Working Paper Ceris-Cnr, N° 4/2009

ISSN print: 1591-0709;
ISSN on line: 2036-8216

Forecast horizon of 5th – 6th – 7th long wave and short-period of contraction in economic cycles

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ABSTRACT: The purpose of this essay is to determine the forecast horizon of the fifth, sixth and seventh long wave. As the period of each long wave can change according to the data, it has been used a deterministic approach, based on historical chronologies of USA and UK economies worked out by several scholars, to determine average timing, period and forecast error of future long waves. In addition, the analysis shows that long waves have average upwave period longer than average downwave one. This result is also confirmed by US Business Cycles that have average contractions shorter than expansions phase over time.

KEYWORDS: Forecast Horizon, Long Waves, Kondratieff Waves, Business Cycles, Asymmetric Path

JEL-CODES: E30, E37

I wish to thank Silvana Zelli and Diego Margon for research assistance and the Italian National Research Council for its financial support to this research. *This article has been accepted at the 38th Annual Conference of Economics, University of Adelaide, Australia.*

WORKING PAPER CERIS-CNR
Anno 11, N° 4 – 2009
Autorizzazione del Tribunale di Torino
N. 2681 del 28 marzo 1977

Direttore Responsabile
Secondo Rolfo

Direzione e Redazione
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del Consiglio Nazionale delle Ricerche
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Distribuzione
Spedizione gratuita

Fotocomposizione e impaginazione
In proprio

Stampa
Grafica Nizza
C.so Francia 113, 10093 Collegno (TO)

Finito di stampare nel mese di dicembre 2009

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Studio in onore di G. Mortara (1885-1967), Professore della Regia Università di Milano

1. BEHAVIOUR AND SHAPE OF ECONOMIC CYCLES

The current debate over long waves or Kondratieff waves (in short K-waves) theory has been ongoing since the first substantial evidence in 1920s (Kondratieff, 1926; Mortara, 1932; Volland, 1987; Ayres, 1990 and 1990a; Berry *et al.,* 1993; Devezas *et al*., 2005; Papenhausen, 2008). From his examination of long run time series, especially price levels, Kondratieff's contribution (1935) argued that there is reason to assume the existence of long waves of an average length of about fifty years in the capitalistic economy. Scholars have found out different long wave periods, depending on the particular countries and time series were looking at (Kuznets, 1965; Mandel, 1980; Stewart, 1982; Van Duijn, 1983; Ayres, 1990; 1990a; Berry, 2000; Berry and Kim, 1994; Berry *et al*., 1993; Devezas *et al.,* 2005 and so on). Bieshaar and Kleinknecht (1984) have carried out econometric tests comparing six of the chronologies, including Mandel's (1980), in terms of average growth rates during upwave and downwave period. They argue that the existence of waves since 1890 is quite strong and robust. In addition, Bieshaar and Kleinknecht (1984) have also shown that certain year timing of long waves are often better for some countries, but not for the world as whole: in fact, heterogeneity of countries, due to different economic structures and reaction capacity of their economic systems, affects patterns and timing of economic cycles over time and space.

Although several works have provided many valuable insights into the theory of long waves, there are also unresolved issues, such as the behaviour of economic cycles over time. In order to investigate these main economic issues, the purpose of this essay is to conjecture the *forecast horizon* (periods between today and the date of forecast) of future long waves as well as to investigate the behaviour of the phases of long waves and business cycles nested within them.

1.1 Forecast horizon

Firstly, to determine the average timing (rhythm) of long waves, it has been calculated the arithmetic mean[1] of several historical chronologies worked out by different scholars and based on price index of the USA and the UK economies, two driving countries for worldwide economic growth patterns: the results of this statistical analysis are the average timing of beginning and end of long waves as well as average period, average upwave, downwave periods and boom timing.

I suppose the following hypothesis:

Hp: Future K-waves have an average rhythm similar to previous long waves.

In addition, the variance of the years of long wave chronologies is measured by the deviation standard (σ). This indicator of variability σ is supposed to be a reliable measure of the forecast error of future timing of K-waves over the forecast horizon.

Modern theory of economic cycles argues that long waves have four phases: prosperity, recession, depression and recovery. These phases form the upwave and downwave period of K-cycles. As there is correlation between rising prices and economic growth (prosperity) and conversely, basic economic theory suggests that sustained prosperity is likely to result in bottlenecks and scarcities that tends to drive prices up. By the same token, stagnation and recession tend to result in underutilization of capital and excess of supply of many commodities, hence (where the markets are unfettered) declining prices (Ayres, 1990). The stylized scheme set forth by Van Gelderen focuses on turning points between inflationary (upwaves) periods and deflationary periods

[1] Arithmetic mean is a robust indicator of central tendency of data.

(downwaves). According to Berry *et al.* (1993), upwave growth starts in recessions and ending in stagflation crises that are associated with diffusion of newly structural innovation to market saturation. Downwave growth cycles are associated with technology successions, when peaked-out paradigms are challenged by ascendant sets of techno-economic alternatives, after the shocks of stagflation crises (Ayres, 1990; 1990a; Kleinknecht, 1990; Reati and Toporowski, 2004; de Groot and Franses, 2008).

Devezas *et al.* (2005), analyzing the 4th Kondratieff wave, argue that the inventions appear during the upwave and during the first recession period, whereas innovations clustering all along the downwave and further recession, and finally the widespread diffusion occurring at the trough and transition period into the fifth K-wave: i.e. during the upwave there is the invention phase, whereas innovations clustering and their widespread diffusion are all along the downwave phase.

Although it can be used complicated models and simulations of forecasting (Diebold, 2004) of K-waves, which are ever affected by some bias *ex-post*, this paper applies a simple approach to conjecture the forecast horizon of future K-waves. In particular, starting from historical chronologies of long waves measured by Kondratieff (1935), Ayres (1990; 1990a), Mandel (1980), Van Duijn (1983), Berry and Kim (1994), it is calculated the average upwave phase, based on price index for the USA, that is 29.50 years for the 1st K-Wave; 28.75 years for the 2nd K-wave; 27.50 years for the 3rd K-wave and 29.00 years for the 4th K-wave. The arithmetic mean of these values is 28.69 years, the deviation standard σ is 0.74 years, which indicates the dispersion around the central tendency. Whereas, the average downwave for US economy is 28.50 years for the 1st K-wave; 25.00 for the 2nd K-wave; 26.25 for the 3rd K-wave and 25.00 for the 4th K-wave. The arithmetic mean of these figures is 26.19 years, the deviation standard σ is 1.43 years.

Mutatis mutandis, it is also calculated the average upwave for the UK economy that is 34.00 years for the 1st K-Wave; 29.50 years for the 2nd K-wave; 25.50 years for the 3rd K-wave, missing values for the 4th K-wave. The arithmetic mean of these values is 29.67 years, the deviation standard σ is 3.47 years. Whereas, the average downwave in UK economy is 24.50 years for the 1st K-Wave; 25.50 for the 2nd K-wave; 25.00 for the 3rd K-wave. The arithmetic mean of these figures is 25.00 years, the deviation standard σ is 0.41, which indicates the dispersion around the central tendency. Table 1 shows these results.

If the joint chronologies of US and UK countries, two driving economies for worldwide economic growth patterns, are considered, the results are described in section 1C of table 1. This empirical analysis shows that average period of long waves over time is roughly 54.94 years with σ equal to 2.37 years. In support of this result, Stewart (1982), fitting total energy and electric energy growth curves with logistics and plotting the residuals as percent deviations from fitting curve, obtains a sinusoidal oscillation of the deviations with a period of about 54 years. Berry (1991) documented that growth rate of prices swing with approximately 54-year rhythms (Kondratieff waves). *Coeteris paribus*, it is supposed that the average period equal to *54.94 years (σ = 2.37)* can be a good proxy of future period (length in years) of K-waves.

Therefore, the forecast horizon of the fifth long wave is from 1992 to 2046.94 (boom year in 2021.15), of the sixth long wave is from 2046.95 to 2101.88 (boom year in 2076.09), of the seventh long wave is from 2101.89 to 2156.82 (boom year in 2131.03). Table 1 shows these fundamental results, whereas figure 1 describes the paths and forecast horizon of future long waves.

TABLE 1: FORECAST HORIZON FOR 5^{TH} – 6^{TH} – 7^{TH} LONG WAVES BASED ON AVERAGE TIMING

	Arithmetic mean of **US** chronologies based on price index [(a)]						
Waves	Upwaves			Downwaves			Duration of cycles
Section 1A	A=begin	B=end	Length B-A=C	A'=begin	B'=end	Length B'-A'=D	C+D
1-K	1778.00	1807.50	29.50	1808.00	1836.50	28.50	58.00
2-K	1836.75	1865.50	28.75	1865.50	1890.50	25.00	53.75
3-K	1890.75	1918.25	27.50	1918.25	1944.50	26.25	53.75
4-K	1944.50	1973.50	29.00	1967.00	1992.00	25.00	54.00
Arithmetic Mean			28.69*			26.19*	54.88*
Dev. St.			*0.74*			*1.43*	*1.81*

	Arithmetic mean of **UK** chronologies based on price index [(a)]						
Waves	Upwaves			Downwaves			Duration of cycles
Section 1B	A=begin	B=end	Length B-A=C	A'=begin	B'=end	Length B'-A'=D	C+D
1-K	1781.00	1815.00	34.00	1815.00	1839.50	24.50	58.50
2-K	1839.50	1869.00	29.50	1869.00	1894.50	25.50	55.00
3-K	1894.50	1920.00	25.50	1920.00	1945.00	25.00	50.50
4-K	-	-	-	-	-	-	-
Arithmetic Mean			29.67*			25.00*	54.67*
Dev. St.			*3.47*			*0.41*	*3.27*

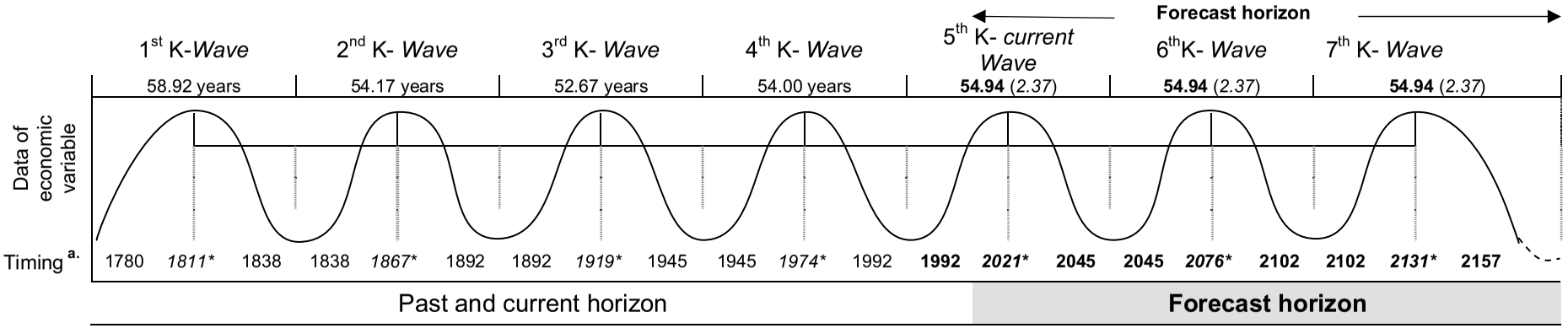
	Arithmetic mean of **USA and UK** chronologies based on price index [(a)]						
Waves	Upwaves			Downwaves			Duration of cycles
Section 1C	A=begin	B=end	Length B-A=C	A'=begin	B'=end	Length B'-A'=D	C+D
1-K	1779.50	1811.25	31.75	1810.33	1837.50	27.17	58.92
2-K	1837.67	1866.67	29.00	1866.67	1891.83	25.17	54.17
3-K	1892.00	1918.83	26.83	1918.83	1944.50	25.83	52.67
4-K [(b)]	1944.50	1973.50	29.00	1967.0 [(c)]	1992.00	25.00	54.00
Arithmetic Mean			29.15*			25.79*	**54.94***
Dev. St.			*1.74*			*0.85*	*2.37*
5-K Forecast	1992.00	2021.15^		2021.15^	2046.94		**54.94*** *2.37*
6-K Forecast	2046.95	2076.09^		2076.09^	2101.88		**54.94*** *2.37*
7-K Forecast	2101.89	2131.03^		2131.03^	2156.82		**54.94*** *2.37*

Note: Data are years; * Arithmetic mean, Deviation Standard in *Italics*; ^is the boom year forecasted.

(a) these years are average timing based on chronologies of long waves worked out by Kondratieff, Ayres, Mandel, Van Duijn, Berry *et al*.

(b) 4 K waves are calculated only on USA data, since UK data are missing value.

(c) this value is not an arithmetic mean.



Note:
All numbers are years and their fractions. In **Bold,** there is average timing and period of 5th -6th -7th K-Waves in the forecast horizon;
(*in parenthesis*) there is the Deviation Standard: it indicates the forecast error of K-waves over the forecast horizon
***** It is the average timing of boom
a. Average timing of long waves based on arithmetic mean of chronologies elaborated by Kondratieff, Ayres, Mandel, Van Duijn, Berry *et al.*

FIGURE 1: FORECAST HORIZON OF FUTURE LONG WAVES BASED ON USA AND UK DATA

1.2 Irregular rhythms of economic cycle phases

Empirical analysis carried out in previous section is a vital background to analyze the behaviour of long waves over time since can have important implication for modern political economy of growth, in presence of global economic downturn. More specifically, it is stated the fundamental proposition 1.

Proposition 1
Negative Asymmetry of Kondratieff Cycle
Let

(1) α = upwave growth of the long wave (upswing period) be the gap from timing of beginning of the cycle to boom (peak), measured in years

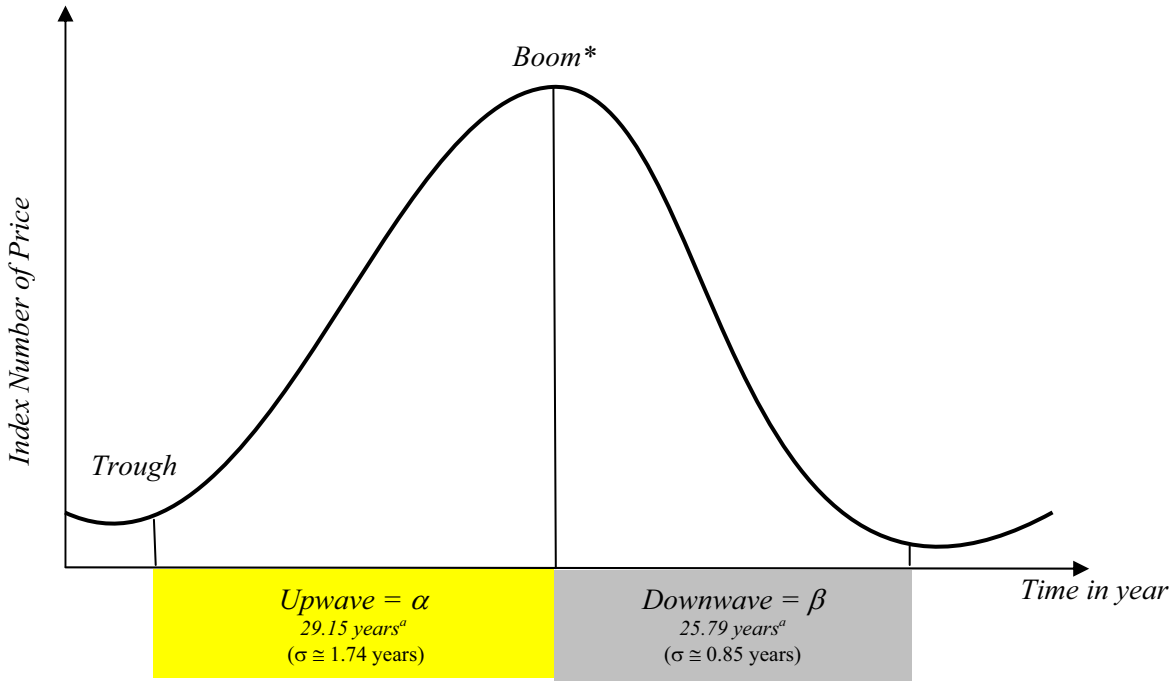
(2) β = downwave be the period (in years) from boom to the timing of end of the long wave

Then the upwave phase α of Kondratieff wave is a longer period than downwave phase β:
$\alpha > \beta$.

Proof.
The up wave growth "α" phase of K-wave has an average value, using data of the USA and the UK, over four K-waves, equal to 29.15 years. The average down wave period is β=25.79 years.
Hence $\alpha > \beta$ *Q.E.D.*

Remark 1.
In general, if we consider the data of the USA and the UK separately, this main finding is confirmed over time (see table 1, section 1A and 1B).

Remark 2.
Geometrical graph is represented in figure 2.



Note: a. is the arithmetic mean of K-wave chronologies based on US and UK data.
Long wave has an average period of 54.94 years (σ= 2.37 years)

FIGURE 2**:** NEGATIVE ASYMMETRY OF KONDRATIEFF WAVE

It is important to note as within the K-Cycles, there are nested the Business cycles (Schumpeter, 1939). The National Bureau of Economic Research (NBER, 2009) of the USA measures US Business Cycle Expansions and Contractions since 1854. The analyses of these data (see Table 1A in the Appendix) provide the following main proposition 2.

Proposition 2
Short-period of contractions and long-period of expansions into Business Cycles

Let

- η the contraction (recession) is a significant decline of the economic activity spread across the economy, measured in months*;*
- τ the expansion is an increase of the economic system, starting from the trough; it is measured in months;

then the contraction phase η of business cycles is a shorter period than expansion phase τ:

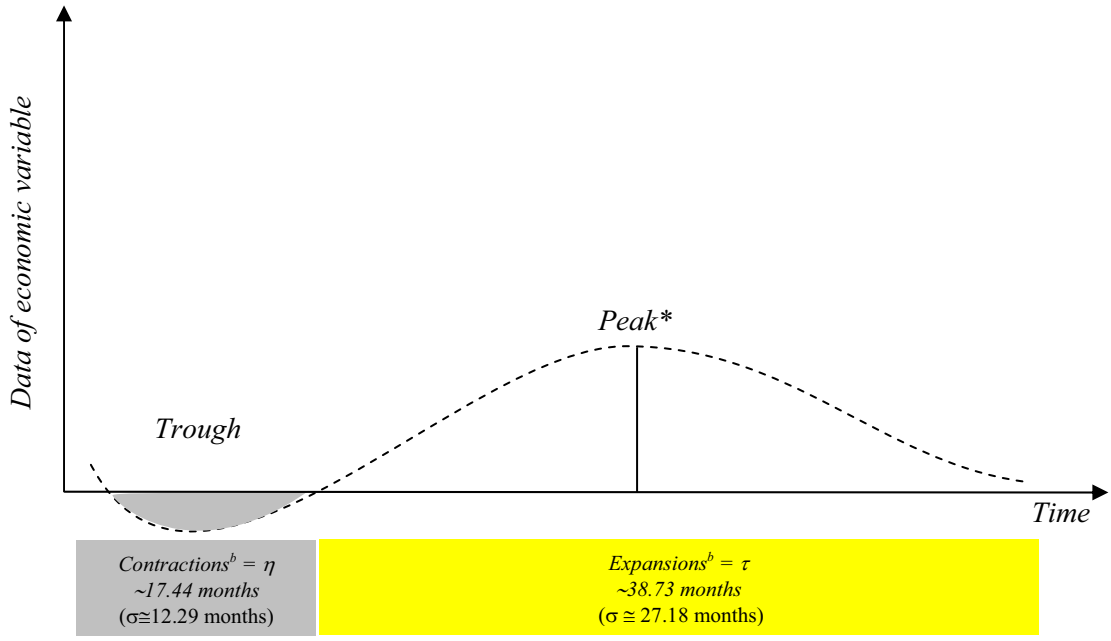
$\eta < \tau$.

Proof.

Average duration in months of US business cycle from 1854 to 2001, is 56.4 months (NBER, 2009).

Contractions η have an arithmetic mean, for all 32 Business cycles, equal to 17.4 months, whereas the average duration of expansions is τ=38.7 months.

Hence $\eta < \tau$, *Q.E.D.*



Note: b. Average of all US Business Cycle 1854-2001 period.
Average duration of US Business Cycle is ~56.44 months (σ≅28.53 months)

FIGURE 3**:** SHORT PERIOD OF CONTRACTION AND LONG-PERIOD OF EXPANSION INTO A CLASSICAL BUSINESS CYCLE OF US ECONOMY

Remark 3.

This behaviour of US business cycles (figure 3 presents a classical business cycle) has been also analyzed by Miles and Scott (2005) and showed by International Monetary Fund (IMF, 2003) for other countries.

Now a natural question is raised:

Why upwaves and expansions of K and Business cycles have a longer period of their downwaves and contractions phases?

In fact, the business cycles (average duration 4.6 years) and long waves (54.94 years) are affected by economic policies as well as by physiologic path of capitalistic systems. As the political economy of growth has been improving over time because of a learning process from economic history, policy-makers apply, more and more, efficacious economic mechanisms aimed to minimize the negative effects of contractions and maximize the positive sides of expansions, increasing so the economic wealth and well-being of countries over long-run. In addition, the capitalistic systems are also driven by economic and technological forces that are accumulated in the economic downturn (such as innovations, see Mensch, 1979; Devezas *et al.,* 2005) and then are spread, generating disproportionate upwave growth.

2. CONCLUDING REMARKS

In conclusion, these results are focused on a deterministic approach based on time series of the USA and UK, which were the leading economies of past K-waves. Current and future global economy will be based on an increasing weigh of Asian economies (such as China, India and Japan), as well as Brazil, Russia, etc.[2]. For instance, Boretos (2009) argues that by 2024, China as new superpower, will probably emerge and become the largest economy of the World. These economies can affect the pattern of future K-waves and next researches have to consider the heavy weight of these countries.

In additions, the world is turbulent and dynamic and there can be probable new stochastic shocks that affect the path of growth of long wave cycles, as the current global economic downturn. In fact, Romer (1991) analyzing economic cycles argues that their volatility is not decreased over time, whereas Stock and Watson (2002) point out that the variability of US cyclical behaviour has been decreasing since 1984 (see also Basu and Taylor, 1999).

It is important to note that forecasting with socio-economic factors is a difficult task because of instability and not ever rational human behaviour as well as continuous new events added to old ones such as financial shocks, terrorism warfare, primary energy resources crisis, and so on, that increase the turbulence of modern global and interrelated economic systems; therefore it is possible to conjecture what likely will happen and will be the forecast horizon and economic behaviour of K-cycles since the human factors permit us only orientation forecasting that, in turn, it has to be updated continuously in order to have more reliability for designing future worldwide scenarios.

[2] Some of these countries are called BRIC countries that is an acronym that refers to the fast-growing developing economies of Brazil, Russia, India, and China.

APPENDIX

TABLE 1A: US BUSINESS CYCLE EXPANSIONS AND CONTRACTIONS

		Duration (in months)		
Trough (Min)	*Peak (Max)*	*Contraction*	*Expansion*	*Cycle*
December 1854 (IV)	June 1857 (II)	--	30	
December 1858 (IV)	October 1860 (III)	18	22	40
June 1861 (III)	April 1865 (I)	8	46	54
December 1867 (I)	June 1869 (II)	32	18	50
December 1870 (IV)	October 1873 (III)	18	34	52
March 1879 (I)	March 1882 (I)	65	36	101
May 1885 (II)	March 1887 (II)	38	22	60
April 1888 (I)	July 1890 (III)	13	27	40
May 1891 (II)	January 1893 (I)	10	20	30
June 1894 (II)	December 1895 (IV)	17	18	35
June 1897 (II)	June 1899 (III)	18	24	42
December 1900 (IV)	September 1902 (IV)	18	21	39
August 1904 (III)	May 1907 (II)	23	33	56
June 1908 (II)	January 1910 (I)	13	19	32
January 1912 (IV)	January 1913 (I)	24	12	36
December 1914 (IV)	August 1918 (III)	23	44	67
March 1919 (I)	January 1920 (I)	7	10	17
July 1921 (III)	May 1923 (II)	18	22	40
July 1924 (III)	October 1926 (III)	14	27	41
November 1927 (IV)	August 1929 (III)	13	21	34
March 1933 (I)	May 1937 (II)	43	50	93
June 1938 (II)	February 1945 (I)	13	80	93
October 1945 (IV)	November 1948 (IV)	8	37	45
October 1949 (IV)	July 1953 (II)	11	45	56
May 1954 (II)	August 1957 (III)	10	39	49
April 1958 (II)	April 1960 (II)	8	24	32
February 1961 (I)	December 1969 (IV)	10	106	116
November 1970 (IV)	November 1973 (IV)	11	36	47
March 1975 (I)	January 1980 (I)	16	58	74
July 1980 (III)	July 1981 (III)	6	12	18
November 1982 (IV)	July 1990 (III)	16	92	108
March 1991(I)	March 2001 (I)	8	120	128
November 2001 (IV)	December 2007 (IV)	8	73	81
Average, all cycles:				
1854-2001 (32 cycles)	Arithmetic mean (*Dev. Standard)*	17.44 *(12.29)*	38.73 *(27.18)*	56.44 *(28.53)*
	Max	65	120	128
	Min	6	10	17
1854-1919 (16 cycles)	Arithmetic mean (*Dev. Standard)*	22.53 *(14.14)*	26.63 *(9.72)*	48.93 *(18.05)*
1919-1945 (6 cycles)	Arithmetic mean (*Dev. Standard)*	18.00 *(12.74)*	35.00 *(25.71)*	53.00 *(32.16)*
1945-2007 (11 cycles)	Arithmetic mean (*Dev. Standard)*	10.18 *(3.25)*	58.36 *(35.01)*	68.55 *(36.02)*

Note: – The NBER does not define a recession in terms of two consecutive quarters of decline in real GDP. Rather, a recession is a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales. For more information, see the latest announcement from the NBER's Business Cycle Dating Committee, dated 12/01/08.
– All numbers are months and their fractions.
– Roman numbers in columns 1 and 2 are the quarterly of the year.

Source: NBER, 2009

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ISSN (print): 1591-0709; ISSN (on line): 2036-8216