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HAS THE POST-WAR US ECONOMY DEVIATED LESS FROM THE STABLE GROWTH REGIME?

by Chulsoo Kim (*) and Michele Manna (**)

Abstract

This paper examines if the US economy has deviated less from the stable growth regime after World War II compared to the pre- World War I period. The analysis is conducted by decomposing output fluctuations into business cycle fluctuations, that is shifts of the growth path of output, and non-business cycle fluctuations, that is movements along the growth path of output. Since policy makers are concerned with preventing major fluctuations, we statistically examine the shifts of the economy between a stable-growth, a recessionary and an expansionary regime. Using a three-regime Markov representation, we find that the post-war economy displays a longer expected duration for the stable growth regime and it has a lower probability of remaining in the recessionary or expansionary regime even if it gets there. Using the data set which was used in the past to argue that there was no post-war stabilisation, we conclude that there was indeed business cycle stabilisation in the post-war period.

Contents

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1. Introduction[1]

The conventional wisdom teaches us that the post-World War II (henceforth, post-war) US economy has been stabilised. Baily (1978), De Long and Summers (1986), and Moore and Zarnowitz (1986) have documented clear post-war stabilisation. In a series of papers, however, Romer (1986a, 1986b, 1986c, 1988, 1989, 1991, 1992) challenges the common belief by suggesting that the pre- World War I (henceforth, pre-war) US data commonly used are flawed. Her new estimates of pre-war data suggest no post-war stabilisation. In other words, the debate on the post-war economy stabilisation has essentially depended on which data set one uses. Yet, it is hard to judge which data is more appropriate unless one is an expert on the data collection process. Thus, the past literature often leave us unconvinced of their conclusion. We thus decide to use Romer's (1992) data set, which was used to argue that there was no post-war stabilisation, and nevertheless we show the post-war business cycle stabilisation.

We decompose output fluctuations into business cycle fluctuations and non-business cycle fluctuations. Business cycle fluctuations are shifts of the growth path of output. Non-business cycle fluctuations are movement along the growth path of output, such as movements induced by idiosyncratic shocks to the output series or shocks due to time lags and overshootings of active government policies over which policy makers have less control. On the basis of such decomposition,

[1] We would like to thank, among others, Michael D. Bordo, Dongchul Cho, William W. Lang, Choon-Geol Moon, Bartholomew J. Moore, Hugh Rockoff, and an anonymous referee for helpful comments and Christina D. Romer for kindly providing us with her data set. The usual disclaimer applies. The first author gratefully acknowledges the financial support from Rutgers Research Council.

we can evaluate whether when output increases, for example, aggregate activity is on an expansionary cycle or it is simply a shock to the idiosyncratic component of the output series itself.

Some degree of fluctuation may not be harmful to the economy, as the real business cycle school believes that fluctuations are products of optimisation problems and therefore policy makers should not intervene in order to stabilise the economy. Thus, we need to measure output fluctuations allowing for some movement along the growth path, rather than simply measuring them from the trend.

We distinguish business cycle fluctuations into stable growth fluctuations, major contractions and major expansions instead of standard NBER contractions and expansions. Indeed, the dichotomy of contractions and expansions often does not represent the state of the economy well. For example, in March 1993, the US economy was in expansion according to the NBER business cycle dating committee. Yet, this was a very slow expansion and it might be more appropriate to call it a minor or stable growth fluctuation.

We model an expectation of a rate of change of a time series as a constant unless a discrete shift takes place following Hamilton (1988, 1989, 1990). Econometricians do not observe the discrete shift, and therefore they need to infer whether the discrete shift takes place along with the transition probabilities and parameters from the observations of the series. We use a three-regime version of Hamilton's model, allowing for both positive and negative shifts, where the former correspond to movements from the stable growth path to the expansionary cycle and the latter to movements from the stable growth path to the recessionary cycle. Our framework enables us to compute persistence, expected duration, and limiting probability of stable growth fluctuations, major expansions and major contractions.

A major goal of post-war macroeconomic policy has been to reduce the size and frequency of recessions since the passage of the Employment Act of 1946 which required the government to stabilise the economy. If Romer is right, then the usefulness of the post-war US macro policies has to be questioned. Our results, however, support the traditional view of the post-war economy stabilisation in terms of business cycle fluctuations. We find that the post-war economy is more likely to remain in the stable growth regime and its regime shifts are less frequent, compared to the pre-war economy. The post-war economy has a longer expected duration for the stable growth fluctuations, a shorter expected duration for the major fluctuations, and a higher limiting probability for the stable growth regime. We conjecture that post-war counteractive policies were not successful enough to prevent minor fluctuations due to time lags and overshootings, but successful enough to prevent major fluctuations.

Section 2 discusses the stabilisation debate, section 3 models the output growth rate as a three-regime Markov process, section 4 conducts the empirical analysis, and section 5 concludes this paper.

2. The post-war output stabilisation debate

The economics profession used to agree that the economy has been stabilised after World War II although it disagreed on its causes. Baily (1978) documents the stability of post-war economy and explains it by the fact that the stabilisation policies that are perceived to be effective are self-fulfilling. Due to the Employment Act of 1946, agents expect government to attempt to stabilise the economy. Therefore, when faced with recessions, agents expect recessions to be short and they do not cut back on their spending, which would lead to less persistence in output. De Long and Summers (1986) attribute the reduced output volatility to the greater public and private efforts to smooth consumption and the increasing rigidities of prices, and refute standard explanations such as structural changes in the economy, discretionary stabilisation policies, and the avoidance of financial panics; due to an easier access to the credit market, agents are less liquidity constrained and they have increased their ability to smooth out their consumption during the post-war period. Moore and Zarnowitz (1986) similarly document the post-war stabilisation.

Romer (1986a, 1986b, 1986c, 1988, 1989, 1991, 1992) is the first to challenge the traditional belief that the post-war economy is more stable than the pre-war economy by showing that pre-war data are excessively volatile. Romer's point is based on the method of construction of pre-war data which are created from series too volatile to proxy for the aggregate series being created. Romer (1986a, 1986c) shows that the pre-war unemployment data ignored the counter cyclical fluctuations in the number of discouraged workers and the pro cyclicity of productivity and hours worked, and therefore the unemployment data were too volatile. Romer (1986c, 1988, 1989) argues that Kuznets' (1961) data set which is the standard estimate of GNP before 1919 is excessively volatile since he ignores a substantial part of GNP which is smoother than commodity output. Also, the official Commerce Department estimates of GNP are inferior even to Kendrick (Kuznets) GNP estimates which are less volatile. Her new estimates of pre-war GNP suggest that there is not significant stabilisation in the post-war period. Romer (1986b) examines the industrial production data and concludes that there is little dampening of business cycle fluctuations. Indeed, pre-war industrial production data are excessively volatile since they rely heavily on the production of materials which are strongly pro cyclical. Romer (1991) shows that the cyclical behaviour of individual production series has changed little between the pre-war and the post-war period, and argues that aggregate economy has not been stabilised. As Romer (1992) notes, the average length of contractions and expansions are (17.7, 24.2) months for the pre-war period and (11.0, 51.5) months for the post-war period using the NBER chronology. Using Romer's (1992) dates, on the other hand, they become (9.7, 32.2) months for the pre-war period and (12.4, 50.3) months for the post-war period.

Balke and Gordon (1989) similarly claim the poor quality of pre-war data, and construct new estimates of real GNP by incorporating information which was not used before, such as CPI, indexes of transportation and communication output, and the index of construction output. They confirm the traditional view that real GNP is more volatile in the pre-war period.

Even examining international evidence does not resolve this debate. Sheffrin (1988) finds no dramatic decrease in the severity of economic fluctuations for the UK, Denmark, Italy, Norway and France, but not for Sweden. Englund, Persson and Svensson (1992) examine Swedish business cycles and conclude that business cycles are very stable over time except during the interior period. They find that the post-war period is much less volatile than the interior period but slightly less volatile than the pre-war period. On the other hand, Backus and Kehoe (1992) find a great deal of regularity in the cyclical behaviour of real quantities for ten countries over the last century. Although pre-war fluctuations are generally larger than post-war fluctuations, they find that the difference varies across the countries and therefore the evidence for the post-war stabilisation across the countries is ambiguous.

As an indirect approach, Shapiro (1988) examines stock prices to test the output stability. Since the data on real output are the source of controversy, he instead examines stock prices on which accurate data are available. He finds that stock returns show no reduction in variance and supports Romer's view that post-war output stabilisation is fictitious. Yet, we do not have a clear link between financial variables and real aggregate activity, and thus we need to be careful about his conclusion.

An alternative way to examine the stabilisation is to examine durations, as opposed to volatility, and once again we have mixed evidence. Diebold and Rudebusch (1992) examine the duration of pre-war and post-war business cycles. They claim that designating turning points as opposed to documenting quantitative changes is consistent between pre-war and post-war periods. They find strong evidence of longer expansions and shorter contractions for the post-war period. Romer (1992), however, argues that there is an important inconsistency between the early and modern NBER reference dates, and therefore we cannot simply compare NBER cycles between pre-war and post-war periods to examine stabilisation questions. She thus devises a loss rule to capture the duration and amplitude criteria used by Burns and Mitchell (1946) to date turning points for the pre-war period, and finds that expansions have become longer but recessions have not got shorter, less severe or less persistent. Watson (1992) also attributes the longer expansions and shorter contractions to the systematic biases in the pre-war data used by early NBER researchers. The number of the series they examined was smaller and the series represented more volatile sections of the economy. He refutes arguments such as smaller shocks to individual sectors of the economy in the post-war period and changes in the relative importance of the sectors.

This literature shows us that the use of different data sets leads to different conclusions and leaves most of us who are not experts on data collection processes confused. We believe that this debate will not be resolved unless we use Romer's data set to show the post-war stabilisation. This is what we attempt to do in this paper.

3. Our model

Taking NBER business cycles too scientifically rather than as a descriptive reference framework may not be appropriate since designating business cycle dates is judgmental rather than mechanical. No single variable can measure aggregate economic activity directly and therefore there exists no formula to date expansions and contractions. Lucas (1977) argues that business cycles are all alike and therefore we need to explain business cycles based on market laws rather than political and institutional aspects. On the other hand, Blanchard and Watson (1986) examine correlations among macro variables, conclude that business cycles are not alike, and therefore question the usefulness of making the business cycle a reference frame for economic time series analysis. Nevertheless, NBER business cycles have been essential in most policy debates. Thus, instead of using rather arbitrary NBER dates, we infer the state of business cycles in a probability sense to obtain well defined statistical properties and examine if the post-war business cycles have been stabilised.

We decompose output into a business cycle component and a non-business cycle or idiosyncratic component. Hamilton (1988, 1989, 1990) represents the rate of change of a time series as the sum of three components: a constant, a realisation of a discrete-state Markov chain and an ARMA process. This specification describes a series whose expectation of the rate of change is constant unless a discrete shift takes place. Let $\tilde{y}_t$ = *log(output)*. Then,

(1) $$\tilde{y}_t = \tilde{n}_t + \tilde{z}_t$$

where

(2) $$(1 - L)\ \tilde{n}_t = \alpha_0 + \alpha_1 s_t$$

(3) $$(1 - L)\ \tilde{z}_t = (1 - \phi_1 L - \phi_2 L^2 - \ldots - \phi_r L^r)^{-1} \varepsilon_t$$

and $\varepsilon_t \sim iid\ N(0,\sigma^2)$ and independent of S_t for all t.

Econometricians observe $\tilde{y}_t$, but not $\tilde{z}_t$ or s_t, the realisation at time *t* of a stochastic Markov process S_t[2]. S_t represents a regime of the economy and may be a proxy for business cycles. In other words, we can decompose output fluctuations into business cycle fluctuations which are represented by $\tilde{n}_t$, and non-business cycle or idiosyncratic fluctuations in output, which are represented by $\tilde{z}_t$.

We assume S_t takes three values: -1, 0, +1. Major contractions correspond to regime -1, stable growth fluctuations to regime 0, and major expansions to regime +1. Major contractions and expansions would correspond to NBER contractions and expansions which are significant, whereas stable growth fluctuations would correspond to minor NBER contractions and expansions. We have two reasons for using a three-regime Markov process rather than a standard two-regime one. First, minor contractions and very slow growth periods may be hard to distinguish, especially for the pre-war data which are detrended. Secondly, policy makers are concerned with preventing major fluctuations since they cannot

2 For any variable of the model, we denote with the uppercase Y_t the stochastic process and with the lowercase y_t its realization.

eliminate all fluctuations due to time lags and overshootings. Further, at least some part of fluctuations may not be harmful to the economy since such part may result from optimal responses of agents to shocks as the real business cycle school believes. Thus, we examine if major fluctuations become less severe in the post-war economy.

The transition probability for Markov process S_t is defined to be time invariant: $P(S_t = j | S_{t-1} = i) = p_{ij}$. Our model is duration independent as Diebold and Rudebusch (1990) find little evidence for duration dependency for the complete samples of expansions and contractions. Also, economy seems to be persistent and unlikely to shift drastically from major contractions to major expansions, or vice versa. Thus, we do not allow for jumps from regime -1 to regime +1, or from regime +1 to regime -1: $p_{-1,+1} = p_{+1,-1} = 0$. Since our data set is monthly, this would be a reasonable simplification.

Our model can capture the asymmetry of time series over the business cycle if the asymmetry exists. As discussed in De Long and Summers (1984), Keynes (1936) and Mitchell (1927) believed that there were fundamentally important cyclical asymmetries which cannot be captured with a standard time series technique. For example, contractions are briefer and more violent than expansions. Neftçi (1984) also suggests that time series are asymmetric over the business cycle. This was one justification for the use of judgmental qualitative analysis. On the other hand, De Long and Summers (1984) examine US and five major OECD countries and find no evidence of asymmetry in the GNP, industrial production and unemployment except for the US unemployment. Thus, they find no evidence in favour of the traditional cyclical technique over modern macroeconometric techniques. Without arbitrarily imposing symmetry a prior, $(p_{-1,-1}, p_{+1,+1})$ and $(p_{0,-1}, p_{0,+1})$ in our model will reveal the asymmetry over business cycles if it exists.

Let $y_t = \tilde{y}_t - \tilde{y}_{t-1}$ and $z_t = \tilde{z}_t - \tilde{z}_{t-1}$. Then,

(4) $$y_t = \alpha_0 + \alpha_1 s_t + z_t$$

where

(5) $$z_t = \phi_1 z_{t-1} + \phi_2 z_{t-2} + \ldots + \phi_r z_{t-r} + \varepsilon_t$$

Econometricians need to infer the probability of being in each regime based on observations $y = (y_1, \ldots, y_T)$, and to estimate the parameters characterising the different regimes and the probability law for the Markov transition matrix. Define $X_t = (S_t, S_{t-1}, \ldots, S_{t-r}, Y_{t-1}, \ldots, Y_{t-r})$, $\theta = (\alpha_0, \alpha_1, \phi_1, \ldots, \phi_r, \sigma)$, $p = (p_{-1,-1}, p_{-1,0}, p_{0,-1}, p_{0,0}, p_{0,+1}, p_{+1,0}, p_{+1,+1})$, $\rho = (\rho_{-1,-1,\ldots,-1}, \rho_{-1,-1,\ldots,0}, \ldots, \rho_{+1,+1,\ldots,+1})$, and $\lambda = (\theta, p, \rho)$. ρ is a collection of the probabilities for the initial unobserved states, and the elements of ρ sum to 1. The sample conditional log likelihood function for y_t is

(6) $$\sum_{t=1}^{T} \sum_{s_t=-1}^{+1} \cdots \sum_{s_{t-r}=-1}^{+1} \log P(y_t | X_t;\ \theta)$$

where

(7) $$P(y_t \mid X_t;\ \theta) = \frac{1}{\sqrt{2\pi\sigma^2}}\, e^{\left\{-\frac{1}{2\sigma^2}\left[(y_t-\alpha_0-\alpha_1 s_t)-\phi_1(y_{t-1}-\alpha_0-\alpha_1 s_{t-1})-\ldots-\phi_r(y_{t-r}-\alpha_0-\alpha_1 s_{t-r})\right]^2\right\}}.$$

We can decompose the variance of Y_t into variances of S_t and Z_t in (4). Since S_t and Z_t are independent, $Var(Y_t) = \alpha_1^2\ Var(S_t) + Var(Z_t)$. Thus,

(8) $$\frac{\alpha_1^2\, Var(S_t)}{Var(Y_t)} = 1 - \frac{Var(Z_t)}{Var(Y_t)}$$

measures output fluctuations due to business cycles, and may indicate the stability of business cycles.

To obtain estimates for λ, Hamilton (1989) maximises the sample conditional log likelihood function (6) numerically with respect to the unknown parameters λ. Hamilton (1990) discusses the computational difficulty of maximising numerically an often ill-behaved likelihood function. He instead suggests using the EM algorithm which finds an analytic solution to the maximum likelihood methods. Following Hamilton's (1990) EM algorithm,

$$(9) \qquad p_{ij}^{(l+1)} = \frac{\sum_{t=r+1}^{T} P(S_t = j,\ S_{t-1} = i \mid y;\ \lambda_l)}{\sum_{t=r+1}^{T} P(S_{t-1} = i \mid y;\ \lambda_l)}$$

for (i, j) = (-1, -1), (0, +1), (0, -1), (+1, +1). We set $p_{-1,0}^{(l+1)} = 1 - p_{-1,-1}^{(l+1)}$, $p_{+1,0}^{(l+1)} = 1 - p_{+1,+1}^{(l+1)}$, and $p_{0,0}^{(l+1)} = 1 - p_{0,+1}^{(l+1)} - p_{0,-1}^{(l+1)}$ due to possible computer rounding errors.

$$(10) \qquad \alpha_0^{(l+1)} = \frac{\sum_{t=r+1}^{T} \sum_{s_t=-1}^{+1} \cdots \sum_{s_{t-r}=-1}^{+1} \left[(y_t - \alpha_1 s_t) - \ldots - \phi_r (y_{t-r} - \alpha_1 s_{t-r})\right] P_t^{(l)}}{(\,T - r\,)\,(1 - \phi_1 - \ldots - \phi_r)}$$

$$(11) \quad \alpha_1^{(l+1)} = \frac{\sum_{t=r+1}^{T} \sum_{s_t=-1}^{+1} \cdots \sum_{s_{t-r}=-1}^{+1} \left[(y_t - \alpha_0) - \ldots - \phi_r (y_{t-r} - \alpha_0)\right] (s_t - \phi_1 s_{t-1} - \ldots - \phi_r s_{t-r})\, P_t^{(l)}}{\sum_{t=r+1}^{T} \sum_{s_t=-1}^{+1} \cdots \sum_{s_{t-r}=-1}^{+1} (s_t - \phi_1 s_{t-1} - \ldots - \phi_r s_{t-r})^2\, P_t^{(l)}}$$

$$(12) \quad (\sigma^{(l+1)})^2 = \frac{\sum_{t=r+1}^{T} \sum_{s_t=-1}^{+1} \cdots \sum_{s_{t-r}=-1}^{+1} \left[(y_t - \alpha_0 - \alpha_1 s_t) - \ldots - \phi_r (y_{t-r} - \alpha_0 - \alpha_1 s_{t-r})\right]^2 P_t^{(l)}}{(\,T - r\,)}$$

and

$$(13) \qquad \rho_{i_r,\ldots,i_1}^{(l+1)} = P(S_r = i_r,\ \ldots\ ,\ S_1 = i_1 \mid y;\ \lambda_l)$$

where $P_t^{(1)} = P(S_t, \ldots, S_{t-r} | y; \lambda_1)$ and superscript $^{(1)}$ denotes iteration 1. ϕ_k solves for $k = 1, \ldots, r$,

$$(14) \sum_{t=r+1}^{T} \sum_{s_t=-1}^{+1} \cdots \sum_{s_{t-r}=-1}^{+1} [(y_t - \alpha_0 - \alpha_1 s_t) - \ldots - \phi_r (y_{t-r} - \alpha_0 - \alpha_1 s_{t-r})](y_{t-k} - \alpha_0 - \alpha_1 s_{t-k}) P_t^{(l)} = 0 .$$

Equation (9) is essentially counting the number of transitions from regime i to regime j divided by the number of times the process started in regime i, all of which are multiplied by their respective probabilities. Similarly, (10) is the sample average of $(y_t - \alpha_1 s_t) - \phi_1(y_{t-1} - \alpha_1 s_{t-1}) - \ldots - \phi_r(y_{t-r} - \alpha_1 s_{t-r})$, (11) is an OLS estimate for α_1, and (12) is a sample variance for ε_t, all of which are weighted by their respective probabilities.

The EM algorithm computes the maximum likelihood estimate as follows. With y and an initial guess for λ_0, we compute the smoothed probability $P(S_t = j, S_{t-1} = i | y; \lambda_0)$ and $P(S_{t-1} = i | y; \lambda_0)$ as discussed in Hamilton (1989, 1990). Using them, we compute $\lambda_1 = (\alpha_0^{(1)}, \alpha_1^{(1)}, \phi_1^{(1)}, \ldots, \phi_r^{(1)}, \sigma^{(1)}, p_{ij}^{(1)}, \rho^{(1)})$ from (9) - (14). With a new λ_1, we compute a new set of smoothed probability $P(S_t = j, S_{t-1} = i | y; \lambda_1)$ and $P(S_{t-1} = i | y; \lambda_1)$. We repeat this process until λ converges. Hamilton (1990) suggests using the criterion that the maximum element of $|\lambda_{1+1} - \lambda_1|$ is less than 10^{-8}.

We examine volatility and duration simultaneously to discuss stability. As Diebold and Rudebusch (1992) argue, some counter cyclical policies such as unemployment insurance which are intended to reduce volatility may increase the duration of contractions. Thus, examining them separately may give us false impressions about the stabilisation of the economy. The computed Markov transition probabilities enable us to compute the expected duration for each regime. Post-war duration stabilisation debates have relied on the NBER business cycle dates, which are judgmental rather than statistical. Thus, we use an output series to infer the regime of business cycles, instead of relying on judgmental NBER business cycle dates. Conditional on being in the expansion regime, the expected duration of an expansion is

$$\text{(15)} \qquad \sum_{k=1}^{\infty} k\, p_{+1,+1}^{k-1} \left(1 - p_{+1,+1}\right) = \frac{1}{1 - p_{+1,+1}}.$$

Similarly, conditional on being in the contraction regime, the expected duration of a contraction is $1/(1 - p_{-1,-1})$, and conditional on being in the stable growth regime, the expected duration of a stable growth is $1/(1 - p_{0,0})$.

The computed Markov transition probability also generates the unconditional probability of being in each regime. The unique fixed point or the limiting probability for the Markov process is

$$\text{(16)} \qquad \left[P(S_t = -1),\ P(S_t = 0),\ P(S_t = +1) \right] =$$

$$\left[\frac{\dfrac{p_{0,-1}}{1-p_{-1,-1}}}{1+\dfrac{p_{0,+1}}{1-p_{+1,+1}}+\dfrac{p_{0,-1}}{1-p_{-1,-1}}},\ \frac{1}{1+\dfrac{p_{0,+1}}{1-p_{+1,+1}}+\dfrac{p_{0,-1}}{1-p_{-1,-1}}},\ \frac{\dfrac{p_{0,+1}}{1-p_{+1,+1}}}{1+\dfrac{p_{0,+1}}{1-p_{+1,+1}}+\dfrac{p_{0,-1}}{1-p_{-1,-1}}} \right].$$

A higher probability of being in the stable growth regime implies more stable business cycle fluctuations.

4. Empirical results

We use Romer's (1992) data set, which includes monthly seasonally adjusted Federal Reserve Board's index of industrial production for 1919 - 1991.6 and the smoothed version of Miron and Romer (1990) industrial production series for 1884.7 - 1918. As Romer (1992) suggests, the industrial production is a reliable monthly indication of aggregate output throughout our sample, and is one of the main series that the current NBER committee on Business Cycle Dating relies on. Romer argues that this data is consistent across periods. Also, the use of an industrial production series, as opposed to GNP or GDP series, allows us to eliminate the sectorial shifts as a possible explanation for the post-war stabilisation. Most developed economies have moved from agricultural productions to industrial productions first and to services sector activities afterwards. These shifts imply a change from sectors which are inherently more volatile to sectors which are less volatile. Thus, the use of GNP or GDP series is more likely to suggest post-war stabilisation due to sectorial shifts. We set the pre-war period as 1884:8 - 1917:12, the interior period as 1918:1 - 1940:12, and the post-war period as 1948:1 - 1991:6 as in Romer (1992). We set y_t equal to 100 times the change in the log of industrial production.

Table 1 presents means and variances for each period. It shows a slight decrease in the variance for the post-war period: from 2.3249 to 2.1416. This is basically the basis of Romer's (1992) point. The standard pre-war data are excessively volatile, and a corrected data set which Romer creates shows no significant decrease in volatility. We will show that the post-war business cycles have been stabilised even with her corrected data set.

We set the number of ARMA lags to be equal to zero for computational simplicity, for now. Table 2 presents maximum likelihood estimates of (4) for pre-war, interior, post-war and pre-war and post-war periods. We obtain the same convergence with wide values of initial guess λ_0. Asymptotic standard errors are numerically computed from the second derivatives of the log likelihood function. t-statistics for α_1 is significant for all periods and is not inconsistent with our three regime Markov representation[3]. The monthly average growth rates for each regime are (-1.5%, 0.4%, 2.3%) for the pre-war period, (-1.5%, 0.5%, 2.5%) for the post-war period, (-4.6%, 0.6%, 5.8%) for the interior period, and (-1.4%, 0.6%, 2.5%) for the pre-war and post-war period. The pre-war and post-war periods are comparable in terms of average growth rates for each regime, and have a much narrower range than the interior period. Although estimates of (4) are very similar between pre-war and post-war periods, $\chi^2_{(9)}$ for the likelihood ratio test for the structural change between the pre-war and post-war periods is 27.22 and significant at 1% confidence level. Furthermore, 1 - $Var(\varepsilon_t)/Var(y_t)$ shows a clear difference between the periods. Output fluctuations due to business cycles decrease from 64% to 30% in the post-war period. Namely, output fluctuations due to regime shifts or business cycles have been stabilised in the post-war period. The interior period certainly has a large volatility, but the business cycle volatility is only 56%.

Table 3 presents the Markov transition probabilities. $p_{0,0}$ = 0.7955 for the pre-war period, and $p_{0,0}$ = 0.9298 for the post-war period. In other words, once the economy is in the stable growth regime, it is more likely to remain there in the post-war period. The probability of shifting to another regime from the stable growth regime is only 7%, compared to 20% for the pre-war period. Similarly, comparing $p_{-1,-1}$ and $p_{+1,+1}$, the post-war economy is less likely to remain in major contractions and expansions even if it gets there. Specifically, the probability of shifting from the major contraction regime to the stable growth regime increase from 23% to 34%. The interior period also exhibits some stability

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[3] Under the null hypothesis that α_1 = 0, however, p_{ij} are not identified, the information matrix is singular and therefore the standard asymptotic tests are not strictly valid though.

in the stable growth regime. The interior period has less fluctuations due to regime shifts but fluctuations in each regime are much more volatile, and this may indicate that the large output volatility is caused by large non-business cycle shocks.

Figure 1 presents $P(S_t \mid y)$, the probability of being in each state, for the pre-war, interior and post-war period. For comparison, NBER peaks and troughs are also noted in Figure 1. It shows a close relationship between $P(S_t \mid y)$ and NBER business cycle peaks and troughs, especially for $P(S_t = -1 \mid y)$ and NBER troughs, and suggests that our three regime Markov process is not an arbitrary formulation. Our expansions and contractions are shorter than NBER's since our expansion and contraction regimes represent only major fluctuations and since NBER designates a cycle only if it achieves a certain maturity. Namely, full cycles of less than one year in duration and contractions of less than six months are unlikely to be designated as a cycle. Figure 1 shows that the post-war period has a greater tendency to be in the stable growth regime and the frequency of switching among regimes is smaller. Specially, after 1961, S_t is likely to be in the stable growth regime.

Table 4 presents expected durations for each regime. The expected duration for the stable growth regime increases from 4.9 months to 14.2 months in the post-war period. Also, the post-war economy has shorter expected durations for major fluctuations compared to the pre-war economy. In particular, the expected duration for a major contraction decreases from 4.3 months to 2.9 months. Similarly, table 5 shows that the limiting probability of the stable growth regime increases from 58% to 83% and those for major fluctuations decrease for the post-war economy. Tables 2 - 5 suggest that the post-war economy is more likely to stay in the stable growth regime, has less frequent regime shifts, and therefore they confirm the traditional view of the post-war stabilisation in terms of business cycle fluctuations.

US business cycles seem to exhibit asymmetry. Table 3 shows that the probability of remaining in a major contraction is slightly higher than that of remaining in a major expansion. Once the economy reaches the stable growth regime, the probability of moving up to the major expansion regime is slightly higher than that of moving down to the major contraction regime for the pre-war and interior periods, and slightly lower for the post-war period. Table 4 shows that the expected duration of major contractions is longer than that of major expansions for all periods. Table 5 shows that the limiting probability of major contractions is smaller than that of major expansions for the pre-war period and higher for the interior and post-war periods. Tables 3 - 5 suggest the existence of business cycle asymmetry.

As a diagnostic test, we regress y_t onto a constant, $P(S_{t-1} = -1 | y)$ and $P(S_{t-1} = +1 | y)$ in addition to lagged y_t's since the knowledge of regime at t-1 is useful in explaining future y_t according to (4):

(17.1) $$E(y_t | S_{t-1} = -1) = \alpha_0 - \alpha_1 p_{-1,-1} + E(z_t)$$

(17.2) $$E(y_t | S_{t-1} = 0) = \alpha_0 + \alpha_1 (-p_{0,-1} + p_{0,+1}) + E(z_t)$$

(17.3) $$E(y_t | S_{t-1} = +1) = \alpha_0 + \alpha_1 p_{+1,+1} + E(z_t).$$

Thus, the economy is expected to grow slower if it is in the major contraction regime, whereas the economy is expected to grow faster if it is in the major expansion regime. Since $P(S_{t-1} | y)$ are computed from $y_1, \ldots, y_T$ and may be correlated with the error term, we instead use $P(S_{t-1} | y_{t-1}, \ldots, y_1)$. Table 6 uses lag 1 or lags 1 - 4 of y_t. Coefficients for $P(S_{t-1} = -1 | y_{t-1}, \ldots, y_1)$ and $P(S_{t-1} = +1 |$

$y_{t-1}, \ldots, y_1$) are all very significant, have correct signs, and therefore provide another evidence for our framework (4).

5. Conclusions

By decomposing output fluctuations into business cycle and non-business cycle fluctuations, we find that post-war business cycle fluctuations have become more stable even if aggregate output fluctuations have not changed very much across periods. We find that the post-war economy is more likely to remain in the stable growth regime and its regime shifts are less frequent, compared to the pre-war economy. The post-war economy has a longer expected duration for the stable growth fluctuations, a shorter expected duration for major fluctuations, and a higher limiting probability for the stable growth regime. Using Romer's (1992) data set which was used in the past to show no post-war stabilisation, we find that post-war business cycles have been stabilised.

Effective stabilisation policies may reduce the persistence of output shocks, but may not reduce the size of initial shocks. Since we find that stable growth fluctuations have become more dominant and the shifts among regimes have become less frequent, we conjecture that post-war stabilisation policies have played an important role in reducing business cycle fluctuations by reducing the persistence of initial shocks. The infrequent shifts among regimes lead to less fluctuations in permanent income, which in turn enable consumers to better smooth out their consumption.

Table 1

STATISTICS FOR Y_t

	mean	variance
Pre-war	0.3482	2.3249
Inter-war	0.2829	13.4342
Post-war	0.2895	2.1416
Pre-war and post-war	0.3150	2.2197

Table 2

ESTIMATIONS (*)

$$y_t = \alpha_0 + \alpha_1 s_t + \varepsilon_t$$

α_0	α_1	σ	ρ_0	log L	$1-\frac{Var(\varepsilon_t)}{Var(y_t)}$
pre-war (1884.8 - 1917.12)					
0.3805	1.8843	0.9206	(0,0,1)	-670.36	0.6355
(0.1305)	(0.1164)	(0.0489)			
inter-war (1918.1 - 1940.12)					
0.5888	5.1923	2.4328	(0,1,0)	-721.11	0.5594
(0.2796)	(0.4215)	(0.1525)			
post-war (1948.1 - 1991.6)					
0.4893	1.9825	1.2261	(1,0,0)	-918.71	0.2980
(0.1217)	(0.2776)	(0.0568)			
pre-war and post-war					
0.5555	1.9720	1.1144	(0,0,1)	-1602.68	0.4405
(0.0844)	(0.1196)	(0.0383)			

(*) The asymptotic standard errors are in parentheses.

Table 3

MARKOV TRANSITION PROBABILITIES (*)

		$S_{t+1}=-1$	$S_{t+1}=0$	$S_{t+1}=+1$
Pre-War	$S_t=-1$	0.7681 (0.0568)	0.2319 (0.0568)	0
	$S_t=0$	0.0816 (0.0225)	0.7955 (0.0503)	0.1229 (0.0419)
	$S_t=+1$	0	0.3412 (0.0722)	0.6588 (0.0722)
Inter-War	$S_t=-1$	0.7202 (0.0939)	0.2798 (0.0939)	0
	$S_t=0$	0.0660 (0.0226)	0.8573 (0.0360)	0.0767 (0.0275)
	$S_t=+1$	0	0.4806 (0.1128)	0.5194 (0.1128)
Post-War	$S_t=-1$	0.6564 (0.0884)	0.3436 (0.0884)	0
	$S_t=0$	0.0542 (0.0292)	0.9298 (0.0325)	0.0160 (0.0113)
	$S_t=+1$	0	0.3743 (0.1956)	0.6257 (0.1956)
Pre- and Post-War	$S_t=-1$	0.7256 (0.0457)	0.2744 (0.0457)	0
	$S_t=0$	0.0724 (0.0166)	0.8960 (0.0266)	0.0316 (0.0141)
	$S_t=+1$	0	0.3372 (0.0940)	0.6628 (0.0940)

(*) The asymptotic standard errors are in parentheses

Table 4

EXPECTED DURATIONS

	S_t =-1	S_t=0	S_t=+1
Pre-War	4.3131	4.8898	2.9311
Inter-War	3.5737	7.0065	2.0808
Post-War	2.9105	14.2477	2.6718
Pre- and Post-War	3.6445	9.6138	2.9657

Table 5

THE LIMITING PROBABILITIES

	S_t =-1	S_t=0	S_t=+1
Pre-War	0.2057	0.5840	0.2103
Inter-War	0.1690	0.7166	0.1144
Post-War	0.1313	0.8330	0.0357
Pre- and Post-War	0.1944	0.7366	0.0690

Table 6

Regressions of y_t onto $P(S_{t-1}=-1|y_{t-1},...,y_1)$ and $P(S_{t-1}=+1|y_{t-1},...,y_1)$ (*)

$$y_t = \beta_0 + \beta_1 P(S_{t-1}=-1|y_{t-1},...,y_1) + \beta_2 P(S_{t-1}=+1|y_{t-1},...,y_1) + \beta_3 y_{t-1} + \beta_4 y_{t-2} + \beta_5 y_{t-3} + \beta_6 y_{t-4} + u_t$$

β_0	β_1	β_2	β_3	β_4	β_5	β_6
			Pre-War			
0.3569	-3.1353	3.2037	-0.2655			
(0.0389)	(0.0991)	(0.0965)	(0.0245)			
0.4238	-3.0806	2.9575	-0.1211	-0.1613	0.0831	-0.1372
(0.0351)	(0.0950)	(0.0949)	(0.0277)	(0.0213)	(0.0241)	(0.0205)
			Inter-War			
0.5001	-7.8177	9.7626	-0.1572			
(0.1163)	(0.3588)	(0.4025)	(0.0313)			
0.5848	-8.0981	9.5748	-0.1038	-0.1098	-0.0662	-0.0144
(0.1113)	(0.3412)	(0.3809)	(0.0316)	(0.0293)	(0.0292)	(0.0262)
			Post-War			
0.8504	-5.2853	6.5765	-0.3136			
(0.0433)	(0.1737)	(0.3069)	(0.0267)			
0.9511	-5.6393	6.7193	-0.2995	-0.1330	-0.1054	-0.0014
(0.0427)	(0.1682)	(0.2869)	(0.0251)	(0.0223)	(0.0219)	(0.0214)
			Pre-War and Post-War			
0.9007	-4.2396	4.7749	-0.3417			
(0.0302)	(0.0894)	(0.1367)	(0.0187)			
1.0096	-4.5106	4.9862	-0.3060	-0.1469	-0.0641	-0.0489
(0.0285)	(0.0834)	(0.1272)	(0.0173)	(0.0148)	(0.0148)	(0.0137)

(*) The asymptotic standard errors are in parentheses

Figure 1a: Prewar

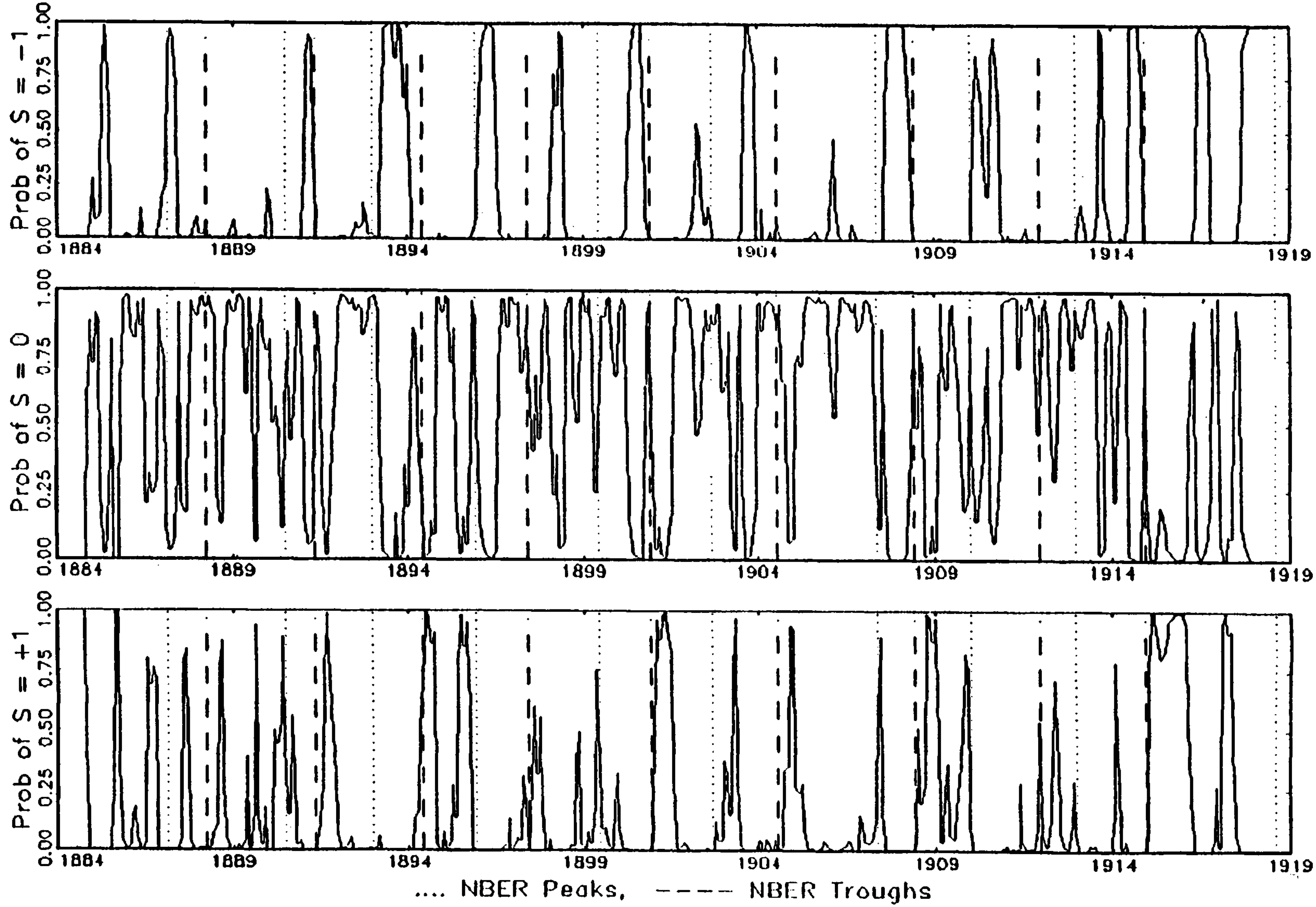


Figure 1b: Interwar

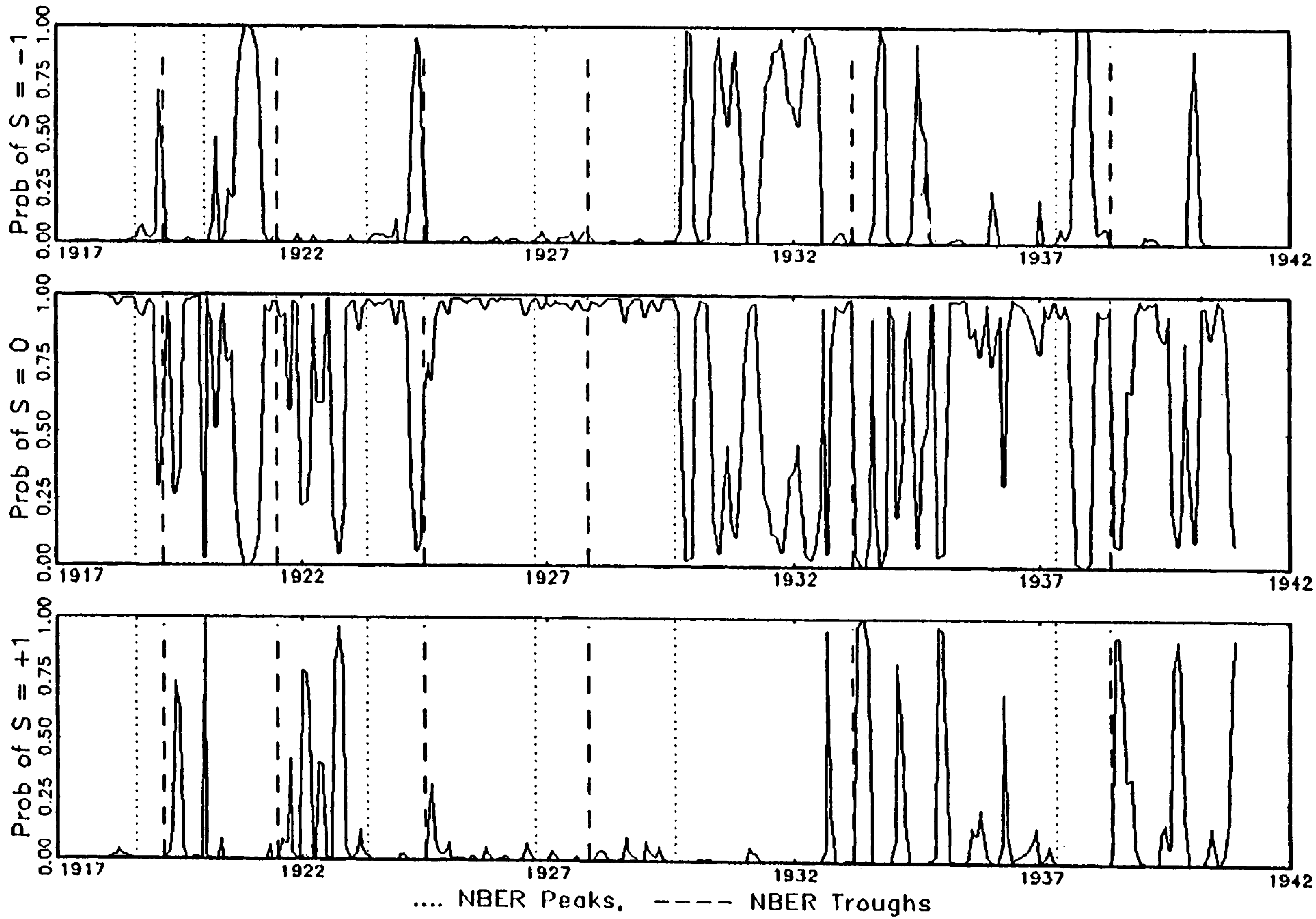
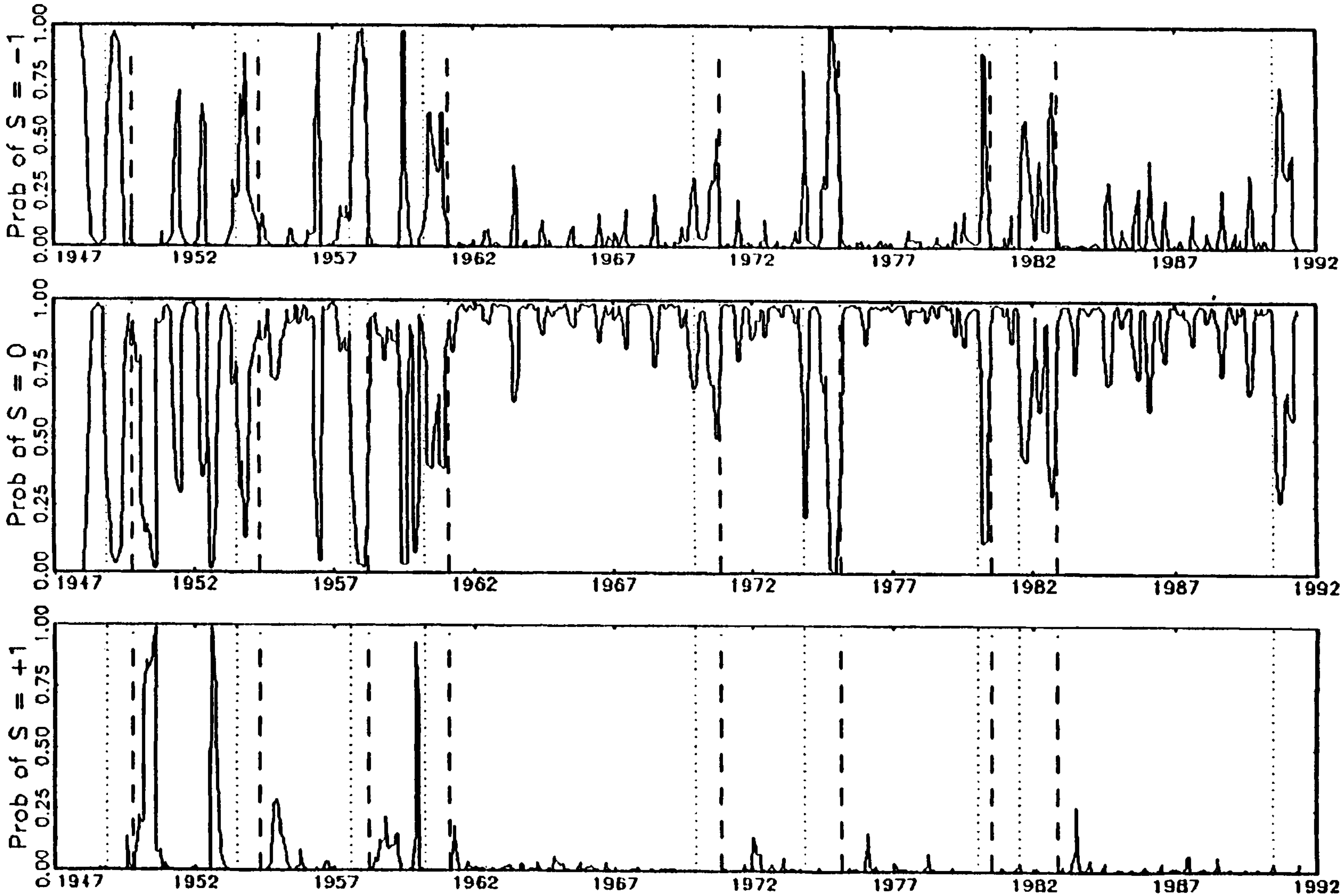


Figure 1c: Postwar



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