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Abstract

This article extends earlier efforts at redating the US industrial cycles for the prewar period (1890-1938) using the methodologies proposed by Bry and Boschan (1971) and Hamilton (1989) and based on the monthly industrial production index constructed by Miron and Romer (1990) and modified by Romer (1994). The alternative chronology detects 90% of the peaks and troughs identified by the NBER and Romer (1994), but the new dates are consistently dated earlier for more than 50% of them, especially as regards the NBER troughs. The new dates affect the comparison of the average duration of recessions and expansions in both pre- WWI and interwar eras. Whereas the NBER reference dates show an increase in average duration of the expansions between the pre-WWI and interwar periods, the new dates show evidence of shortened length of expansions. However, the new dates confirm the traditional finding that contractions lasted longer in the post-war period than during the pre-war period.

Keywords: Industrial business cycle; Dating chronology.

JEL Classification: C22; E32; N21; N22.

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1 Introduction

In their seminal contribution to the classical business cycle literature, Burns and Mitchell (1946) define business cycles as follows:

> "*Business cycles are a type of fluctuations found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own*" (Burns and Mitchell, 1946, p. 3).

These rules on the business cycles are the basis of the methodology employed by the National Bureau of Economic Research (NBER) for producing the business cycle reference dates for the United States, which show the peaks and troughs of economic activity from the mid-1800s to today. Nevertheless, some researchers question the accuracy of the NBER reference dates and particularly the consistency of these dates over time. For example, Diebold and Rudebusch (1992) state:

> "*All of the researchers who have designated NBER turning points have cautioned that there is some uncertainty about the precise timing of the general turns in business activity. One indication of the uncertainty associated with the official dates is the discrepancy between these dates and a number of alternative dates that have been suggested by NBER researchers and by independent observer*" (Diebold and Rudebusch, 1992, p. 996).

Furthermore, even Burns and Mitchell (1946) state:

> "*This is not to say that the reference dates must remain in their present state of rough approximation. Most of them were originally fixed in something of a hurry; revisions have been confined mainly to large and conspicuous errors, and no revision has been made for several years. Surely, the time is ripe for a thorough review that would take account of extensive new statistical materials, and of the knowledge gained about business cycles and the mechanics of setting reference dates since the present chronology was worked out*" (Burns and Mitchell, 1946, p. 95).

Although the general dating procedures employed in the NBER have not changed, both the number and quality of the underlying individual series examined have greatly increased over time as well as statistical techniques and the understanding of economic fluctuations. Indeed, the increase in the number of underlying individual series used by the NBER was accompanied by an increase in the quality of most series, implying an increased reliability of the NBER dates, especially in the post- World War II (WWII, thereafter) period. Nevertheless, there is evidence of uncertainty in the literature about some of the pre-WWII NBER dates due to the varying quality of the data. More precisely, the turning point dates before World War I (WWI, thereafter) seem to be more questionable than those in the interwar period (1918-1940). Romer (1994) shows that the methods used to date the early cycles are quite different from those used in the postwar era. The most important difference between the early and modern methods is that the business cycle reference dates before 1927 appear to be derived primarily from detrended data, whereas the dates after 1927 are based on data that include the secular trend. This difference can lead to (i) the misclassification of growth cycles, as defined by deviation to the long term trend by Mintz (1969) as genuine business cycles in the pre-1927 era, which can cause more cycles to be identified in the early period than in the post-WWII; (ii) the misidentification of business cycle dates, which can affect the duration of the contractions and expansions between two periods.

In this paper, we propose an alternative set of monthly peaks and troughs of the US industrial cycles for the pre-WWII period (1884-1940) by using the monthly industrial production index proposed by Miron and Romer (1990) and modified by Romer (1994), and the methodologies suggested by Bry and Boschan (1971) and Hamilton (1989) in order to identify turning points in economic cycles. Romer (1994) also used the adjusted Miron-Romer index of industrial production for dating business cycles. She derived an alternative dating algorithm that parsimoniously incorporates the duration and amplitude criteria rather than Burns-Mitchell rules for identifying specific cycles, which are expressed in terms of duration and amplitude, because these rules are complex and cumbersome.[1] Nevertheless, these rules such as the computer algorithm developed by Bry and Boschan (1971) mimic NBER specific cycle dating procedures. Their methodology allows to select turning points as defined by Burns and Mitchell (1946), and is generally considered to be quite successful at replicating the dates chosen by the NBER (e.g., Watson, 1991; King and Plosser, 1994; Harding and Pagan, 2003; Stock

[1] Note that Romer (1994) states concerning her algorithm that "*the only cases in which this rule might fail are a very short but sharp recession, or a very long but mild one*" (Romer, 1994, p. 584).

and Watson, 2010). This algorithm is a set of ad hoc filters and rules that determine business cycle turning points in a macroeconomic time series. Essentially, the algorithm isolates local minima and maxima in a time series, subject to constraints on both the length and amplitude of expansions and contractions. Markov-Switching (MS) models, popularized by Hamilton (1989), have been widely used in business cycle analysis in order to reproduce economic fluctuations, (see for example Ferrara, 2003; Clements and Krolzig, 2003; Artis et al., 2004; Chauvet and Hamilton, 2006; Anas et al., 2007; Layton and Smith, 2007 or Chauvet and Piger, 2008). Actually, the popularity of the work of Hamilton is mainly grounded on the ability of this specific parametric model to reproduce the NBER business cycle dating estimated by expert claims within the Dating Committee. More recently, some other non-linear parametric models able to account for asymmetries and changes in regimes have been put forward in order to replicate business cycles. We refer for example to the threshold autoregressive (TAR) model, introduced by Tong (1990) or the smooth transition autoregressive (STAR) model, put forward by Teräsvirta (1994), Such models differ from MS models in the sense that the variable governing changes in regimes is observed, leading thus to easier statistical inference. Those models have also proved useful to identify business cycles as shown for example by Deschamps (2008) or Billio et al. (2013). However, in this latter paper on euro area data, it has been shown that MS models tend to be more reliable as they send fewer false signals of recessions. While it seems useful to perform further comparisons on non-linear models for business cycle analysis, we prefer in this paper to focus only on MS models.

Based on both non-parametric and parametric approaches, we propose an alternative industrial business cycle chronology, for which the MS approach is employed to give some robustness of new peaks and troughs obtained from the Bry-Boschan approach. The alternative chronology detects 90% of the peaks and troughs identified by the NBER and Romer (1994), but the new dates are consistently dated earlier for more than 50% of them, especially as regards the NBER troughs. The new dates affect the comparison of the average duration of recessions and expansions in both pre-WWI and interwar eras. Whereas the NBER reference dates show an increase in average duration of the expansions between the pre-WWI and interwar periods, the new dates show evidence of shortened length of expansions. This result confirms the view that "*The NBER's chronology has been faulted for seriously exaggerating both the frequency and the duration of pre-Fed cycles and for thereby exaggerating the Fed's contribution to* *economic stability.*" (Selgin et al., 2012, p. 581).[2]

However, the new dates confirm the traditional finding that contractions lasted longer in the post-war period than during the pre-war period.

The remainder of this paper is organized as follows: Section 2 describes the monthly industrial production index created by Miron and Romer (1990); Section 3 briefly presents the methodologies of Bry and Boschan (1971) and Hamilton (1989) for dating the cycles; Section 4 discusses the alternative chronology and compares it with those of the NBER and Romer (1994). The conclusion is drawn in Section 5.

2 Data

For dating the industrial cycles, we use the index of industrial production derived by Miron and Romer (1990) for the period 1884 to 1940. This aggregate series is useful for mimicking the NBER procedures because industrial production is one of the most comprehensive aggregate series that is available monthly and is one of the main series employed by the NBER for setting reference dates. Furthermore, the NBER classifies this aggregate as a coincident indicator.[3]

Miron and Romer (1990) created a monthly index of industrial production for the period 1884 to 1940. This aggregate series is not truly consistent with the modern Federal Reserve Board's (FRB) index[44] because it is based on many fewer series than is the modern FRB index, and many sectors of the economy are either over- or underrepresented relative to their actual share of value added. Romer (1994) adjusted the Miron-Romer index because this index is more volatile than the FRB index and tends to have more random movements. To be more comparable to the FRB index, she estimates a regression between the FRB index and the Miron-Romer series in a period of overlap (1923-1928). Then, this estimated relationship is used to form adjusted values for the Miron-Romer index for the period before 1919. The resulting prewar index of industrial production combines the adjusted Miron-Romer series for the period 1884 to 1918 and the FRB index for the period 1919 to 1940.

[2] Further, Selgin et al. (2012) argue that the Fed has never done better with respect to price stability, real economic stability and financial stability compared to the regime which preceded it – the classical gold standard, national banking, US Treasury and Clearing House regime.

[3] Moreover, Romer (1994) states that "*One piece of evidence that industrial production is roughly as good an indicator for the prewar economy as for the postwar economy is the fact that manufacturing and mining, the two main components of any index of industrial production, have not become a larger or smaller fraction of the economy between 1884 and today.*" (Romer, 1994, p. 589).

[4] The FRB index of industrial production is one of the main series that the current NBER Committee on Business Cycle Dating considers in setting modern reference dates.

The main advantage of the Miron-Romer index is that it has not already been detrended, seasonally adjusted, or otherwise manipulated. This is in contrast to the existing prewar indexes of industrial production, which are typically available only in highly adjusted forms.

3 Methodologies of business cycle dating

In the empirical literature on business cycle analysis, two main methods are generally considered when the aim is to generate a chronology of business cycle turning points. The first approach is a non-parametric approach put forward by Bry and Boschan (1971) relying on a pattern recognition algorithm to identify peaks and troughs in a time series. The second approach builds on a time series model introduced by Hamilton (1989) that enables him to account for non-linearities of the business cycles through a first order Markov chain governing changes in regimes. This section presents both approaches and discusses main advantages and drawbacks for business cycle dating.

3.1 Bry-Boschan approach

Bry and Boschan (1971) provide a nonparametric, intuitive and easily implementable algorithm to determine peaks and troughs in individual time series, based on Burns-Mitchell rules for identifying specific cycles, expressing in terms of duration and amplitude. Although the method is quite commonly used in the literature, we briefly sketch its main sequential steps here.[5] First, on the basis of some well-specified criterion, extreme observations are identified and replaced by corrected values. Second, troughs (peaks) are determined for a 12-month moving average of the original series as observations whose values are lower (higher) than those of the five preceding and the five following months. In case two or more consecutive troughs (peaks) are found, only the lowest (highest) is retained. Third, after computing some weighted moving average, the highest and lowest points on this curve in the ±5 months-neighborhood of the previously determined peaks and troughs are selected. If they verify some phase length criteria and the alternation of peaks and troughs, these are chosen as the intermediate turning points. Fourth, the same procedure is repeated using an unweighted short-term moving average of the original series. Finally, in the neighborhood of these intermediate turning points, troughs and peaks are determined in the unsmoothed time series. If these pass a set of duration and amplitude restrictions, they are selected as the final

[5] For a detailed description, the reader is referred to Bry and Boschan (1971).

turning points. The adherent analytical steps and set of decision rules for selecting turning points are summarized in the Appendix.

3.2 Markov-switching approach

We present below a univariate version of the MS model with $K = 2$ regimes, which can be easily extended to more than two regimes. We define the second order process $(X_t)_{t\in Z} = (X^1_t, \ldots, X^N_t)_{t\in Z}$ as a MS(2)-AR(p) if it verifies the following equation:

$$X_t - \mu(S_t) = \sum_{i=1}^{p} \phi_i(S_t)(X_{t-i} - \mu(S_{t-i})) + \sigma(S_t)\varepsilon_t, \tag{1}$$

where $(S_t)_t$ is a random process with values in $\{1,2\}$, where $(\varepsilon_t)_{t\in Z}$ is a white noise Gaussian process with finite unit variance and where $\phi_1(S_t), \ldots, \phi_p(S_t)$ are autoregressive parameters depending on the regime S_t, as well as the standard error $\sigma(S_t)$. The full representation of the model requires the specification of the variable $(S_t)_t$ as a first order Markov chain with two regimes. That is, for all t, S_t depends only on S_{t-1}, i.e.:

$$P(S_t = j|S_{t-1} = i, S_{t-2}, S_{t-3}, \ldots) = P(S_t = j|S_{t-1} = i) = p_{ij} \quad \text{for } i, j = 1, 2. \tag{2}$$

The probabilities p_{ij} $(i, j = 1, 2)$ are the transition probabilities; they measure the probability of staying in the same regime and switching from one regime to the other. They provide a measure of the persistence of each regime. Obviously, we get: $p_{i1} + p_{i2} = 1$, for $i = 1, 2$. Estimated durations of regimes, $D(S_t = i)$ for $i = 1, 2$, are given by: $D(S_t = i) = 1/(1 - p_{ii})$. The estimation step enables to get, for each date t, the forecast, filtered and smoothed probabilities of being in a given regime i, respectively defined by $P(S_t = i|\hat{\theta}, X_{t-1}, \ldots, X_1)$, $P(S_t = i|\hat{\theta}, X_t, \ldots, X_1)$ and $P(S_t = i|\hat{\theta}, X_T, \ldots, X_1)$, where $\hat{\theta}$ is the estimated parameter. In our dating framework, we will consider only the smoothed probabilities. Estimation is carried out using the EM algorithm proposed by Hamilton (1990).

The choice of the number of regimes K is always an issue when dealing with empirical applications. Some testing procedures have been put forward in the literature to test the number of regimes but cannot be easily implemented (we refer for example to Hansen, 1992, or Hamilton, 1996). In this paper, we assume that K = 2 in order to reproduce the expansion/recession sequence initially considered by Burns and Mitchell (1946). Note however that, from our empirical results, the inclusion of a third regime does not help to improve the interpretation of the model.

3.3 Comparison of both approaches for business cycle dating

Both previous approaches have been widely used in the literature on business cycle analysis, especially as regards the construction reference turning point chronologies. When the objective is to build a turning point chronology, some properties can help to compare the methods, as for example transparency (the dating method must be replicable to every one), adaptability of the method to different series and countries, robustness to extreme values, and to the sample or stability of the chronology through time (see for example Anas et al., 2007).

When looking at the empirical literature, it turns out that MS models, since the seminal paper of Hamilton (1989), have often proved useful to replicate business cycles. However, there is no guarantee that the MS model is able to distinguish periods of recessions, as defined by common tradition. The model only separates regimes in accordance to the specification of the model in order to fit the data. This separation will be different if we change the specification: variances depending on regimes, time-varying transition probabilities, autoregressive terms, etc…. It is not certain that we may find the best specification that identifies business cycles by minimizing criteria like AIC or BIC, on the contrary, many alternative models, i.e. representations, are possible. For example, it seems that there are equivalent combinations of estimates of autoregressive terms and transition probabilities as both parameters capture the time dependence of data.

As a result, MS models do not necessarily provide a turning point chronology that is robust to the sample, that is estimating the model by sub-samples does not necessarily generate the same dates for turning points. Typically the addition of new data points to the sample can lead to a modification of the turning point dates, therefore not ensuring turning point stability through time. This is the reason why when using MS models in order to replicate business cycles, some authors impose a higher threshold than the natural threshold of 0.5 before sending a signal of recession based on the estimated conditional probability (see Darné and Ferrara, 2011). Also, Chauvet and Hamilton (2006) imposed ad-hoc constraints on the conditional probability to recognize a recession. Overall, it seems to us that non-parametric approaches are more suitable for the dating of past turning points, in the line of Harding and Pagan (2002).

4 Dating results

4.1 Alternative Dating

Following the conclusions exposed in the previous section, our strategy in this

paper is to apply both the BB and MS approaches, but we consider the BB chronology as the benchmark, while the MS chronology is used by comparison.
We apply the Bry-Boschan algorithm as well as the MS model to the adjusted index of industrial production (1884-1940) to propose new peak and trough dates.
As regards the MS model, various autoregressive degree p are considered ranging from $p = 0$ to $p = 6$. When considering the smoothed probability of being in the low regime ($S_t = 1$), it turns out that $p = 0$ provides the clearest description of the recession phases and is therefore retained.

According to the results presented in Table 1, the low regime (St = 1) is characterized by a negative mean growth of -1.914, consistent with a mean growth rate of recession periods, while the high regime (St = 2) presents a positive mean growth rate of 0.929. The low regime is also characterized by an average duration of 5 months, which is lower than durations observed in post-WWII recessions, close to one year. The average duration of the high regime (18 months) is also lower than those estimated after WWII.

Starting from the estimated smoothed probability of being in the low regime presented in Figure 1, i.e. $P(S_t = 1 | \hat{\theta}, X_T, \ldots, X_1)$, we identify peaks and troughs of

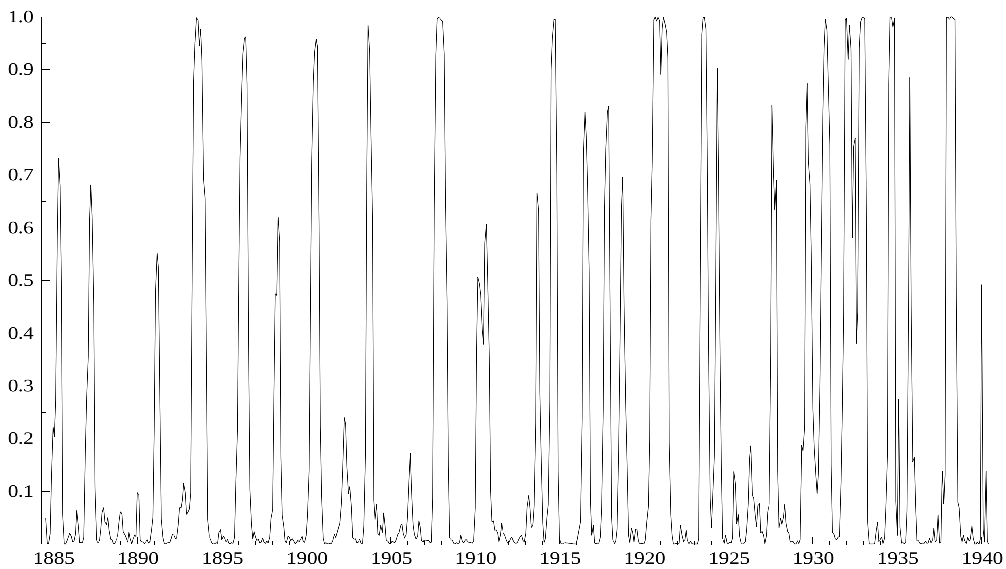
	$\mu(S_t = 1)$	$\mu(S_t = 2)$	$\sigma_\varepsilon(S_t = 1)$	$\sigma_\varepsilon(S_t = 2)$	p_{11}	p_{22}	$D(S_t = 1)$	$D(S_t = 2)$
IPI	-1.914 (0.286)	0.929 (0.106)	1.755	1.568	0.791	0.943	5	18

Table 1: Parameter estimates for the MS model over the period 1884-1940. Durations D of each regime are expressed in months. Standard deviations are given in parentheses.

the industrial business cycle by saying that when this probability is higher than the threshold of 0.50, with a confidence interval of 5%, then the economy is in recession, and conversely. Thus a peak is determined the month before the beginning of this low regime and a trough is identified the last month of this low regime. In addition, we adopt a censoring rule saying that an identified period must last at least 5 consecutive months.

Dates of peaks and troughs provided by the Bry-Boschan and MS approaches are presented in Table 2. From this table, we estimate 14 complete cycles from peak-to-peak, which is a bit less than the other estimations (see Table 4), 8 cycles occurring before WWI, and 6 cycles during the interwar period. Dating results are generally consistent between both methods because 50% of the dates are exactly the same and 71% with a maximum delay of one month. A notable exception concerns the 1892-1894 and 1913-1914 recessions, which exhibit a difference of 10 and 17 months for the peak. Note that for the 1913-1914 recession, the Bry-Boschan approach dates the peak in January 1913, as proposed by the NBER, while the MS approach dates it in June 1914, as suggested by Romer (1994). Moreover, the dates of peaks in the industrial business cycle provided by the MS model are lagged between 2 and 17 months, while the dates of troughs are slightly leading. The average absolute value of discrepancy between the two methodologies is 1.7 months, but if we exclude the two largest discrepancies, the average falls to 0.8 months. Overall, the dates from both approaches are very similar, except for few dates, and thus give us some robustness of the new peaks and troughs. In addition to previous measures of duration, we also consider losses in output during a peak and a trough (last column of Table 2). Losses are bounded between 6.2% and 39.0% during the Great Depression. It is noteworthy that the average loss goes from 11.9% in the pre-WWI period to 20.8% in the interwar period. Even if we exclude the Great Depression phase, the average loss in the interwar period is of 17.2%, showing an increase in the amplitude of loss.

Figure 1: Smoothed probability of being in an industrial recession regime over the period 1884-1940.



4.2 Comparisons

Table 3 displays the chronology proposed by the NBER and Romer (1994) as well as our new alternative chronology. Table 3 reveals important similarities but also key differences between the NBER and Romer dates and our alternative dates. We find that 14 cycles in our revised chronology correspond exactly with the incidence of the NBER and Romer cycles. However, there are some questions about the turning point dates, especially before WWI.

The revised industrial business-cycle dates are more selective in isolating genuine contractions in the post-WWI period. The new chronology dismisses several NBER and Romer recessions as merely growth cycles. The revised dating removes one and two cycles for both NBER and Romer chronologies, respectively, but none is common to the two references. The elimination of the two recessions (1890-1891, and 1916-1917) is consistent with other measures which suggest that these recessions should be reclassified as growth cycles. The identification of these spurious recessions will not surprise many economic historians.

Table 2: Dates of peaks and troughs in the pre-WWII US industrial economy.

Bry-Boschan dates		Markov-Switching dates		Deviations		Loss (in %)
Peak	Trough	Peak	Trough	Peak	Trough	
Pre-WWI industrial cycles						
1886:11	1887:06	1887:02	1887:06	3	0	7.1
1892:05	1894:02	1893:03	1894:01	10	-1	17.3
1895:10	1896:08	1896:01	1896:07	3	-1	10.8
1900:03	1900:10	1900:03	1900:10	0	0	10.0
1903:07	1903:12	1903:07	1903:12	0	0	9.5
1907:07	1908:05	1907:07	1908:05	0	0	20.0
1910:01	1910:11	1910:02	1910:10	1	-1	9.1
1913:01	1914:11	1914:06	1914:11	17	0	11.8
Interwar industrial cycles						
1918:06	1919:01	1918:08	1918:12	2	-1	6.2
1920:05	1921:06	1920:05	1921:06	0	0	27.7
1923:04	1924:08	1923:04	1924:06	0	-2	18.3
1927:04	1927:12	1927:07	1927:11	-3	-1	6.2
1929:04	1933:03	1929:07	1933:03	3	0	39.0
1937:11	1938:07	1937:11	1938:07	0	0	27.5

As found by Romer (1994), the 1890–1891 contraction identified by the NBER does not seem to be a recession. For Williamson (1974) for example, some portion of the decline can be explained simply by the retardation of labor force growth. This cycle is one that other researchers have frequently mentioned as being questionable. Indeed, Thorp (1926) affixes the word “brief” for this contraction, Fels (1959) describes it as “singularly mild”, and Zarnowitz (1981) lists it among the mildest prewar cycles.

The new chronology confirms that the 1916–1917 recession is not a contraction, whereas Romer identifies it as a cycle. This (possible) recession is associated with the start of WWI in Europe. As mentioned by Temin (1998, p. 29), no narrative can be developed about the 1916-1917 period for which no information could be found. Note that the lowest discrepancy between the new dates and the NBER dates occurs for the 1913-1914 cycle, whereas Romer found the peak 17 months later (in June 1914 rather than in January 1913).

There are differences in the dates of peaks and troughs among the seven cycles identified by the three chronologies in the post-WWI period. There is agreement on the date of the peak or trough in some instances with the NBER and Romer dates (February 1894, July 1903, July 1907 and December 1927 for Romer, January 1913 and March 1933 for the NBER, and January 1910 for both references). The average absolute value of the discrepancy between the new dates and those of the NBER and Romer is 5.3 months and 3.2 months, respectively.[6] The largest discrepancy occurs for the peak in May 1892 (8 months before) in the Romer chronology, and for the trough in November 1910 (14 months before) in the NBER reference. Note that the 1907-1908 recession displays the lowest discrepancy between the three chronologies.

The dates in the interwar period (1918-1940) appear to be less questionable than those in the pre-WWI period. Indeed, only the short 1939–1940 recession associated with the start of WWII in Europe, suggested by Romer (1994), is not identified by the new chronology as well as by the NBER. This can be explained by the fact that this recession is very short, only three months, and cannot be considered as a business-cycle recession. Furthermore, the discrepancies between the NBER and Romer dates with those of the new chronology average 2.5 months. This result confirms the small account of uncertainty in the interwar dates.

Finally, over all cycles that are identified in the three chronologies, the differences are sometimes systematic. The new dates lead the NBER and Romer troughs (5.4 months and 2.6 months in average, respectively) and the Romer peaks (4.9 months in average) in the post-WWI era.

[6] Note that Romer (1994) finds an average absolute value of the discrepancy between NBER dates and her dates for this period of 4.5 months.

Table 3: Dates of peaks and troughs in the prewar US industrial economy.

NBER reference dates		Romer dates		Alternative dates		Deviations NBER		Deviations Romer Peak	
Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough
Pre-WWI industrial cycles									
1887:03	1888:04	1887:02	1887:07	1886:11	1887:06	-4	-10	-3	-1
1890:07	1891:05								
1893:01	1894:06	1893:01	1894:02	1892:05	1894:02	-8	-4	-8	0
1895:12	1897:06	1896:01	1897:01	1895:10	1896:08	-2	-10	-3	-5
1899:06	1900:12	1900:04	1900:12	1900:03	1900:10	9	-2	-1	-2
1902:09	1904:08	1903:07	1904:03	1903:07	1903:12	10	-8	0	-3
1907:05	1908:06	1907:07	1908:06	1907:07	1908:05	2	-1	0	-1
1910:01	1912:01	1910:01	1911:05	1910:01	1910:11	0	-14	0	-6
1913:01	1914:12	1914:06	1914:12	1913:01	1914:11	0	-1	-17	-1
		1916:05	1917:01						
Interwar industrial cycles									
1918:08	1919:03	1918:07	1919:03	1918:06	1919:01	-2	-2	-1	-2
1920:01	1921:07	1920:01	1921:03	1920:05	1921:06	4	-1	4	3
1923:05	1924:07	1923:05	1924:07	1923:04	1924:08	-1	1	-1	1
1926:10	1927:11	1927:03	1927:12	1927:04	1927:12	6	1	1	0
1929:08	1933:03	1929:09	1932:07	1929:04	1933:03	-4	0	-5	8
1937:05	1938:06	1937:08	1938:06	1937:11	1938:07	6	1	3	1
		1939:12	1940:03						

Notes: The NBER business cycle chronology is from Moore and Zarnowitz (1986) and Diebold and Rudebusch (1992). The Romer business cycle chronology is from Romer (1994).

We propose to examine in detail the differences between the three various turning point chronologies proposed by the NBER, Romer (1994) and our alternative estimation. The characteristics of the revisions in the peaks and troughs are given in Table 4. The most salient feature of the revised chronology is that peaks and troughs are consistently dated earlier than those inferred from the NBER and Romer chronologies. Indeed, of the fourteen common peaks and troughs, the revised chronology predates seven to nine peaks and troughs.

Table 4: Differences in the industrial cycle chronologies.

		Revised peaks			Revised troughs		
Cycles	Numbers	Earlier	Same	Later	Earlier	Same	Later
NBER cycles	15	6	2	6	10	1	3
Romer cycles	16	8	3	3	8	2	4
Revised cycles	14						

Notes: The NBER business cycle chronology is from Diebold and Rudebusch (1992). The Romer business cycle chronology is from Romer (1994).

Even if the new chronology identifies 90% of the peaks and troughs suggested by the NBER and Romer (1994), more than 50% of them are consistently dated earlier, especially with the NBER troughs (70%). Therefore, these changes can have some implications on the characteristics of cycles, namely the frequency and duration. Table 5 shows that the new chronology displays an average frequency of contractions more important during the period 1918-1940 (42%) than during the period 1887-1917 (28%). This result is in contradiction with the NBER chronology for which the average frequency of recessions is close for the both periods. The average durations of contractions are higher for the period 1918-1940 than for the period 1887-1917 from the three chronologies. This result confirms the view that the NBER's chronology tends to increase both the frequency and the duration of pre-Fed cycles. (Selgin et al., 2012, p. 581). Nevertheless, the new peaks and troughs truncate the average length of recessions by one-third for the period 1887-1917 when compared with the NBER chronology, as found by Romer (1994). The new chronology, and that of Romer (1994), exhibit average durations of expansions less important for the period 1918-1940 than for the period 1887-1917, whereas the NBER chronology displays the contrary. Finally, the average expansion in the pre-WWI era is roughly three times as long as the average contraction for the revised and Romer chronologies, whereas they are slightly different for the NBER chronology.

As suggested by Diebold and Rudebusch (1992), we use a Wilcoxon rank-sum test[7] of whether the mean duration of expansions and recessions are equal between two samples, namely between the pre-WWI period (1887-1917) and the interwar period (1918-1940), for the different chronologies. Table 5 shows that there is no appreciable change in the duration of the cycles between these two periods, whatever the chronology.

5 Conclusion

In this paper we proposed an alternative set of monthly peaks and troughs of the US industrial cycles for the prewar period (1890-1938) using the methodologies proposed by Bry and Boschan (1971) and Hamilton (1989) on the monthly industrial production index constructed by Miron and Romer (1990) and modified by Romer (1994). The alternative chronology detects 90% of the peaks and troughs identified by the NBER and Romer (1994), but they are consistently dated earlier for more than 50% of them, especially with the NBER troughs (70%). The revised industrial business-cycle dates are more selective in isolating genuine contractions in the post-WWI period, namely by removing one (1890-1891) and two (1916-1917 and 1939-1940) cycles for both NBER and Romer chronologies, respectively.

The new dates affect the comparison of the average duration of recessions and expansions in the post-WWI and interwar eras. Whereas the NBER reference dates show an increase in average duration of the expansions between the post-WWI and interwar periods, the new dates show a decline in the length of expansions. However, the new dates confirm the traditional finding that contractions lasted longer in the post-war period than during the pre-war period.

[7] Diebold and Rudebusch (1992) proposed a Wilcoxon rank-sum test to test the null hypothesis of no duration stabilization, that is, that the distributions of durations between two sample are identical

Table 5: Frequency and duration of US industrial business cycles.

	Sample size		Average duration		Average duration		Test	
Cycles	1887-1917	1918-1940	1887-1917	1918-1940	1887-1917	1918-1940	Wilcoxon	*p*-value
Contractions								
NBER cycles	9	6	45.8	45.4	16.3	18.0	28.5	0.91
Romer cycles	9	7	24.2	33.3	9.7	13.1	24.5	0.49
Revised cycles	8	6	27.6	40.4	11.5	16.5	20.0	0.65
Expansions								
NBER cycles	9	6	54.2	54.6	21.8	26.0	16.0	0.61
Romer cycles	9	7	75.8	66.7	34.0	28.0	31.0	0.41
Revised cycles	8	6	72.4	59.6	34.4	29.2	22.0	0.52

Notes: Average frequency is given in percentage. Average duration and Wilcoxon statistic are given in months.

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Appendix

Table 6: Bry-Boschan procedure for determining turning points.

Step	Procedure
1	Determination of extremes and substitution of values
2	Determination of cycles in 12 month moving average (extremes replaced)
	(A) Identification of higher (or lower) than 5 months on either side
	(B) Enforcement of alternation of turns by selecting highest of multiple peaks (or lowest of multiple troughs)
3	Determination of corresponding turns in Spencer curve (extremes replaced)
	(A) Identification of highest (or lowest) value within ± 5 months of selected turn in 12 month moving average
	(B) Enforcement of minimum cycle duration of 15 months by eliminating lower peaks and higher troughs of shorter cycles
4	Determination of corresponding turns in short-term moving average of three to 6 months, depending on months of cyclical dominance (MCD)
	(A) Identification of highest (or lowest) value within ± 5 months of selected turn in Spencer curve
5	Determination of turning points in unsmoothed series
	(A) Identification of highest (or lowest) value within ± 4 months, or MCD term, whichever is larger, of selected turn in short term moving average
	(B) Elimination of turns within 6 months of beginning and end of series
	(C) Elimination of peaks (or troughs) at both ends of series which are lower (or higher) than values closer to the end
	(D) Elimination of cycles whose duration is less than 15 months
	(E) Elimination of phases whose duration is less than 5 months
6	Statement of final turning points

Source: Bry and Boschan (1971, p. 21).