Reconstruction of Pre-war U.S. Business Cycle Dates Using Markov Regime-Switching Model*

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Contents

Since the naissance of macroeconomics, one of major policy goals of economic authorities around the world has been to stabilize business fluctuations, and policy makers have strived to achieve the goal through a various set of policies. Until recently, from the comparison of pre-war and post-war aggregate data, macroeconomists have long believed that the US economy has stabilized over the post-war era due to relevant and effective policies. Some even argued that, from the Keynesian perspective, this fact provides evidence for successful government policy after World War II.

* This paper was supported by the 2009 research fund of Hankuk University of Foreign Studies
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However, the conventional belief of the post-war stabilization was seriously challenged by a series of provocative articles by Romer (1986a, 1986b, 1986c, 1989, 1994). Through the comprehensive and meticulous investigation for pre-war data, and construction of alternative pre-war aggregate series of her own, she argues that the post-war stabilization is a myth, simply a ‘pigment of data’. In particular, she claims that the seemingly apparent higher volatility in some macro series for pre-war era is simply due to the dubious quality of pre-war data, or the poor construction method of the data.

However, her contention was also questioned by authors of the traditional view. For instance, Balke and Gordon (1989) used previously unutilized data on individual industries for the period 1869-1928 to construct a new pre- Great Depression GDP series. They found that the volatility of pre- 1929 business cycles based on the new series is fairly close to that of Kuznets series, one of conventional/popular pre-war aggregate data sources. And others (for instance, Lebergott, 1986) further question Romer's methodology, arguing that her data construction also depends on dubious ungrounded assumptions, and so that her series suffer from the low reliability as well, not free from the data accuracy problem.

From a broader perspective of the controversy, discussions above are mainly centered on the volatility and/or amplitude aspect of business cycle fluctuations. Since business cycle dynamics is characterized not only by their severity or amplitude but also by length or duration, some participants of the stabilization debate fail to note duration, another important aspect of economic fluctuations.

In this article, I focus on the duration aspect of pre-war business cycles and attempt to reassess the post-war stabilization hypothesis. My work shares the same idea with Diebold and Rudebusch (1992) and Watson (1994) in that they also approach the stabilization issue from the duration perspective.

The distinguishing feature of the article is to employ Markov regime−switching model to identify the pre−war boom and recession periods and construct alternative business cycle reference dates. In addition, in an environment where poor quality data of pre−war periods is rampant, I used more reliable data source, made available by Miron and Romer (1990) to get around the data quality problem. These newly constructed business cycle dates from the regime−switching model provides several useful and significant implications for pre−war business cycle fluctuations. Finally, based on the newly created dates, I test the post−war stabilization hypothesis using Wilcoxon test. The empirical results largely support the hypothesis.

1. Markov-Switching Model and Derivation of New Pre-war Business Cycle Turning Points.

In this section, a simple Markov−switching model for pre−war industrial production index is presented, and based on the inferred smoothed probability of recession derived from the model, I will construct new business cycle turning points. Markov regime−switching models, developed by Hamilton (1989), have been evaluated as flexible and powerful tools in capturing dynamic, nonlinear behavior of macroeconomic time series and attracted many empirical macroeconomists. In particular, when applied to the post−war U.S. GDP data, the model performs remarkably well: the periods inferred as booms from the model are quite similar to the official NBER business cycle reference dates (Hamilton, 1989; Kim and Nelson, 1999a, 1999b), and they also succeed in providing sharp distinctions between boom and recession periods.

As discussed in the previous section, the existing pre-war aggregate data suffer from low reliability, and therefore the NBER business cycle reference dates for that era also are questionable due to this. Indeed, many authors point out and question the validity of pre-war NBER reference dates (Cloos, 19631, 1963b; Zarnowitz, 1963a, 1963b, More and Zarnowitz, 1986). All these elements imply that researchers of business cycle fluctuations live in an environment of uncertainty for pre-war business cycle dynamics, with unreliable information about qualitative changes of the economy. In this sense, Markov-Switching model can provide useful implications for this problem.

Consider the following AR(4) Markov-Switching model for pre-war industrial production index:

(2-1) $$(\Delta y_t - \mu_{S_t}) = \sum_{j=1}^{4} \phi_j (\Delta y_{t-j} - \mu_{S_{t-j}}) + \varepsilon_t$$

(2-2) $$\varepsilon_t \sim i.i.d.N(0, \sigma^2)$$

(2-3) $$\mu_{S_t} = \mu_0(1 - S_t) + \mu_1 S_t$$

(2-4) $$\Pr[S_t = 1 | S_{t-1} = 1] = p, \qquad \Pr[S_t = 0 | S_{t-1} = 0] = q,$$

where y_t's are the logarithm of industrial production, and μ_{S_t} is the (regime-dependent) mean growth rate of industrial production (see the next section for the choice of data variables). In this model, the mean growth rate switches depending on regime: the binary state variables, S_t takes the value of 1 during expansions or 0 during recessions, so that the mean of the growth rate in the industrial production is μ_1 or μ_0. And these regimes-switches are determined by the transition probabilities, p and q.

The parameters in above model are estimated with Maximum Likelihood Estimation (MLE), and then the inference about the state variables S_t is made. Also, depending the amount of information used in making the inference on S_t, I obtain filtered and/or smoothed probabilities. (Technical details on computations and filtering algorithm can be found in Kim, Chang-Jin and Nelson, Charles, 1999a).

2. Empirical Results

A. Data

As discussed before, in the case of pre-war aggregate data, it seems difficult to find comprehensive and high frequency data appropriate for business cycle dynamics analysis. Most available series cover rather short period or suffer from low reliability for a variety of reasons. Although relatively more accurate data have been constructed from the process of the debate discussed in Section 1, the data are mostly annual data. This prevents researchers from capturing monthly dynamic aspects of business cycles and makes it difficult to date critical phases, or turning points. Recently, however, more reliable data source was made available by Miron and Romer (1990): new industrial production (IP) index from 1884:1 1940:12. This new index has several advantages over other existing series; covering comprehensively longer span, it was constructed using only industry component series that is consistent over time, without relying on indirect proxies or making ad hoc adjustments to the data. In contrast to the existing pre-war monthly IP indices (FRB, Macaulay's pig iron, Person's index, etc.) most of which are believed to be full of limitations, Miron and Romer index is significantly improved and reliable measurement of industrial production. So I used this data to estimate the model.

The use of industrial production index for business cycle turning points analysis can be justified by following reasons. First, the index of industrial production is one of few comprehensive aggregates available at monthly frequency for pre-war periods. Since monthly dates are commonly used as key reference frequency in business cycle studies, and post-war- and NBER dates are determined on a monthly basis, one needs to use a monthly series for consistent comparison. Second, the index of industrial production is one of primary series that the current NBER researchers rely on in determining the present business cycle dates, and the NBER classifies it as a coincident indicator. Therefore, the industrial production index can be thought of as a good proxy in capturing the important qualitative aspects of the business fluctuations.

Since Miron and Romer index is available as raw data, seasonal adjustments were necessary before using it to estimate the model. To do so, I first regressed the raw series on a constant, two autoregressive terms, and eleven monthly dummies; then removed the seasonal effects. And in order to capture any possible idiosyncrasies from structural changes during the Great Depression, I included monthly dummy variables for 1929-1933.

B. Estimation Results

The estimates for the parameters in the model are presented in Table 1. The result is successful by and large. Most of the estimates are significant. Although the estimate for mean growth rate during recessions is positive, it is much smaller than that of the boom period and is statistically insignificant.

Unfortunately, the smoothed probabilities fail to make clear distinctions between boom and recession periods in a few occasions, unlike other benchmark models previously mentioned. I suppose this result is induced by the monthly nature of the data, which contain relatively more noise than quarterly or annual data. Indeed, previous researchers employing Markov regime-switching models have mostly used quarterly data.

Nevertheless, I noticed that some features of the smoothed probabilities are interesting and still useful for our purpose. A careful inspection of the smoothed probabilities reveals that they also display nice business cycle-like fluctuations, i.e., the sharp changes in smoothed probabilities can match with turning points of actual business cycles (as troughs and peaks, respectively). In other words, the smoothed probabilities may provide good guideline to identify possible business cycle turning points. Noting that, I attempted to create new business reference dates based on the model.

In identifying new business cycle dates and creating turning points, I followed the following rules: (i) I ignored some minor and negligible fluctuation occurring for relatively short periods (mainly due to the nature of monthly data and possible measurement errors), i.e. within a year. (ii) when the smoothed probability series fail to make clear display of turning points and regimes (as in late 1930's), I mainly followed the Romer (1994) dates with reference to actual industrial production index and NBER dates.

The new pre-war business cycle turning points created by this procedure are presented in table 2 along with NBER dates and Romer (1994) dates, which also attempted to derive her own alternative dates based on Miron and Romer IP index. Overall, the new dates depart from those of NBER and Romer dates in a non-negligible way, although all three are similar in terms of the number of peaks and troughs. The exact timing of turning points varied for most individual cycles; the new peak and trough dates often lagged a few months, even up to a year, and some new cycles undetected in two previous dates are identified, while some cycles recorded by NBER or Romer are not captured by the new dates at all.

3. Test of Post-war Stabilization: Duration Perspective

In this section, I attempted to test the post−war stabilization in duration perspective using the new turning point dates derived in the previous section. First, newly constructed business turning points for the pre−war period are summarized in terms of its duration and whole cycles in table 3, together with the post−war NBER reference dates for comparison purposes. A simple glance reveals that post−war economy can be characterized by relatively longer expansions, and slightly shorter recessions.

To test the stabilization hypothesis formally, this article relied on the Wilcoxon or rank−sum test, which is a distribution−free statistical procedure. Consider the two samples of pre−war $(X_1, X_2, \cdots, X_n)$ and post−war $(Y_1, Y_2, \cdots, Y_m)$ durations with distribution functions $F(x)$ and $G(y)$, respectively. Under the null hypothesis, that is, no post−war stabilization, it is true that $F(z) = G(z)$ for all z, while the one−sided alternative hypothesis of stabilization implies that $G(z) < F(z)$. Or more intuitively, when the samples are drawn from distribution $F(x)$ and $F(x+\Delta)$ respectively, one−sided alternative hypothesis means $\Delta > 0$.

Using the above sample notation, the Wilcoxon test statistic is defined as:

$$W = \sum_{i=n+1}^{n+m} R_i \quad ,$$

where R_i is the rank of post-war samples.

As discussed in Section 3, the newly constructed dates are not completely successful in capturing the turning points for entire pre-war periods considered, and in addition the economic fluctuations are occasionally affected by non-economic events such as wars. So, in order to check the robustness of the results, I consider three alternative samples (all the possible samples considered are summarized in Table 4):

(i) In the first alternative sample, I replaced the problematic post-Great Depression dates of the new dates with the NBER official reference cycle dates.

(ii) In the second set of samples, I also considered three pre-war samples with different ending points: pre-World War II (~1938:2), pre-Great Depression (~1929:8), and pre-World War I (~1914:12).

(iii) Finally, I considered the sample pairs excluding the war-time expansions for both eras.

With these issues taken into account, the Wilcoxon test results for expansions and contractions are shown in Tables 5 and 6 along with 5% and 1% critical values, respectively. For expansions, results are remarkably strong and robust with respect to samples used: except for only two cases, the null hypothesis of no longer post-war expansion is rejected at 5% significance level, and is rejected at 1% level about half sample pairs. However, for contractions, the hypothesis of shorter post-war contractions is rejected for all pairs of samples, although the mean duration of post-war samples is about two thirds of that of pre-war's.

While test results are clear for expansions and contractions, results were somewhat mixed depending on the selected sample when the Wilcoxon test was applied to the whole cycle samples. As Table 7 shows, for 9 out of 14 sample combinations, the null hypothesis of no stabilization of post-war business cycles was rejected at 5% significant level, but when war-time expansions are excluded from the post-war samples, most results did not support the post-war stabilization hypothesis. Hence, although the post-war business fluctuations are more persistent as a whole, this fact is mainly due to war-time expansions. On average, peace-time cycles are longer than the preceding periods, while their distributions are not statistically different.

In summary, when compared with the pre-war era, the post-war U.S. economy has seen mildly longer, if not the same, business cycles, and it is typically characterized by longer expansions (by almost twice), and slightly shorter recessions.

4. Concluding Remarks

This paper attempted to create new pre-war business cycle turning point dates through utilizing the Markov regime-switching model and reevaluate the U.S. post-war stabilization in terms of duration rather than traditional volatility. Using the Wilcoxon test, a distribution free statistical procedure, this paper has reassured the standard conclusion. Overall test results suggest that there are evidences in support of the shift toward longer expansions for post-war periods along with slightly shorter contractions, making the whole cycles more persistent in some cases, all of which is consistent with a broad interpretation of the stabilization hypothesis.

Seeking for evidence of post-war economic stabilization has important implications in macroeconomics, and it provides sufficient motivation for efforts in identifying the causes for that change, although this paper does not cover the latter point in detail. Furthermore, an understanding of the reasons for the improvement in (post-war) macroeconomic stability has invaluable implications for policies. Until mid 80's, there seemed at least two explanations of the possible factors alleged to have led to greater stability (Taylor, 1986; DeLong and Summers, 1986). They are: (i) the change in the propagation mechanism of shocks: through the rigidities of price and wage, the smaller shocks are translated into prolonged movements in output during the post-war period. Combined with this factor, the accommodative monetary policy may also have contributed to this. (ii) public and private efforts to smooth consumption: growth in the number of consumer credit of various types has led to smoother consumption, enhancing stability. However, some criticisms for above views and other researches with different approaches for this topic still exist.

In this regard, it is worth mentioning that recent various approaches with theoretical development and the improvement in macroeconometric methodology seem to be very useful for analyzing this issue. In particular, with dynamic stochastic general equilibrium (DSGE) model and vector autoregression (VAR) models with time-varying coefficients, researchers have been to trying to identify the various sources and the magnitude of so-called the great moderation, a term coined to refer to the noticeable decrease in aggregate volatility around mid 80's (for example, Kim, Nelson, and Piger, 2004; Justiniano and Primiceri, 2008). As this line of research has been very active recently and a few consensuses seem to have started to emerge, we may soon expect more persuasive and clearer answer to the issue.

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Table 1: Estimates of the Model

parameter	p	q	ϕ_1	ϕ_2	ϕ_3	ϕ_4	μ_0	μ_0
estimate	0.9141	0.8427	0.8133	−0.7529	0.3041	−0.1540	0.1008	0.4500
standard error	0.0261	0.0798	0.0584	0.1441	0.1391	0.0527	0.2032	0.1956

Table 2: Comparison of Pre-war Peaks and Troughs

NBER Reference Dates		Romer Dates		New Alternative Dates	
Peak	Trough	Peak	Trough	Peak	Trough
1887:3	1884:4	1887:2	1887:7	1888:4	1889:10
1890:7	1891:5			1890:7	1891:3
1893:1	1894:6	1893:1	1894:2	1893:7	1894:10
1895:12	1897:6	1896:1	1897:1	1896:3	1897:3
1899:6	1900:12	1900:4	1900:12	1900:5	1901:02
1902:9	1904:8	1903:7	1904:3	1903:7	1904:11
1907:5	1908:6	1907:1	1908:6	1907:10	1908:8
1910:1	1912:1	1910:1	1911:5	1910:1	1910:11
1913:1	1914:12	1914:6	1914:12	1913:7	1914:12
		1916:5	1917:1	1916:2	1917:5
1918:8	1919:3	1918:7	1919:3	1919:5	1920:1
1920:1	1921:7	1920:1	1921:3	1920:9	1922:6
1923:5	1924:7	1923:5	1924:7	1920:9	1922:6
1926:10	1927:11	1927:3	1927:12	1927:8	1928:3
1929:8	1933:3	1929:9	1932:7	1930:6	1933:10
1937:5	1938:6	1935:5	1938:6	1935:5	1936:3
		1939:12	1940:3	1938:2	1940:4

Table 3: New Business Cycle Reference Dates and Duration

Trough	Peak	Contraction	Expansion	Cycles	
				Trough to trough	Peak to peak
1889:10	1890:7	–	9	–	–
1891:3	1893:7	8	28	17	36
1894:10	1896:7	15	17	43	32
1897:3	1990:5	36	38	29	50
1901:2	1903:7	7	29	47	38
1904:11	1907:10	16	35	45	39
1908:8	1910:1	10	17	45	25
1910:11	1913:7	10	32	27	42
1914:12	1916:2	17	**14**	**49**	**31**
1917:5	1919:5	13	**24**	**29**	**39**
1920:1	1920:9	7	8	32	16
1922:6	1923:6	19	12	29	33
1924:8	1927:8	14	36	26	50
1928:3	1930:6	7	27	43	34
1933:10	1935:5	40	19	68	59
1936:3	1938:2	10	23	29	33
1940:4		26	–	37	–
1938:6	1945:2	13	**80**	63	**93**
1945:10	1948:11	8	37	**88**	45
1949:10	1953:7	11	**45**	48	56
1954:5	1957:8	10	39	55	49
1958:4	1960:4	8	24	47	32
1961:2	1969:12	10	**106**	34	**116**
1970:11	1973:11	11	36	**117**	47
1975:3	1980:1	16	58	52	74
1980:7	1981:7	6	12	64	18
1982:11	1990:7	16	92	28	108
1991:3	2001:3	8	120	104	136
2001:11		8		128	

Table 4: Description of Samples

Ⅰ. Pre-World war Ⅱ
- Ⅰ1: all observations
- Ⅰ2: Ⅰ1, replacing 1935-1936 contraction with NBER dates
- Ⅰ3: Ⅰ1, excluding war-time observations
- Ⅰ4: Ⅰ2, excluding war-time observations

Ⅱ. Pre- Great Depression
- Ⅱ1: all observations
- Ⅱ2: II1, excluding war-time observations

Ⅲ. Pre-World War Ⅰ (1889:10 ~ 1914:12)
- Ⅲ-1: all observations

Ⅳ. Post-World War Ⅱ (1945:2 ~ 1990:7)
- Ⅳ-1: all observations
- Ⅳ-2: Ⅳ-1, excluding war-time observations

Note: Figures printed in bold italic in Table 3 are the wartime expansions (Civil War, World Wars I and II, Korean War, and Vietnam War); the postwar contractions, and the full cycles that include the wartime expansions.

Table 5: Wilcoxson Test for Expansion

sample		sample size		mean duration		**Wilcoxson test**		
X	*Y*	*n*	*m*	$\bar{x}$	$\bar{y}$	*W*	*W*(0.05)	*W*(0.01)
I−1	IV−1	16	9	37.1	60.6	144.5*	141	152
I−2	IV−1	16	9	37.4	53.3	144.5*	141	152
I−3	IV−1	14	9	37.5	60.6	129.5*	129	139
I−4	IV−1	14	9	37.8	53.3	129.5*	129	139
I−1	IV−2	16	7	37.1	60.6	88.5	105	114
I−2	IV−2	16	7	37.4	53.3	88.5	105	114
I−3	IV−2	14	7	37.5	60.6	106.5**	95	103
I−4	IV−2	14	7	37.8	53.3	106.5**	95	103
II−1	IV−1	13	9	35.9	60.6	125.5*	123	132
II−2	IV−1	13	9	36.1	53.3	112.5*	111	119
II−1	IV−2	11	7	35.9	60.6	86.5	91	91
II−2	IV−2	11	7	36.1	53.3	75.5	81	87
III	IV−1	8	9	37.4	60.6	92.5*	92	99
III	IV−1	8	7	37.4	53.3	61.5	66	71

Notes: W is Wilcoxson test statistics, and W(0.05) and W(0.01) are respectively, 5% and 1% one−sided critical values for the null hypothesis of no change in the duration distribution. * and ** denote the statistics are significant for 5% and 1% levels, respectively.

Table 6: Wilcoxon Test for Contraction

sample		sample size		mean duration		Wilcoxson test		
X	*Y*	*n*	*m*	$\bar{x}$	$\bar{y}$	*W*	*W*(0.05)	*W*(0.01)
I−1	IV−1	15	9	15.3	10.7	98	84	73
I−2	IV−1	15	9	16.2	10.7	93	84	73
II−1	IV−1	13	9	13.8	10.7	93	78	68
III	IV−1	8	9	14.9	10.7	73	63	57

Notes: W is Wilcoxson test statistics, and W(0.05) and W(0.01) are respectively, 5% and 1% one−sided critical values for the null hypothesis of no change in the duration distribution. * and ** denote the statistics are significant for 5% and 1% levels, respectively.

Table 7: Wilcoxon Test for Peak to Peak Cycles

sample		sample size		mean duration		Wilcoxson test		
X	Y	N	m	$\bar{x}$	$\bar{y}$	W	W(0.05)	W(0.01)
I−1	IV−1	15	9	37.1	60.6	144.5*	141	152
I−2	IV−1	15	9	37.4	53.3	144.5*	141	152
I−3	IV−1	13	9	37.5	60.6	129.5*	129	139
I−4	IV−1	13	9	37.8	53.3	129.5*	129	139
I−1	IV−2	15	7	37.1	60.6	88.5	105	114
I−2	IV−2	15	7	37.4	53.3	88.5	105	114
I−3	IV−2	13	7	37.5	60.6	106.5**	95	103
I−4	IV−2	13	7	37.8	53.3	106.5**	95	103
II−1	IV−1	12	9	35.9	60.6	125.5*	123	132
II−2	IV−1	10	9	36.1	53.3	112.5*	111	119
II−1	IV−2	12	7	35.9	60.6	86.5	91	91
II−2	IV−2	10	7	36.1	53.3	75.5	81	87
III	IV−1	7	9	37.4	60.6	92.5*	92	99
III	IV−1	7	7	37.4	53.3	61.5	66	71

Notes: W is Wilcoxson test statistics, and W(0.05) and W(0.01) are respectively, 5% and 1% one−sided critical values for the null hypothesis of no change in the duration distribution. * and ** denote the statistics are significant for 5% and 1% levels, respectively.

Abstract

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This article attempts to (re)assess the post-war stabilization hypothesis for U.S. economy. Unlike most works that look at the issue in terms of volatility and/or amplitude aspect of business cycles, I approach the stabilization issue from the duration perspective, in line with Diebold and Rudebusch (1992) and Watson (1994). One of the distinguishing features of the article is, in identifying the pre-war boom and recession periods, to employ the Markov regime-switching model and construct alternative pre-war business cycle reference dates. These newly constructed business cycle dates from the regime-switching model provide useful and significant implications for pre-war business cycle fluctuations. Finally, based on the newly created dates, I test the post-war stabilization hypothesis. The empirical results largely support the hypothesis.

Key words: Markov regime-switching model, post-war stabilization hypothesis, business cycle duration
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논문접수일: 2009. 11. 2
심사완료일: 2009. 11.12
게재확정일: 2009. 12.14

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