - \sigma_{21}\rvert$	$\lvert\sigma_{22} - \sigma_{23}\rvert$	$\lvert\sigma_{33} - \sigma_{31}\rvert$	$\lvert\sigma_{33} - \sigma_{32}\rvert$
15.03	28.50**	15.81	45.78**	24.48**	37.39**

B. Multivariate VAR Model

Factual		
$\sigma_{11} = \sigma_1(A_1, \Sigma_1)$	$\sigma_{22} = \sigma_1(A_2, \Sigma_2)$	$\sigma_{33} = \sigma_1(A_3, \Sigma_3)$
36.03	51.37	5.13

Counterfactual					
$\sigma_{12} = \sigma_1(A_1, \Sigma_2)$	$\sigma_{13} = \sigma_1(A_1, \Sigma_3)$	$\sigma_{21} = \sigma_1(A_2, \Sigma_1)$	$\sigma_{23} = \sigma_1(A_2, \Sigma_3)$	$\sigma_{31} = \sigma_1(A_3, \Sigma_1)$	$\sigma_{32} = \sigma_1(A_3, \Sigma_2)$
50.08	10.76	32.93	6.60	27.35	41.78

Differences of Counterfactual Variances by structure ($\lvert\sigma_{ii} - \sigma_{ji}\rvert$)					
$\lvert\sigma_{11} - \sigma_{21}\rvert$	$\lvert\sigma_{11} - \sigma_{31}\rvert$	$\lvert\sigma_{22} - \sigma_{12}\rvert$	$\lvert\sigma_{22} - \sigma_{32}\rvert$	$\lvert\sigma_{33} - \sigma_{13}\rvert$	$\lvert\sigma_{33} - \sigma_{23}\rvert$
3.10	8.68**	1.28	9.59**	5.63	1.47

Differences of Counterfactual Variances by shock ($\lvert\sigma_{ii} - \sigma_{ij}\rvert$)					
$\lvert\sigma_{11} - \sigma_{12}\rvert$	$\lvert\sigma_{11} - \sigma_{13}\rvert$	$\lvert\sigma_{22} - \sigma_{21}\rvert$	$\lvert\sigma_{22} - \sigma_{23}\rvert$	$\lvert\sigma_{33} - \sigma_{31}\rvert$	$\lvert\sigma_{33} - \sigma_{32}\rvert$
14.05	25.27**	18.44	44.76**	22.22**	36.64**

Notes: Prewar period is 1890-1914, interwar period is 1920-1939, and postwar period is 1950-2001. (**) and (*) denote statistical significance at the 5% and 10% significance levels using Bootstrap and Monte Carlo critical values from 1000 replications.

variances for the three periods using a lag length of one. Focusing on the factual variances first, Table 1 makes it clear that interwar volatility ($\sigma_{22} = 52.06$) is clearly the highest. In fact it is 50% larger than the prewar variance ($\sigma_{11} = 34.48$) and 10 times higher than postwar volatility ($\sigma_{33} = 5.13$). This is impressive but not entirely surprising given the evidence of Fig. 1. Table 1 also indicates that these estimated factual variances are virtually identical to the actual sample variances, $\sigma_1^2 = 33.59$, $\sigma_2^2 = 51.74$, and $\sigma_3^2 = 5.14$.

Proceeding to the counterfactual estimates, σ_{12}, the variance that would have obtained if the prewar structure had been combined with the interwar shocks, equals 49.52, and thus is very similar in magnitude with σ_{22} and σ_2^2. Also, σ_{21}, the variance that would have resulted from the combination of interwar structure and prewar shocks, equals 36.26, and so it is closer to σ_{11} and σ_1^2. It is therefore clear that the interwar period's higher volatility (relative to the prewar period) is the result of more violent shocks, rather than a less stable structure. In time-series terminology, the estimates show that the main reason behind the increase in volatility between the prewar and interwar periods were the impulses and not the propagation mechanism.

Moving on to a comparison of the interwar and postwar periods, σ_{23}, the variance that would have obtained if the interwar structure had been combined with the postwar shocks, equals 6.29, very similar with σ_{33} and σ_3^2. At the same time, σ_{32}, the variance that would have resulted from the combination of postwar structure and interwar shocks, equals 42.52, and so it is closer to (though less than – see below) σ_{22} and σ_2^2. Again, the postwar period's lower volatility (relative to the interwar period) is shown to be mostly (though not entirely) the result of milder shocks, and less of a more stable structure. Once more, the main reason behind the decrease in volatility between the postwar and interwar periods were the impulses and not the propagation mechanism.

Finally, we can compare the prewar and postwar periods. σ_{13}, the variance that would have obtained if the prewar structure had been combined with the postwar shocks, equals 5.98 (very similar with σ_{33} and σ_3^2), while σ_{31}, the variance that combines postwar structure and prewar shocks, is 29.61 (and so closer to σ_{11} and σ_1^2). Just like for the previous two cases, these estimates show that the main reason behind the increase in volatility between the prewar and postwar periods were the impulses (more volatile shocks) and not the propagation mechanism (a less stable structure).

Panel A of Table 1 also reports the absolute values of the differences between pairs of the variances, together with critical values that have been calculated using bootstrapping and Monte Carlo techniques. Note that $|\sigma_{ii} - \sigma_{ji}|$ computes the difference in counterfactual variances holding the shocks constant, while $|\sigma_{ii} - \sigma_{ji}|$ holds constant the structure. Note, for example, that $|\sigma_{33} - \sigma_{23}|$ is quite small (1.51) and statistically insignificant. This suggests that changing the model's structure from interwar to postwar while keeping the same postwar shocks would have no significant effect on output variability. On the other hand, $|\sigma_{33} - \sigma_{32}|$ is both large (37.39) and decisively statistically significant. This means that changing the shocks between interwar and postwar periods while keeping the same postwar structure would make a big difference for volatility.

Similarly, $|\sigma_{33} - \sigma_{13}|$ is very small (0.84) and also statistically insignificant, implying that alternating between prewar and postwar structure while keeping the same postwar shocks would have virtually no effect on output variability. On the contrary, $|\sigma_{33} - \sigma_{31}|$ is both large (24.48) and statistically significant, meaning that changing the shocks between prewar and postwar periods while keeping the same postwar structure would again have a big effect on volatility.

In general, the estimated $|\sigma_{ii} - \sigma_{ji}|$s are small and (with two exceptions) statistically insignificant. This implies that, in most cases, changes in the structure are not responsible for the observed changes in output volatility. The two exceptions are $|\sigma_{11} - \sigma_{31}|$ and $|\sigma_{22} - \sigma_{32}|$ which, though not very large, are statistically significant, indicating a small role for structure changes in these two cases.

On the contrary, the estimated $|\sigma_{ii} - \sigma_{ji}|$s are large and (again with two exceptions, $|\sigma_{11} - \sigma_{12}|$ and $|\sigma_{22} - \sigma_{21}|$ statistically significant. This means that, in most cases, changes in the shocks are responsible for most of the observed changes in output volatility.

To get a sense of the magnitudes involved, let us focus on the comparison between the interwar and postwar periods. The difference between the two periods' estimated output volatilities is $\sigma_{22} - \sigma_{33} = 52.06 - 5.13 = 46.93$. Considering that $\sigma_{32} = 42.52$, we conclude that the shocks are responsible for around 80% of the decreased volatility ($|\sigma_{33} - \sigma_{32}|/|\sigma_{33} - \sigma_{22}|$=37.39/46.93 = 0.797), while the structure is responsible for the remaining 20% ($|\sigma_{22} - \sigma_{32}|/|\sigma_{33} - \sigma_{22}| = 9.54/46.93 = 0.203$).

3.2. A multivariate model for the US

In this section, we expand the estimated system to a multivariate VAR that includes two additional variables that are predicted by economic theory to influence aggregate output: the growth rate of the M1 money supply, capturing monetary policy, and government purchases, capturing fiscal policy. The goal is to make sure that, in using the univariate model of the previous section, we are not minimizing the importance of structural stability and/or assigning an excessively large role to the impulses because of the omission of relevant variables.

Panel B of Table 1 reports the multivariate results for the US model. The lag length is again set equal to one. The most intriguing feature of Panel B is its similarity with Panel A. Thus, σ_{22} is 51.37, still 50% higher than σ_{11} which equals 36.03 and 10 times higher than σ_{33} which is 5.13.

Unsurprisingly, the counterfactual variances tell the same story. For example, σ_{12}, the variance that would have obtained if the prewar structure had been combined with the interwar shocks, equals 50.08, and is very similar in magnitude with σ_{22} and σ_2^2. Also, σ_{21}, the variance that would have resulted from the combination of interwar structure and prewar shocks, equals 32.93, and so it is closer to σ_{11} and σ_2^2. Comparing the interwar and postwar periods, σ_{23}, the variance that would have obtained if the interwar structure had been combined with the postwar shocks, equals 6.60, very similar with σ_{33} and σ_3^2. At the same time, σ_{32}, the variance that would have resulted from the combination of postwar structure and interwar shocks, equals 41.78, and so it is closer to σ_{22} and of. Finally, focusing on a comparison of the prewar and postwar periods, σ_{13}, the variance that would have obtained if the prewar structure had been combined with the postwar shocks, equals 10.76 (closer to σ_{33} and σ_3^2), while σ_{31}, the variance that combines postwar structure and prewar shocks, is 27.35 (and so closer to σ_{11} and σ_1^2). Overall, as in the last section, differences in volatility between any two periods are shown to be mostly (but not entirely) the result of different shocks, and less of a change in structure.

The variance differences in Panel B are equally more supportive of the idea that impulses, much more than propagation, are responsible for changes in output volatility. In particular, the estimated $|\sigma_{ii} - \sigma_{ji}|$s are smaller and less statistically significant than the estimated $|\sigma_{ii} - \sigma_{ij}|$s, suggesting again that changes in the structure are less responsible than the shocks for the observed changes in output volatility.

As a numerical example along the lines of the last section, let us compare again the interwar and postwar periods. The difference between the two periods' estimated output volatilities is now $\sigma_{22} - \sigma_{33} = 51.37 - 5.13 = 46.24$. Considering that now $\sigma_{32} = 41.78$, we find that the shocks are once more responsible for around 80% of the reduction in volatility ($|\sigma_{33} - \sigma_{32}|/|\sigma_{33} - \sigma_{22}| = 36.64/46.24 = 0.792$), while the structure is again responsible for the remaining 20% ($|\sigma_{22} - \sigma_{32}|/|\sigma_{33} - \sigma_{22}| = 9.59/46.24 = 0.207$).

It follows that adding the two monetary and fiscal variables to the estimated VARs does not alter our finding that the shocks account for most of the difference in output volatility, leaving little of the responsibility to changes in the structure.

3.3. Four other economies

As a second robustness check, we have considered data from four other economies with sufficiently long data series: the UK, Italy, Australia, and Sweden.[4] Table 2 presents our variance estimates for these four countries based on bivariate VARs that include the growth rate of real GDP and government purchases. Univariate and several other multivariate models were also estimated for these countries, but, as their results are similar to those of the (output, government) bivariate ones, we do not report them to preserve space.

Panel A of Table 2 looks at the UK estimates. Just like for the US, UK interwar volatility ($\sigma_{22} = 9.94$) is the highest, being almost 20% higher than the prewar variance ($\sigma_{11} = 8.10$) and about three times as high as postwar volatility ($\sigma_{33} = 3.43$).

An even more exaggerated situation describes Australia and Sweden (panels C and D of Table 2). In Australia, interwar volatility ($\sigma_{22} = 47.81$) is almost three times as large as the prewar period's ($\sigma_{11} = 16.08$) and more than 10 times higher than postwar volatility ($\sigma_{33} = 4.37$), while in Sweden, interwar volatility ($\sigma_{22} = 37.44$) is almost twice as high as the prewar period's ($\sigma_{11} = 20.64$) and again more than 10 times larger than postwar volatility ($\sigma_{33} = 3.34$).

Italy (panel B of Table 2) is somewhat different in that its interwar output volatility is actually lower than the prewar: $\sigma_{11} = 16.13$ and $\sigma_{22} = 12.38$. Even for Italy, however, postwar fluctuations are much smoother. In particular, postwar volatility in Italy ($\sigma_{33} = 6.76$) equals about (less than) one half of the interwar (prewar) value. Note that for all four countries, the estimated factual variances are again very close to the actual sample variances, giving us confidence in the estimated models.

With respect to the counterfactual estimates, comparing the interwar and postwar periods, σ_{23}, the variance that would have obtained if the interwar structure had been combined with the postwar shocks, equals 3.28 in the UK, 5.65 in Italy, 5.59 in Australia, and 2.36 in Sweden, thus being very similar with σ_{33} and σ_3^2 in all cases. At the same time, σ_{32}, the variance that would have resulted from the combination of postwar structure and interwar shocks, equals 9.82 in the UK, 14.88 in Italy, 40.80 in Australia, and 42.25 in Sweden, and so it is closer to σ_{22} and σ_2^2. Once more, the postwar period's lower volatility (relative to the interwar period) is shown to be mostly the result of milder shocks, and less the consequence of a more stable structure. In time series terminology, the main reason behind the decrease in volatility between the postwar and interwar periods appears to be the impulses and not the propagation mechanism.

We can also compare the prewar and postwar periods. σ_{13}, the variance that would have obtained if the prewar structure had been combined with the postwar shocks, equals 4.17 in the UK, 8.04 in Italy, 4.95 in Australia, and 5.01 in Sweden (very similar with the σ_{33} and σ_3^2 values), while σ_{31}, the variance that combines postwar structure and prewar shocks, is 6.68 in the UK, 13.71 in Italy, 13.90 in Australia, and 15.22 in Sweden (and so closer to σ_{11} and σ_1^2). Just like before, these estimates indicate that the main reason behind the increase in volatility between the prewar and postwar periods were the impulses (more volatile shocks) and not the propagation mechanism (a less stable structure).

The four panels of Table 2 also report the absolute values of the differences between pairs of the variances, together with critical values that have been calculated using bootstrapping and

[4] Country selection has been dictated only by data availability.

Table 2
Four other countries

A. UK VAR with government expenditure

Actual

Prewar	Interwar	Postwar
$\sigma_1^2 = 7.21$	$\sigma_2^2 = 12.55$	$\sigma_3^2 = 3.43$

Factual

$\sigma_{11}=\sigma_1(A_1, \Sigma_1)$	$\sigma_{22}=\sigma_1(A_2, \Sigma_2)$	$\sigma_{33}=\sigma_1(A_3, \Sigma_3)$
8.10	9.94	3.43

Counterfactual

$\sigma_{12}=\sigma_1(A_1, \Sigma_2)$	$\sigma_{13}=\sigma_1(A_1, \Sigma_3)$	$\sigma_{21}=\sigma_1(A_2, \Sigma_1)$	$\sigma_{23}=\sigma_1(A_2, \Sigma_3)$	$\sigma_{31}=\sigma_1(A_3, \Sigma_1)$	$\sigma_{32}=\sigma_1(A_3, \Sigma_2)$
11.86	4.17	6.98	3.28	6.68	9.82

Differences of Counterfactual Variances by structure ($|\sigma_{ii} - \sigma_{ji}|$)

$\|\sigma_{11} - \sigma_{21}\|$	$\|\sigma_{11} - \sigma_{31}\|$	$\|\sigma_{22} - \sigma_{12}\|$	$\|\sigma_{22} - \sigma_{32}\|$	$\|\sigma_{33} - \sigma_{13}\|$	$\|\sigma_{33} - \sigma_{23}\|$
1.12	1.42	1.92	0.11	0.74	0.15

Differences of Counterfactual Variances by shock ($|\sigma_{ii} - \sigma_{ij}|$)

$\|\sigma_{11} - \sigma_{12}\|$	$\|\sigma_{11} - \sigma_{13}\|$	$\|\sigma_{22} - \sigma_{21}\|$	$\|\sigma_{22} - \sigma_{23}\|$	$\|\sigma_{33} - \sigma_{31}\|$	$\|\sigma_{33} - \sigma_{32}\|$
3.76	3.93	2.96	6.66*	3.25	6.39**

B. Italy VAR with government expenditure

Actual

Prewar	Interwar	Postwar
$\sigma_1^2 = 15.75$	$\sigma_2^2 = 12.40$	$\sigma_3^2 = 6.74$

Factual

$\sigma_{11}=\sigma_1(A_1, \Sigma_1)$	$\sigma_{22}=\sigma_1(A_2, \Sigma_2)$	$\sigma_{33}=\sigma_1(A_3, \Sigma_3)$
16.13	12.38	6.76

Counterfactual

$\sigma_{12}=\sigma_1(A_1, \Sigma_2)$	$\sigma_{13}=\sigma_1(A_1, \Sigma_3)$	$\sigma_{21}=\sigma_1(A_2, \Sigma_1)$	$\sigma_{23}=\sigma_1(A_2, \Sigma_3)$	$\sigma_{31}=\sigma_1(A_3, \Sigma_1)$	$\sigma_{32}=\sigma_1(A_3, \Sigma_2)$
18.25	8.04	11.69	5.65	13.71	14.88

Differences of Counterfactual Variances by structure ($|\sigma_{ii} - \sigma_{ji}|$)

$\|\sigma_{11} - \sigma_{21}\|$	$\|\sigma_{11} - \sigma_{31}\|$	$\|\sigma_{22} - \sigma_{12}\|$	$\|\sigma_{22} - \sigma_{32}\|$	$\|\sigma_{33} - \sigma_{13}\|$	$\|\sigma_{33} - \sigma_{23}\|$
4.44*	2.42*	5.87**	2.50	1.28*	1.11

Differences of Counterfactual Variances by shock ($|\sigma_{ii} - \sigma_{ij}|$)

$\|\sigma_{11} - \sigma_{12}\|$	$\|\sigma_{11} - \sigma_{13}\|$	$\|\sigma_{22} - \sigma_{21}\|$	$\|\sigma_{22} - \sigma_{23}\|$	$\|\sigma_{33} - \sigma_{31}\|$	$\|\sigma_{33} - \sigma_{32}\|$
2.11	8.09*	0.69	6.73	6.95*	8.12*

Table 2 (*Continued*)

C. Australia VAR with government expenditure					
Actual					
Prewar		Interwar		Postwar	
$\sigma_1^2 = 15.74$		$\sigma_2^2 = 40.97$		$\sigma_3^2 = 4.37$	
Factual					
$\sigma_{11} = \sigma_1(A_1, \Sigma_1)$		$\sigma_{22} = \sigma_1(A_2, \Sigma_2)$		$\sigma_{33} = \sigma_1(A_3, \Sigma_3)$	
16.08		47.81		4.37	
Counterfactual					
$\sigma_{12} = \sigma_1(A_1, \Sigma_2)$	$\sigma_{13} = \sigma_1(A_1, \Sigma_3)$	$\sigma_{21} = \sigma_1(A_2, \Sigma_1)$	$\sigma_{23} = \sigma_1(A_2, \Sigma_3)$	$\sigma_{31} = \sigma_1(A_3, \Sigma_1)$	$\sigma_{32} = \sigma_1(A_3, \Sigma_2)$
45.98	4.95	16.81	5.59	13.90	40.80
Differences of Counterfactual Variances by structure ($\lvert\sigma_{ii} - \sigma_{ji}\rvert$)					
$\lvert\sigma_{11} - \sigma_{21}\rvert$	$\lvert\sigma_{11} - \sigma_{31}\rvert$	$\lvert\sigma_{22} - \sigma_{12}\rvert$	$\lvert\sigma_{22} - \sigma_{32}\rvert$	$\lvert\sigma_{33} - \sigma_{13}\rvert$	$\lvert\sigma_{33} - \sigma_{23}\rvert$
0.73	2.18	1.82	7.00**	0.58	1.22
Differences of Counterfactual Variances by shock ($\lvert\sigma_{ii} - \sigma_{ij}\rvert$)					
$\lvert\sigma_{11} - \sigma_{12}\rvert$	$\lvert\sigma_{11} - \sigma_{13}\rvert$	$\lvert\sigma_{22} - \sigma_{21}\rvert$	$\lvert\sigma_{22} - \sigma_{23}\rvert$	$\lvert\sigma_{33} - \sigma_{31}\rvert$	$\lvert\sigma_{33} - \sigma_{32}\rvert$
29.90**	11.13	30.99**	42.21**	9.53	36.43**

D. Sweden VAR with government expenditure					
Actual					
Prewar		Interwar		Postwar	
$\sigma_1^2 = 20.11$		$\sigma_2^2 = 37.50$		$\sigma_3^2 = 3.40$	
Factual					
$\sigma_{11} = \sigma_1(A_1, \Sigma_1)$		$\sigma_{22} = \sigma_1(A_2, \Sigma_2)$		$\sigma_{33} = \sigma_1(A_3, \Sigma_3)$	
20.46		41.01		3.34	
Counterfactual					
$\sigma_{12} = \sigma_1(A_1, \Sigma_2)$	$\sigma_{13} = \sigma_1(A_1, \Sigma_3)$	$\sigma_{21} = \sigma_1(A_2, \Sigma_1)$	$\sigma_{23} = \sigma_1(A_2, \Sigma_3)$	$\sigma_{31} = \sigma_1(A_3, \Sigma_1)$	$\sigma_{32} = \sigma_1(A_3, \Sigma_2)$
36.11	6.14	18.56	22.89	16.45	30.34
Differences of Counterfactual Variances by structure ($\lvert\sigma_{ii} - \sigma_{ji}\rvert$)					
$\lvert\sigma_{11} - \sigma_{21}\rvert$	$\lvert\sigma_{11} - \sigma_{31}\rvert$	$\lvert\sigma_{22} - \sigma_{12}\rvert$	$\lvert\sigma_{22} - \sigma_{32}\rvert$	$\lvert\sigma_{33} - \sigma_{13}\rvert$	$\lvert\sigma_{33} - \sigma_{23}\rvert$
1.90	4.01*	4.90*	10.67**	2.80	19.55**
Differences of Counterfactual Variances by shock ($\lvert\sigma_{ii} - \sigma_{ij}\rvert$)					
$\lvert\sigma_{11} - \sigma_{12}\rvert$	$\lvert\sigma_{11} - \sigma_{13}\rvert$	$\lvert\sigma_{22} - \sigma_{21}\rvert$	$\lvert\sigma_{22} - \sigma_{23}\rvert$	$\lvert\sigma_{33} - \sigma_{31}\rvert$	$\lvert\sigma_{33} - \sigma_{32}\rvert$
15.65*	14.32**	22.45**	18.12**	13.11**	27.00**

Notes: Prewar period is 1886-1914, interwar period is 1920-1939, and postwar period is 1950-2001. ** and * denote statistical significance at the 5% and 10% significance levels using Bootstrap and Monte Carlo critical values from 1000 replications.

Monte Carlo techniques. Note again that the $|\sigma_{ii} - \sigma_{ji}|$s compute the difference in counterfactual variances holding the shocks constant, while the $|\sigma_{ii} - \sigma_{ij}|$s hold the structure constant.

Similar to the US cases examined earlier, the estimated $|\sigma_{ii} - \sigma_{ji}|$s for these four economies are generally smaller than the corresponding $|\sigma_{ii} - \sigma_{ji}|$s, some of which are quite large and more often statistically significant. This suggests that, with very few exceptions, changes in the shocks are responsible for most of the observed changes in output volatility, while changes in the structure have made a smaller contribution.[5]

To get an idea of the relative importance of shocks and structure for output variability in these four economies, we consider four numerical examples similar to those conducted for the US estimates in the last two sections. Comparing the interwar and postwar periods, the difference between the estimated output volatilities ($\sigma_{22} - \sigma_{33}$) is $9.94 - 3.43 = 6.51$ for the UK, $12.38 - 6.76 = 5.62$ for Italy, $47.81 - 4.37 = 43.44$ for Australia, and $37.44 - 3.34 = 34.10$ for Sweden. Considering that $\sigma_{32} = 9.82$ in the UK, 14.88 in Italy, 40.80 in Australia, and 42.25 in Sweden, we conclude the following. The shocks are responsible for 98% of the reduced volatility in the UK ($|\sigma_{33} - \sigma_{32}|/|\sigma_{33} - \sigma_{22}| = 0.982$), while the structure accounts for only 2%. In Australia, milder shocks are responsible for 84% of the reduction in output variability ($|\sigma_{33} - \sigma_{32}|/|\sigma_{33} - \sigma_{22}| = 0.839$), while a more stable structure accounts for 16%. Finally, the shocks are found to be responsible for *more than 100%* of the reduced volatility in Italy and Sweden ($|\sigma_{33} - \sigma_{32}|/|\sigma_{33} - \sigma_{22}| = 1.445$ for Italy and 1.141 for Sweden), while the structure is responsible for a *negative* amount.[6] This means that, while milder shocks have been contributing to a smoother postwar business cycle in these two economies, their postwar structure has actually become less stable. Fortunately, the destabilizing effects of the change in structure have been quantitatively dominated by the stabilizing ones of the change in shocks in all four countries.

3.4. Other robustness checks

We have performed a number of other robustness checks in order to make sure that our conclusions are not dependent on the specifications outlined above.

First, we experimented with various lag lengths, in both the univariate and multivariate specifications. Second, we tried a number of different sets of variables in the VARs, including the inflation rates. Third, we redefined the interwar period to include the war years 1914–1918 and 1939–1945.

While all of these estimates are not reported because of space considerations,[7] the results were found to be consistent with our central conclusions in the overwhelming majority of cases. To illustrate further, Table 3 reports the estimated counterfactual variances for all the US estimated models with at least 15 degrees of freedom. With very few exceptions, the results are robust.[8] Particularly stable are the variances that involve the prewar and postwar periods, where the degrees of freedom are more abundant.

---

[5] The only exceptions are and $|\sigma_{11}–\sigma_{21}|$ and $|\sigma_{22}–\sigma_{12}|$ for Italy which are both statistically significant and higher than $|\sigma_{11}–\sigma_{12}|$ and $|\sigma_{22}–\sigma_{21}|$, respectively.

[6] This is of course another way of saying that $\sigma_{32} > \sigma_{22}$ for these two economies.

[7] All results are available on request. See http://web.econ.uic.edu/kls/klspaper JEB.htm for some of these results.

[8] The exceptions are concentrated in the σ_{21} and σ_{23} estimates, which is not surprising: because of the small number of interwar observations, the interwar models have very few degrees of freedom when the number of estimated parameters is high.

Table 3
US Counterfactual estimates for different specifications

LAGS	VARIABLES	$\sigma_{12}=\sigma_1$ (A_1, Σ_2)	$\sigma_{13}=\sigma_1$ (A_1, Σ_3)	$\sigma_{21}=\sigma_1$ (A_2, Σ_1)	$\sigma_{23}=\sigma_1$ (A_2, Σ_3)	$\sigma_{31}=\sigma_1$ (A_3, Σ_1)	$\sigma_{32}=\sigma_1$ (A_3, Σ_2)
1	GDP	49.52	5.98	36.26	6.29	29.61	42.52
	GDP, M1	51.55	10.36	32.74	5.93	27.31	43.03
	GDP, G	48.53	5.85	35.90	6.56	29.67	41.91
	GDP, P	51.35	5.42	37.86	6.12	30.77	47.27
	GDP, M1, G	50.08	10.76	32.93	6.60	27.35	41.78
	GDP, M1, P	57.06	12.82	38.83	8.57	26.90	42.84
	GDP, G, P	50.89	5.33	38.06	6.12	32.95	49.47
	GDP, M1, G, P	58.93	15.33	38.20	8.56	28.04	45.48
2	GDP	53.57	6.19	37.06	6.28	28.95	42.51
	GDP, M1	53.87	10.92	34.22	6.48	26.98	41.36
	GDP, G	51.84	6.03	38.04	6.17	28.92	41.23
	GDP, P	53.40	5.46	38.55	5.83	30.06	46.54
	GDP, M1, G	42.82	10.96	52.35	21.66	27.06	30.91
	GDP, M1, P	56.38	14.35	61.71	21.18	25.89	35.08
	GDP, G, P	51.39	4.82	36.89	4.85	33.98	59.89
3	GDP	58.56	6.63	34.63	6.37	27.08	43.95
	GDP, M1	47.09	17.74	46.44	18.48	22.41	30.10
	GDP, G	46.35	7.00	45.46	8.08	26.51	34.46
	GDP, P	56.88	5.86	30.93	4.92	30.46	57.12

4. Discussion and conclusions

Why has output volatility been so remarkably lower in the postwar period relative to either the interwar or prewar periods? One possible answer is that the economic structure underwent a significant change, making it sufficiently more stable in the postwar period to account for the entire reduction in volatility. Another possibility is that the structure remained essentially the same, and the reduced variability is entirely the result of a less volatile economic environment, characterized by milder economic shocks. A third, and an *a priori* more plausible answer, is one that combines the first two, giving some of the praise to the structure (the propagation mechanism) and the rest to the shocks (the impulses).

This paper has investigated the issue using an econometric technique developed by James (1993), extended by Simon (2001), and recently employed by Stock and Watson (2002, 2003). Using annual data from the US, the UK, Italy, Australia, and Sweden, we have estimated several models over three time periods: the prewar period, 1886–1914 (1890–1914 for the US); the interwar period, 1920–1939; and the postwar period, 1950–2001. The estimates have allowed us to calculate "counterfactual" variances for output; i.e., the hypothetical variances that would have obtained if one period's structure had been combined with another period's shocks. Comparing these values to the actual variances observed (or estimated) for each of the three periods, it becomes possible to compare the relative contribution of propagation and impulses to the variability changes.

Our findings are easy to summarize. We find that the reduced postwar output volatility is mostly (often entirely) the result of milder shocks, and less (often not at all) due to a more stable structure. Put differently, we show that if the interwar (or prewar) structure had been combined with the postwar shocks, interwar (or prewar) economic activity would have been almost as smooth as it turned out to be after 1950. Conversely, if the postwar structure had been combined with the prewar (or interwar) shocks, output since 1950 would have been almost as volatile as it was before 1914 (or during 1920–1939). These results hold for all five countries and all estimated models.

Quantitatively, in the US we calculate that milder shocks are responsible for around 80% of the reduction in output variance between interwar and postwar periods, while a more stable structure has contributed the remaining 20%. In the other four economies examined, the contribution of the shocks ranges from 84% in Australia and 98% in the UK, to more than 100% in Italy and Sweden, so that the responsibility of the structure ranges from a maximum of 16% in Australia to a negative contribution in Italy and Sweden.

Our findings on the comparison of the interwar and postwar fluctuations have interesting implications for the Great Depression, the causes of which continue to be vigorously debated.[9] Because of the uniqueness, severity, and international character of this episode, the Great Depression has been analyzed from a wide variety of perspectives. Two very influential opposing views contrasted those who blamed monetary factors (Friedman & Schwartz, 1963) with those who emphasized “real” shocks (Temin, 1976). More recently, and in an attempt to assess the relative importance of different shocks, VAR techniques have been employed by a vast and growing literature, but again without settling the issue.[10] If an outline of a consensus can be said to have emerged, it is probably the “synthetic view” of Eichengreen (1992, 2002, 2004), which is very relevant to the present paper’s framework because it offers an explanation of the Great Depression that combines shocks and structure. Eichengreen’s view assigns responsibility both to “monetary policy blunders in the United States, Germany and France” and to “the unstable monetary and financial system” for “amplifying these negative impulses and transmitting them to the rest of the world” largely through the gold standard (Eichengreen, 2004, p. 24). In terms of the present paper’s terminology, the “policy blunders” represent the shocks or impulses, while the “unstable system” represents the structure or propagation mechanism. Our quantitative results then can be used to evaluate the relative importance of the two basic ingredients of the “synthetic view,” suggesting that the greater interwar volatility was much more the result of those policy shocks and less due to the unstable structure.

A question, of course, that remains is what have been the causes of the less volatile shocks in the postwar period, and whether this has been accidental or the consequence of deliberate economic policy. Although beyond the scope of the present paper (and probably not amenable to the methodology employed here), this is a very interesting question for future research.

Acknowledgements

We wish to thank David VanHoose, an anonymous referee, and seminar and conference participants at UIC, DePaul, and the Illinois Economic Association for helpful comments and suggestions. Any errors and omissions remain our own.

References

Backus, D. K., & Kehoe, P. J. (1992). International evidence on the historical properties of business cycles. *American Economic Review*, *82*, 864–888.

[9] We thank an anonymous referee for urging us to emphasize this connection.

[10] Examples include Sims (1980), Cecchetti and Karras (1994), Bordo et al. (1995), Bordo, Choudhri, and Schwartz (1995, 2002). In addition to the VAR methodology, a number of researchers have used stochastic general equilibrium models. See Evans, Hasan, and Tallman (2004) for a recent survey.

Baily, M.N. *Stabilization policy and private economic behavior*. Brookings Papers of Economic Activity, No. 1, 1978. 11–50.
Bordo, M., Choudhri, E. U., & Schwartz, A. J. (1995). Could stable money have averted the great contraction? *Economic Inquiry*, *33*, 484–505.
Bordo, M., Choudhri, E. U., & Schwartz, A. J. (2002). Was expansionary monetary policy feasible during the great contraction? An examination of the gold standard constraint. *Explorations in Economic History*, *39*, 1–28.
Cecchetti, S., & Karras, G. (1994). Sources of output fluctuations during the interwar period: further evidence on the causes of the great depression. *Review of Economics and Statistics*, *76*, 80–102.
DeLong, J. B., & Summers, L. H. (1986). The changing cyclical variability in the United States. In R. J. Gordon (Ed.), *The American business cycle: Continuity and change*. University of Chicago Press.
Effron, B. (1979). Bootstrap methods: Another look at the Jackknife. *Annals of Statistics*, *9*, 1218–1228.
Eichengreen, B. (1992). *Golden fetters: The gold standard and the great depression 1919–1939*. Oxford University Press.
Eichengreen, B. (October 2002). *Still fettered after all these years*. NBER Working Paper No. 9276.
Eichengreen, B. (2004). Viewpoint: Understanding the great depression. *Canadian Journal of Economics*, *37*, 1–27.
Evans, P., Hasan, I., & Tallman, E. W. (2004). Monetary explanations of the great depression: A selective survey of empirical evidence. *Federal Reserve Bank of Atlanta Economic Review*, *3*, 1–23.
Friedman, M., & Schwartz, A. J. (1963). *Monetary history of the United States 1876–1960*. Princeton University Press.
International Monetary Fund. International Financial Statistics on CD-ROM.
Inoue, A., & Kilian, L. (2002). Bootstrapping smooth functions of slope parameters and innovation variances in VAR(∞) models. *International Economic Review*, *43*(No 2), 309–331.
James, J. A. (1993). Changes in economic instability in 19th-century America. *American Economic Review*, *83*, 710–731.
Kilian, L. (1997). *Impulse response analysis in vector autoregressions with unknown lag order*, Manuscript, Department of Economics, University of Michigan.
Liesner, T. (1990). *One hundred years of economic statistics*. Facts of File, New York/Oxford.
Lucas, R. E., Jr. (2003). Macroeconomic priorities. *American Economic Review*, *93*, 1–14.
Romer, C. D. (1989). The prewar business cycle reconsidered: New estimates of gross national product, 1869–1908. *Journal of Political Economy*, *97*, 1–37.
Romer, C. D. (1991). The cyclical behavior of individual production series, 1889–1984. *Quarterly Journal of Economics*, *106*, 1–31.
Runkle, D. E. (1987). Vector autoregressions and reality. *Journal of Business and Economic Statistics*, *5*, 437–442.
Sheffrin, S. M. (1988). Have economic fluctuations been dampened? A look at evidence outside the United States. *Journal of Monetary Economics*, *21*, 73–83.
Simon, J. (March 2001). *The decline in Australian output volatility*. Research Discussion Paper 2001-01, Reserve Bank of Australia.
Sims, C. A. (1980). Comparison of interwar and postwar business cycles: Monetarism reconsidered. *American Economic Review*, *70*, 250–257.
Stine, R. A. (1987). Estimating properties of autoregressive forecasts. *Journal of the American Statistical Association*, *82*, 1072–1078.
Stock, J. H. & Watson, M. W. (September 2002). *Has the business cycle changed and why?* NBER Working Paper No. 9127.
Stock, J. H. & Mark, W. W. (July 2003). *Understanding changes in international business cycle dynamics*, NBER Working Paper No. 9859.
Temin, P. (1976). *Did monetary factors cause the great depression?* W.W. Norton.