CHAPTER FOUR

The Long Wave Debate 3: Empirical Arguments

In this chapter I review the past empirical evidence for long waves, comparing and sifting evidence presented by adherents of different theoretical schools. This combined with the preceding theoretical discussions will facilitate sorting out the alternative hypotheses of different schools and subschools and their respective strengths in chapter 7.

What Variables to Include?

I have organized my review of empirical evidence around the different variables of interest. From the theoretical discussions of chapters 2 and 3, the relevant variables and time span of the long wave can be identified.[1] The time span of interest is maximally 1495 to the present, with distinction between the preindustrial and industrial periods (before and after about 1790).[2] There are seven basic variables of interest:

1. *Prices:* Are there synchronous long price waves in the core countries? How early can they be found, and in what countries? These questions interest almost all long wave scholars since prices are the most readily available economic data and since all schools posit long waves of prices.
2. *Production:* Are there alternating phases of fast and slow growth in core countries' production? In what countries and time periods can they be found? These questions are central to the capitalist crisis school as well as to certain liberal critics who see long waves as "only price waves."
3. *Innovation and Invention:* Are waves or clusters of innovations synchronous with long waves? Are they directly or inversely correlated with economic growth phases? These questions are central to the innovation school.
4. *Capital Investment:* Do spurts of capital investment correlate with the early

1. A few "outliers" beyond this domain are ignored.
2. Again, I use 1790 as shorthand to refer to the transition to industrial economies. Note that for production (except for scanty data on harvests), innovation, and capital investment, virtually no data are available for the preindustrial period and that the temporal scope under discussion begins around 1790.

upswing of the long wave? The correlation of investment levels with long waves is of particular concern to the capital investment school.
5. *Trade:* Do levels of exports or other indicators of international trade follow the long wave phases? Trade concerns some members of the capitalist crisis school who see capitalism as production for a world market.
6. *Real Wages and Working-Class Behavior:* Do real wages fluctuate with the long wave? Do strikes and other worker protests follow long wave phases? These questions concern the capitalist crisis school.
7. *War:* Do major wars tend to occur at one point in the long wave? Does the timing of major wars correlate with long wave phases? These questions concern the war school and the participants in the debates discussed below in chapter 5.

These seven variables encompass the essential variables of interest to all schools. But the choice of what variables one examines depends on one's theoretical approach to long waves and the world view that underlies it. Marxists tend to be concerned with the means of production and the accumulation of surplus as well as with class struggle—and hence try to measure the total growth of production, the overall rate of profit, the unemployment rate, and such indicators of working-class behavior as strikes. Monetary variables, representing exchange relations rather than production relations, are of much less interest to Marxists. Neo-Schumpeterians try to measure the rate of innovation, invention, or the diffusion of innovations. Capital investment theorists are interested in such variables as total investment in capital plant. The differences in variables of interest to different theoretical schools contribute to the difficulty in cumulating results across schools (see chapter 7).

Of all the questions concerning the scope of the long wave, the central issue is whether long waves exist only in *prices* and other monetary variables (for example, interest rates) or also in *production* and other "real" variables (for example, employment, capital investment, volume of trade). Most long wave studies have treated prices and production as moving in synchrony, particularly since periods of marked depression have generally combined both stagnant production and falling prices.[3] But in recent decades, production and prices seem less synchronous, especially with the stagflation (high inflation combined with stagnation of production and employment) of the 1970s. This has led to somewhat divergent interpretations of the long wave.[4] I will take up this puzzle directly in my analysis in Part Two.

All variables are not equally accessible to investigation. Price data are relatively plentiful, while data on innovations and worker protests are much scantier and less reliable. Prices have one big advantage over all other variables—the availability and consistency of data.

In the preindustrial age (which makes up more than half of the total period of my

3. This assumption of synchrony is taken for granted in many long wave theories. My reinterpretation is given in chap. 10.

4. As noted earlier, Rostow's long wave dating based on prices opposes most other datings based on production.

study) prices are virtually the only good economic data available.[5] Economic historians have been able to dig up annual or monthly price series in quite a few cases from records kept by institutions that made regular purchases. In some cases they have pieced a number of these series together to make an overall price index for a region or country. However, for production variables (as well as employment, investment, innovation, and so forth) there are no comparable data sources. No one kept central records on the total production of a region or country in the preindustrial period. The very concept of a "national product" (GNP) is a twentieth-century creation. Economic historians have reconstructed some national production totals, but only back to the late eighteenth century at best.

Methodologies

In addition to focusing on different variables, scholars have used different methodologies to study long waves. Almost all empirical studies, however, actually use one or more of just six basic methodologies:[6]

1. *Visual inspection* of time series or intermittent data or the synthesis of qualitative economic histories are used to establish historical datings of upswing and downswing periods in particular variables or in national or international economies.
2. *Moving averages*[7] are used to bring out underlying long wave movements in long time series. This method attempts to eliminate short business cycles by using long-term (for example, nine-year) moving averages.
3. Growth rates are calculated[8] for economic variables within predefined historical *phase periods*. Growth rates are compared between upswing and downswing phases to show alternating behavior in successive phases.
4. *Trend deviations* are used to bring out long-term movements around an underlying secular trend. The form of the underlying curve must be specified.[9]
5. Long waves are analyzed in terms of the shorter *business cycles* they contain.[10]
6. *Spectral analysis* and related statistical techniques[11] use sophisticated statistical routines to search for regular fixed periodicities (not irregular periods, as the above methods allow) in time series data.

5. With a few exceptions (see chap. 8).
6. Discussed further in chap. 8.
7. A moving average at a given point in time is the average value of data for a certain number of years on either side.
8. The nontrivial question of how to calculate those growth rates is discussed in chap. 8.
9. First the form of the trend equation is given and estimates are calculated from the data to find the coefficients in that equation that best fit the long-term curve. Then the residuals—the difference between the fitted curve and the actual data at a given time—are graphed or otherwise analyzed to find long waves.
10. The characteristics of business cycles (e.g., growth from one peak or trough to the next) on the long wave expansion phase are compared with those on the stagnation phase.
11. Spectral analysis creates a function in which the degree of correlation of a sine wave to the time series data is expressed in relation to the wavelength of the sine wave. Cross-spectral analysis concerns the correlation among more than one series conceived as sine waves. Fourier analysis breaks a time series down into a set of sine waves of different wavelengths whose sum best approximates the series.

The Dating Game

All of these methods,[12] applied to all the variables of interest, have one goal in common—to identify or validate the dates of long wave phases. A *dating scheme,* delineating the turning points between phase periods, defines a long wave pattern historically. The general aim of empirical studies is to show either how such a dating scheme may be derived from data or how data support the claim of alternating phases embodied in the dating scheme.

A comparison of dating schemes can show whether scholars are talking about very different cycles or essentially the same cycles with slight variations in the dating of turning points. I will compare the dating schemes arrived at by thirty-three long wave scholars and demonstrate a strong consensus around a single basic dating of long wave phases.

As a framework of reference with which to compare these dating schemes, I will use a *base dating scheme* that I developed by splicing together four scholars' datings.[13] The base dating scheme uses the dates of Braudel (1972:896) for the phases of the European economy from 1495 to 1650.[14] It then uses Frank's (1978) dates of the phases of development of the British economy from 1650 to 1790.[15] From 1790 to 1917, the dates of Kondratieff ([1926] 1935) are used,[16] and from 1917 on, those of Mandel (1980).[17]

The dates of the base dating scheme are:

		1st wave		2d		3d		4th		5th		6th		
Peak	(1495)		1529		1559		1595		1650		1720		1762	
Trough		1509		1539		1575		1621		1689		1747		1790
						7th		8th		9th		10th		
Peak							1814		1872		1917		1968[18]	
Trough						1790		1848		1893		1940		

12. With the possible exception of spectral analysis.

13. This base dating scheme will also form the starting point for my own empirical analysis (see chap. 8). All four sources of this dating lean toward a Marxist or material interpretation of economic history. However, the dates through the 1920s derive mainly from prices, while Mandel's dates are explicitly based on production. In chap. 10, when it becomes clear that prices and production are not synchronous, I revise Mandel's last date to reconcile prices and production.

14. Although Braudel does not call these long waves, he later (1984:80) makes clear that this was his intention, stating that the Kondratieff wave predates 1790 by hundreds of years and is a cycle defined by prices (Imbert, whom Braudel cites, also relies on prices). Braudel gives troughs of 1539 and 1575 without dating the peak between them. Imbert (1959:196–201) finds this cycle nonexistent in data from France, Strasbourg, Germany, or Italy but evident in data from England (peaking at 1556/58) and Spain (peaking at 1562). I chose 1559 for this peak.

15. This is used in lieu of an explicitly international measure. There is a 20-year gap between the end of Braudel's account in 1650 and the beginning of Frank's in 1670. I included this period with the following downswing based on Imbert's (1959) dating of this downswing phase from 1650 to 1685/88.

16. I used the middle year of the range of years Kondratieff gave for each turning point.

17. Mandel lists 1940 as the trough for the United States and 1948 for Europe. I used 1940, since the United States was the leading world economy. Bieshaar and Kleinknecht (1984:290) test both dates (actually 1939 and 1948) and find the earlier date to be "the more realistic demarcation point."

18. The 1968 turning point is modified to 1980 in chap. 10.

Dating Schemes for the Industrial Age

Kondratieff ([1926] 1935) put forward an overall dating scheme for the world economy based on a variety of price and production series since the late eighteenth century:

Peak		1810/17		1870/75		1914/20
Trough	1787/93		1844/51		1890/96	

These are the three long waves around which the literature has centered (along with a fourth, more recent, wave), and these dates are used in my base dating scheme for the period 1790–1917.

Mandel[19] provides four sets of dates of long waves based on the growth of industrial production and trade:

British industrial production:							
Peak	1827		1876		1914		1968
Trough		1848		1894		1939	
United States industrial production:							
Peak			1874		1914		1968
Trough		1849		1894		1939[20]	
German (and then West German) industrial production:							
Peak			1875		1914		1968
Trough		1850		1898		1939	
World trade:							
Peak	1820		1870		1913		1968
Trough		1840		1891		1938	

Mandel's dates correspond closely with Kondratieff's through 1913 (after which Mandel's own dates are used in the base dating scheme).

Imbert (1959:47) gives the following dates for upswing and downswing phases of prices:

France:								
Peak		1817		1872		1926		(1954+)
Trough	(1787)		1851		1896		1935	
United States:								
Peak		1814		1865		1920		(1954+)
Trough	(1791)		1849		1896		1932	

19. Mandel (1975:141–42) summarized by Eklund (1980:413).
20. In Mandel's later book, on which my base dating scheme is based, this upswing is dated from 1940.

Germany:								
Peak		1808		1873		1925		(1954+)
Trough	(1792)		1849		1895		1933	
England (based on *Sauerbeck*):								
Peak		1810		1873		1920		(1954+)
Trough	1786/89		1849		1896		1933	
Belgium (based on *Loots*):								
Peak				1873		1929		
Trough			1852		1895		1934	
Italy (based on *Loots*):								
Peak						1926		
Trough					1897		1934	

Imbert (1959:38) also lists the dating schemes of several other long wave scholars. *Simiand*'s (1932b) dates for prices and production in France are:

Peak		1815/20		1875		1928/29
Trough	late 18th c.		1850		1896/97	

Those of *Dupriez* (1947 2:24) for wholesale prices in the major countries are:

Peak		1808/14		1872/73		1920	
Trough	1789/92		1846/51		1895/96		1939[21]

For *Van Gelderen* [Fedder] (1913:268), the following dates are given for general economic movements of major countries:

Peak		1873		(1913+)
Trough	1850		1895	

For *De Wolff* (1924:21), the long wave dating is:

Peak	1825		1873/74		1913
Trough		1849/50		1896	

Hansen's (1941:30) dating of general economic movements is:

Peak		1815		1873		1920/21
Trough	1787		1843		1897	

21. Van Duijn (1983:163) notes Dupriez's (1978) continuation, with 1939/46 as the trough and 1974 as the next peak.

The dating of *Woytinsky* (1931:5, 10) based on Spiethoff's study of major countries is:

Peak	1822		1873		1920
Trough		1842		1894	

That of *Ciriacy-Wantrup* (1936) representing general economic movements in major countries is:

Peak		1815		1875		1913
Trough	1792		1842		1895	

Åkerman's (1932:87) dating for general economic movements is:

Peak	1817		1873		1920
Trough		1848		1896	

Imbert continues with closely corresponding dating schemes from *Wicksell, Estey, Edie, Marjolin, Rouquet La Garrigue, Lescure,* and *Sirol* (Imbert, 1959:38).

Schumpeter's (1939) dating for general economic movement does not specify the upper turning points but is anchored by the lower turning points, which match the general dating scheme as follows:

Trough	1787	1842	1897

Kuznets (1940) elaborates Schumpeter's scheme with the advice and consent of Schumpeter:[22]

Peak		1814		1870		1925
Trough	1787		1843		1898	

Burns and *Mitchell* (1946) give the following dates based on prices:

United States:							
Peak		1814		1864		1920	
Trough	1789		1843		1896		1932

22. Kuznets's full scheme has four phases in each cycle: prosperity, recession, depression, and recovery.

Great Britain:							
Peak		1813		1873		1920	
Trough	1789		1849		1896		1933
France:							
Peak		1820?		1872		1926	
Trough			1851		1896		1935
Germany:							
Peak		1808		1873		1923	
Trough	1793		1849		1895		1933

Rostow (1978) generally follows the base dating until World War II, where his emphasis on prices leads him away from dating schemes based on production (see chapter 3):

Peak		1815		1873		1920		1951	
Trough	1790		1848		1896		1935		1972

Van Duijn (1983:155), who focuses on world industrial production, finds the evidence unconvincing for Kondratieff's first long wave but dates the subsequent waves in rough synchrony with other schemes:[23]

Peak		1872		1929		1973
Trough	1845		1892		1948	

Ischboldin[24] bases dates for long waves in Europe and in North America on prices. He finds long waves of about fifty years' duration only since 1815, arguing that before then only longer-term phases can be found:

North America:										
Peak				1812		1865		1929		(?)
Trough			1790		1843		1897		1939	
Europe:										
Peak		(1650)		1815		1873		1920		(?)
Trough	(1500)		(1721)		1848		1896		1938	

After 1815 there is a one-to-one correspondence between Ischboldin's long waves and the base dating scheme.

23. Like Kuznets, Van Duijn adopts a four-phase dating scheme, of which I have indicated only the transitions between upswings and downswings.

24. Ischboldin (1967:319–22) discussed in Baqir (1981).

Cole (1938:107) gives the following dating scheme for long-term movements in wholesale commodity prices in the United States:

Peak	1720		1778?		1814/19		(1860)
Trough		1744		1789		1843	

Again there is one-to-one correspondence with the base dating scheme, although one date (1778) differs by fifteen years.[25]

Dupriez (1951:247–48) dates trends in gold holdings and currency issue in six countries (Great Britain, France, Germany, Belgium, the Netherlands, and the United States) as follows:

Peak		1818		1873		1913
Trough	1791		1844		1898	

These dates also match the base dating scheme quite closely.

Dating Schemes for the Preindustrial Age

For the preindustrial age, scholars rely more on qualitative data and price histories and reach more tentative conclusions, but again they demonstrate surprising consensus.

Braudel (1972:896) states that economic historians agree on the following periodization of upswings and downswings in the European economy:

Peak		1483		1529		(1559)		1595		1650
Trough	1460		1509		1539		1575		1621	

These are the dates used in the first century and a half of the base dating scheme shown above.

Imbert's (1959:181–200) price datings since 1495 are:[26]

25. The date 1860 precedes Kondratieff's peak of 1872, but Cole's study covers only the period through 1860.

26. Imbert (1956) identifies five long waves between 1286 and 1510—predating the period of this study but of interest in terms of historical continuity. These waves are found in French wheat prices (p. 224–25), various British commodity prices (p. 225–30), and, for the last two cycles, prices in Flanders (p. 230–31), Strasbourg (p. 232) and Spain (p. 232–33). The following dating is from the French series:

Rising	*Declining*
1286–1313/16	1313/16–1335/38
1335/38–1349/70 (stayed high)	1370–1380/86
1380/86–1391/93	1391/93–1410/12
1410/12–1421/39 (stayed high)	1439–1450/70
1450/70–1482/83	1482/83–1509/10

These very early long waves seem to join well with my base dating scheme, since Imbert's last wave corresponds with the first wave of the base dating scheme (from Braudel).

England:

Peak	(1480/90)	1530	1556/58	1597	1649	1710	
Trough		1507	1540	1569/71	1617/20	1685/88	1732/43

The fit to the base dating for 1495–1650 is excellent,[27] and the fit after 1650 is good.

France:

Peak		1530	—	1595	1650	1712	
Trough	1510	1539	—	1612	1671	1733	

The dating matches that for England, although Imbert is unable to identify the third English cycle in the French data.

Spain:

Peak		1530	1562	1601/05	
Trough	1510	1540/55	1594		1618

These continue to match the English dates roughly.

Germany:

Peak		(1535)	(1570)	1590	1620	1700	
Trough	1505	(1546)	(1580)	1605	1670	1720/30	

These dates correspond in a one-to-one manner with the base dating scheme, but the particular turning points deviate more than in most dating schemes.

Moving to the late preindustrial period (about 1650–1790), *Frank* dates the phases of development of the British economy. These dates were used in the base dating:

Peak	(pre-1670)	1720	1762	
Trough		1689	1747	1790

Baehrel (1961:50–51, 83–86) dates economic phases of grain prices in Provence:

Peak		1594	1655	1725	1785
Trough	1573	1625	1689	1754	

Baehrel's dating corresponds closely with the base dating through 1650 but diverges by about 1750.[28]

27. As it should be; Braudel, from whom that part of the base dating scheme derives, cites Imbert as a main source.

28. See also Baehrel, below, in section on preindustrial prices.

Wagemann (1931:368) gives the following dates for the expansion and stagnation phases of the world economy in the late preindustrial and industrial periods:

Peak		1720		1763		1815		1873		1920	
Trough	1690		1730		1790		1845		1895		(1931+)

These dates correspond closely with those of Frank and Kondratieff (except for a difference in dating one trough, which Wagemann puts at 1730 while Frank suggests 1747) and indicate a continuity to the dating of the long wave between the preindustrial and industrial eras.

Mauro (1964:313) elaborates upswings and downswings in world trade, particularly between the core and periphery (Europe and the Americas), and taking account of wars and production of precious metal in the periphery. His dates are:

Peak	1590		1640		(1670)		1720		1775		1815		1873
Trough		1620		(1660)		1690		1730		1792		1850	

This dating corresponds roughly, in a one-to-one manner, with the base dating scheme except for the addition of an extra cycle by Mauro, which I have indicated in parentheses.

In addition to the above dating schemes, there are occasional "stray" dating schemes in which a scholar claims to identify "long waves" substantially different in length or timing from those defined by the consensus of above datings. *Metz*[29] provides one example of such datings. For example, Metz's dating of "long waves" for wheat prices in Cologne hardly corresponds with the base dating:

Metz:														
Peak	1494		1534		1591		1636		1703		1762			
Trough		1518		1569		1613		1680		1724		1780		
Base dating:														
Peak	(1495)		1529		1559		1595		1650		1720		1762	
Trough		1509		1539		1575		1621		1689		1747		1790

Leaving aside one or two "stray" dating schemes, however, there is a remarkable consensus on dating among thirty-three scholars from all theoretical schools of the long wave debate.

Past Empirical Work

Given the agreement on dating phases, what is the evidence for long waves in each of the economic variables of interest: prices, production,

29. Metz (1983:216–17; 1984b:614–17), Irsigler and Metz (1984).

innovation, and other variables? The latter (for which little past empirical work is available) include capital investment, wages and worker protests, trade, and war.[30] A summary of the empirical studies showing each researcher's theoretical orientation, methodology, variables, time period, countries of analysis, and summary results appears in table 4.1, which may be a useful guide to the following pages.

Prices in the Industrial Period

Kondratieff ([1926] 1935) uses moving averages and trend deviation to show long waves in time series data on wholesale prices, interest rates, wages, foreign trade, and production—mainly for Great Britain, France, and the United States. The results for non-price series will be discussed in a later section.

Kondratieff identifies long waves in prices by graphing price series and their moving averages.[31] Some of these were shown in chapter 2 at the top of figure 2.2. The methodology for prices differs from that used for production and other "nonstationary" time series[32] (see below) in that the latter also involve trend deviation.

Kondratieff's use of long-term moving averages has been criticized. Slutsky (1937) shows that a statistical effect (the Yule-Slutsky effect) arising from long-term smoothing of the type done by Kondratieff shifts the spectra of the series toward the longer wavelengths. As Garvy (1943:219) notes, "In many series, [shorter] cyclical swings of particularly large amplitude influence moving averages strongly enough to produce the illusion of major cycles." These methodological criticisms, however, apply mostly to Kondratieff's study of non-price series (see below), while his price waves have been more widely accepted.

Gordon (1978:24) presents data on U.S. price changes averaged by long wave phase periods, basing the dates of turning points on the peaks and troughs of short price cycles (business cycles) derived from the National Bureau of Economic Research (NBER) (Burns and Mitchell 1946:432). The average annual percent change in prices in each period is:

1800–1814 (upswing)	+1.7%
1815–1843 (downswing)	−1.9%
1844–1864 (up)	+0.9%
1865–1896 (down)	−1.4%
1897–1920 (up)	+5.8%
1920–1940 (down)	−1.5%

These results support the idea of long waves in prices.

Van Ewijk (1982) uses spectral analysis to search for long waves in several price and production series from Britain, France, the United States, and Germany from the late eighteenth century. By limiting his time frame to 1770–1930, Van Ewijk excludes the anomalous price behavior since World War II. Despite some meth-

30. War, however, is reserved for chaps. 5 and 6.
31. Nine-year moving averages are used in order to eliminate the effects of shorter business cycles.
32. Series with an underlying long-term secular trend.

Table 4.1. Summary of Empirical Long Wave Studies

Prices since 1790

Author / Year	School / Method	Variables / Countries	Time span / Find waves?
Kondratieff 1920s	CI MA	Commodity prices Major capitalist countries	ca. 1790-1922 yes
Gordon 1978	CC BC	Prices U.S.	1800-1940 yes
Van Ewijk 1982	? SA	Prices Britain, France, U.S., Germany	1770-1977 only to 1930
Cleary and Hobbs 1983	? VI	Price, prod., innov., invest., employ. U.S., Britain	ca.1756-1979 mostly prices

Prices before 1790

Author / Year	School / Method	Variable / Countries	Time span / Find waves?
Imbert 1959	I/W VI	Agricultural prices mainly Various European countries	1286-1954 yes
Baehrel 1961	? MA	Grain prices and harvests Southern France	1573-1789 yes, and correlate
Margairaz 1984	? VI	Wheat prices France by region	1756-1870 yes
Grenier 1984	? SA	Prices France	1500-1790 no
Metz and Irsigler 1983-84	CC? MA/SA	Prices and other variables Germany, England	ca. 1530-1950 yes(irregular)

Production

Author / Year	School / Method	Variables / Countries	Time span / Find waves?
Kondratieff 1920s	CI TD/MA	Production, trade, etc. Major capitalist countries	ca. 1790-1922 yes
Oparin 1920s	CC? TD/MA	Prices, wages, trade Major capitalist countries	ca. 1790-1922 prices only
Isard 1942	? VI	Various commodity production U.S.	ca. 1825-1934 no
Burns and Mitchell 1946	? BC	Short business cycles U.S.	ca. 1860-1940 no
Mandel 1975	CC PP	Industrial output, trade U.S., Britain, Germany	c.a. 1830-1967 yes
Gordon 1978	CC PP	Industrial production World	1865-1938 yes
Gordon 1978	CC BC	National growth US, Britain, Germany	1848-1940 yes
Kleinknecht 1981a	CC/I PP	National production Ger., Italy, Brit., Swed., Den., Nor.	ca. 1850-1969 yes
Bieshaar and Kleinknecht 1984	CC/I PP	National production 11 national series	ca. 1890-1980 weakly yes

Production – cont.

Author / Year	School / Method.	Variables / Countries	Time span / Find waves?
Kuczynski 1982, 1978	CC PP	Industrial production, agri. prod., exports World	1830-1980 yes
Screpanti 1984	CC PP	Industrial production France, OECD countrie	ca. 1846-1970 yes
Van der Zwan 1980	CI TD/PP	Production, national income, trade U.S., U.K., Germany, world	ca. 1850-1940 no
Van Duijn 1980	I/CI BC	Industrial production U.S., Britain, France Germany, world	ca. 1790-1973 yes (?)
Delbeke 1982	I BC	Industrial production Belgium	1831-1913 yes (?)
Kuczynski 1978	CC SA	Production, exports, innovation World	1850-1976 weakly yes?
Van Ewijk 1982	? SA	GNP, industrial prod., invest., trade Britain, France, U.S.	ca. 1800-1977 no

Innovation

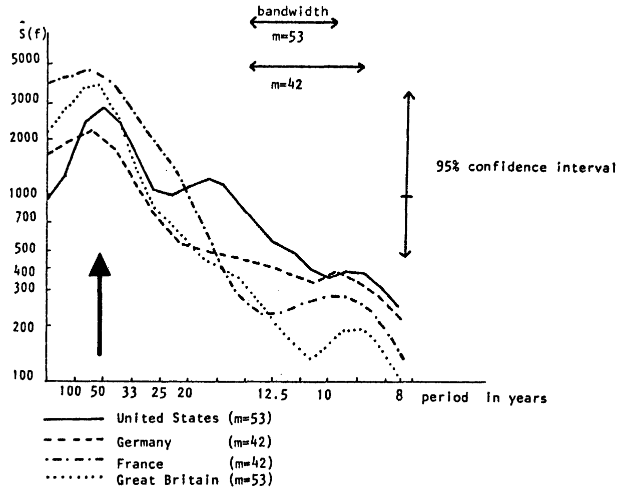
Author / Year	School / Method.	Variables / Countries	Time span / Find waves?
Mensch 1979	I VI	Innovations (list 1) World	ca. 1850-1950 yes
Clark and Freeman 1981	I VI	Innovations (list 2) World	ca. 1850-1950 no
Van Duijn 1981	I/CI PP	Innovations (list 3) World	1921-1957 yes (?)
Kleinknecht 1981b	I/CC VI	Innovations (list 4) World	ca. 1860-1970 yes
Hartman and Wheeler 1979	? PP	Patents Britain, U.S.	ca. 1800-1974 Brit. only
Kuczynski 1978	CC PP	Basic innovations World	1878-1955 yes

Other Variables

Author / Year	School / Method.	Variables / Countries	Time span / Find waves?
Dupriez 1951	? PP	Central bank note issue Britain, France, Ger., Bel., Neth., U.S.	1791-1939 yes
Gordon et al. 1983	CC BC	Labor costs U.S.	1890-1981 yes
Sau 1982	CC VI	Profit rates U.S., Britain, France, Germany, Japan	1960-1975 peak ca. 1967

Note: Theoretical schools: CI = Capital investment; I = Innovation; CC = Capitalist crisis; W = War. Methodologies: VI = Visual inspection; MA = Moving averages; PP = Phase period growth rates; TD = Trend deviation; BC = Business cycle analysis; SA = Spectral analysis.

Figure 4.1. Van Ewijk's Spectra of Price Series



Note: Graph represents sample spectra of price series for Great Britain, France, Germany and the United States, 1770-1930. Only the spectral estimates for the low-frequency bands (0 to 0.125 cycles per year) are shown.

Source: Van Ewijk, *KYKLOS* (1982: 481) by permission of *KYKLOS*.

odological problems,[33] Van Ewijk does find long waves in the price data. As shown in figure 4.1, prices in all four countries show a peak in their spectra around fifty to sixty years.[34] Van Ewijk (1982:482) finds "no trace" of a long wave in price spectra in the longer period extended to 1977 rather than 1930 (from 1770). This is attributed to either nonstationarity or perhaps changes in the long wave since 1930.

Cleary and *Hobbs* (1983) use mainly visual inspection to weigh the empirical evidence for long waves.[35] They examine data on prices and on various indicators of production, innovation, capital formation, and unemployment mainly for the United States and Great Britain. They conclude:

The strongest empirical evidence in favour of the long-wave hypothesis undoubtedly comes from price series. Supporting evidence can also be found in the behaviour of long-term interest rates, world energy production and innovation. Limited and not very convincing evidence can be seen in world industrial production, U.S. mineral production, unemployment and investment (p. 180).

33. Inadequate degrees of freedom, which Van Ewijk says can only be resolved by waiting one or two centuries.

34. "As could be expected, given the relatively short series, the spectral peaks are small relative to the 95% confidence interval. However, both from the stability of the location of these 'long wave' peaks, when the number of lags is varied, and from the great international similarity, it may be concluded that these peaks are a real trace of a long wave in prices" (Van Ewijk 1982:482).

35. "While not disputing the value of statistical analysis techniques, in this paper we are asking the readers to use their eyes and trust their own judgement" (p. 165).

The above empirical results generally converge in showing fairly strong evidence for long waves in prices in the major economies since around 1790 (at least up through the 1930s), despite a variety of methodological and theoretical approaches.

Prices in the Preindustrial Period

Imbert ([1956] 1959) has done the most detailed work on preindustrial prices. He discusses the various statistical approaches to the identification of long waves in time series data and adopts "direct observation of the raw data" as his method for identifying long waves (1959:45).

As mentioned above, Imbert dates long waves from about 1500 to 1790 in a variety of European countries. In addition to the national datings discussed above, he dates long waves in a variety of specific (mostly agricultural) commodities in this period (p. 198–201). These datings follow fairly closely a one-to-one correspondence with his English dates and with the base dating scheme.[36] From these price histories Imbert concludes that internationally synchronized long waves of prices date back through the entire period to 1495 and before. Only the third downswing of 1557–70, which appears in the English data, is not found in some countries (and appears only weakly in others).

Baehrel (1961) identifies phases of increasing and decreasing grain prices in southern France from 1573 to 1789. She builds on the work of Imbert in identifying preindustrial price waves and uses a methodology similar to his, relying on inspection of time series data.

Baehrel claims that these price waves correlate inversely with long-term fluctuations in harvests during that period, as seen in harvest data smoothed by moving averages.[37] For Galignan harvest data I have reconstructed the following table based on Baehrel's dating of price phases (p. 98):[38]

Turning point in prices	Change in harvest level from previous turning point
1573 (trough)	
1594 (peak)	−30% (approximately)
1625 (trough)	+60% (approximately)
1655 (peak)	−20% (approximately)
1689 (trough)	? (−15% to +5%?)
1725 (peak)	−25% (approximately)
1754 (trough)	+5% (approximately)
1785 (peak)	? (about zero?)

36. The series include grain prices at Avenel (1510–1733), wheat and grain prices at Paris (1531–1745), grain prices at Grenoble (the third cycle of 1557–97 is not found), wheat prices at Strasbourg and Bale (1595–1730, earlier periods showing only longer-term movements), prices of wheat, oats, butter, and cheese in Flanders (1585–1733), and prices on the Amsterdam stock exchange (1620–1734).

37. Harvests really belong with production, below, rather than prices, but since this is the only study of preindustrial production I have not made it a separate section, particularly since Baehrel connects harvests with prices.

38. Baehrel's own analysis uses different transition dates to show harvest phases than for her earlier price analysis.

As mentioned earlier, Baehrel deviates from my base dating scheme after 1725. The changes in harvest for the last two phase periods can be roughly recalculated from Baehrel's data using the base dating scheme (derived from Frank's dates) as follows:

Turning point in prices	Change in harvest level from previous turning point
1747 (trough)	+2% (approximately)
1762 (peak)	−20% (approximately)
(1782)	+20%? (data fragmentary)

Thus Baehrel's harvest data seem to correlate more closely with the base dating scheme than with her own price phases when the two diverge (a minor victory for the base dating scheme).

Baehrel's conclusion (p. 100) that downswing phases in harvests correlate with upswing phases in prices (and vice versa) should be treated cautiously because of the poor quality of data. Her analysis also leaves open the questions of whether harvest waves *cause* price waves, whether a third factor such as war affects trends in both harvests and prices,[39] and whether long waves in harvests are connected with later long waves in industrial economies.

Margairaz (1984:673) investigates the variations in long-term movements of wheat prices among different regions of France from 1756 to 1870 (before and after the start of the industrial age). She finds prices rising from 1756 to 1812 (an up-down-up on the base dating scheme), with the intermediate downswing appearing after 1770 except in the southern regions. The next downswing, from 1812 to 1850/52, appears in twenty-eight of thirty-one regions, and the timing of the turning points corresponds between regions. Thus, "there exist[s] a real interdependence of long regional fluctuations" of prices in that era.

Grenier (1984) applies spectral analysis to French price series from about 1500 to 1790. Although he finds long-term movements ranging up to thirty years (p. 435), Grenier's spectra do not show peaks in the long wave range (pp. 443–44). He concludes that one can find regular price movements but not cycles involving a continuity of motion (p. 438).[40]

Metz (1983, 1984b) and Irsigler and Metz (1984) apply a combination of trend deviation and spectral methods to analyze preindustrial economic data. Metz proposes a new method for defining and then eliminating a secular trend and finding long waves in the residual data. Metz's (1983:185) method for eliminating the long-term

39. See later chapters on war. Major European wars will be shown plausibly both to depress harvests (destruction caused by war) and to raise prices. Baehrel (1961:101–2), rejects weather cycles as a cause of the harvest/price waves.

40. Grenier suggests (p. 442) dropping the idea of "long cycle" (with fixed periodicity as searched for by spectral analysis), in favor of "long phases" (where the alternation of upswing and downswing is not systematic). See chap. 8.

trend uses complex statistical filters though which the time series data are passed and which damp out the long wavelength spectral frequencies (longer than sixty years).[41]

Metz (1983:181) analyzes nine German and English economic time series.[42] He concludes that only agrarian prices show cycle lengths typical of "Kondratieff" cycles in the spectral analysis (p. 204). I note that only German wheat and rye prices (1561–1934) show even a rough correspondence with the base dating scheme (p. 216).[43] Metz (1984b:601) conducts a similar analysis for twelve preindustrial (northern European) time series on prices, money, and metal. He concludes that in the preindustrial series analyzed, "in all series concerning the agrarian sector, long waves could be shown" (p. 629).

Irsigler and Metz (1984:385) examine series for prices and agrarian production in preindustrial times (and for production indicators and capital investment in industrial times). Only the consumer price index for western Brabant (1410–1700) matches the base dating scheme reasonably well. Thus in each study Metz claims to identify "long waves" that are synchronous across countries and variables,[44] but as noted above these do not correspond in most cases with the timing of other scholars' long waves (Metz 1983:216–17; 1984b:614–17; Irsigler and Metz 1984).

To recap the evidence for long waves in preindustrial prices, then, there is agreement among those using a visual inspection methodology as to the existence and dates of cycles in agricultural prices. Those using spectral analysis, however, are generally unable to identify those same cycles statistically.[45]

Production in the Industrial Period

The evidence for long waves in production[46] and related "real" variables cover only the industrial period since around 1790.

Kondratieff claims to show long waves in a number of production series, although there are others in which he does not find long waves.[47] Long waves that do appear in series seem to be closely correlated among the different series, including those from different countries. For example, 1893 to 1917[48] shows a rising trend in curves for

41. Unfortunately, Metz's "trend" is even more complicated than was Kondratieff's (discussed below). The "detrended" series may show long-term oscillations, but these are difficult to interpret.

42. Four agricultural price series from the preindustrial period and five production, wage, or investment series from the industrial period.

43. All the other series that exhibit long-term oscillations called long waves by Metz are quite irregular and vary in length. "It would . . . be wrong to emphasize the importance of the different datings of the upswings and downswings," says Metz (1984b:613). But the datings show Metz to be describing different long-term movements than those discussed by other scholars of the long wave.

44. Some do appear to be synchronous.

45. This indicates the divergence of the approaches requiring fixed periodicities from those requiring only an alternating sequence of historical phases of variable length.

46. Production series include overall production indexes (national product), indexes of industrial production, and production series for particular industries.

47. Eklund (1980:396) points out that Kondratieff found long waves in only 11 of the 21 production and consumption series analyzed.

48. A period of rising English, French, and U.S. prices.

English wages, French foreign trade, and French and British production of coal, iron, and lead (see fig. 2.2). The preceding period, 1872 to 1893, shows declining trends in these curves. From this evidence Kondratieff concludes that long waves exist across the entire economy and are international.

Kondratieff's empirical work on production (and other nonprice) series has been strongly criticized. Garvy (1943:209) notes that in the Russian criticisms of Kondratieff's work, "the methodological part of Kondratieff's work in particular attracted the attention of his critics." Foremost among the methodological criticisms have been those directed against Kondratieff's use of trend curves.[49] Kondratieff's method is first to fit a long-term trend to a series and then to use moving averages to bring out long waves in the residuals (the fluctuations around the trend curve). But "when he eliminated the trend, Kondratieff failed to formulate clearly what the trend stands for" (Garvy 1943:209). The equations Kondratieff uses for these long-term trend curves (as fitted to the data) appear in table 4.2 and include rather elaborate (often cubic) functions. This casts doubt on the theoretical meaning and parsimony of the resulting long waves, which cannot be seen as simple variations in production growth rates.

Oparin, a leading contemporary and critic of Kondratieff, illustrated his objections to Kondratieff's trend curves by extending some of Kondratieff's series forward to the 1920s and fitting new trend curves to them. The latter differed considerably from Kondratieff's and showed long waves with a different timing and amplitude. Many of Kondratieff's contemporaries thus concluded that long waves "were definitely established only for series including the price element" (Garvy 1943:210–11).

In the 1920s Oparin conducted his own analysis of long time series data to test Kondratieff's conclusions. He found that "long waves can be observed only in the movement of prices and of the long-term interest rates. The long waves immediately disappear from wage and foreign trade series when changes in the price level are eliminated" (quoted in Garvy 1943:211).

Other of Kondratieff's Russian critics arrived at a similar conclusion (Garvy 1943:211). In 1928 Gerzstein asserted that movements of prices and production do not coincide and thus that Kondratieff's price waves do not represent production phases. Gerzstein, using qualitative economic history, argued that great development of productive forces took place on Kondratieff's (price) downswing periods, at least as much as on the upswings. Garvy himself (1943:217) arrives at the same conclusion regarding Kondratieff's long waves in production series: "Even the few production series which Kondratieff considered as demonstrative of long cycles fail, upon closer examination, to support his conclusions."[50] Snyder (1934) likewise finds long waves in prices but not in production (Barr 1979:704).

49. This criticism applies only to Kondratieff's work with real series, which have a secular trend, not with prices. Garvy (1943:211) notes that Kondratieff's *data* did not come under criticism by and large.

50. The central problem, Garvy (1943:218) agrees, is in Kondratieff's trend deviation methodology for these series: "Less arbitrariness in the choice of the period to which the trend was fitted, and more adequate trend formulas, would have yielded, for nearly all series, deviations of a different shape."

Table 4.2. Kondratieff's Trend Equations

(Long waves are found in deviations from these trends)

Commodity prices (England, France, U.S.):	(no secular trend)
Quotations of English consols:	$y = 112.57 + .26x - .012x^2 - .0002x^3$
Quotations of French rente:	$y = 78.99 + .23x$
Wages in English cotton industry:	$y = 64.128 + 1.053x + .0099x^2 - .00023x^3$
Wages in English agriculture:	$y = 91.587 + .454x$
English foreign trade:	$y = 10\,(1.0293 + .0096x - .00006x^2)$ [a]
French foreign trade:	$y = 146.39 + 3.46x + .006x^2$
English coal production:	$y = 10\,(3.6614 + .0063x - .000094x^2)$ [a]
French mineral fuel consumption:	$y = 539.21 + 16.9x + .1326x^2 + .00026x^3$
English pig iron production:	$y = 193.3 + 2.28x - .0556x^2$
English lead production:	$y = 10\,(0.0278 - .0166x - .00012x^2)$ [a]
French savings bank liabilities:	$y = 1133.9 + 57.227x + .7704x^2$
English commodity prices on a gold base:	$y = 139.0 - 1.113x - .0028x^2 + .000196x^3$

Source: Kondratieff ([1928] 1984: 110-135)
a. In these equations 10 is raised to the power of the expression shown

Walter Isard (1942a:156) reexamines some of Kondratieff's production variables for the United States. He "accepts the existence of the Kondratieff cycle in the price data . . . [but] can find no evidence of Kondratieff cycles in other data." Isard traces pig iron production (a variable in which Kondratieff claimed to find long waves) for the United States and finds "no evidence whatsoever of Kondratieff's long waves." Similar results obtain for coal production, lead output, cotton acreage, and the number of spindles in the cotton industry (also variables used by Kondratieff). Isard suggests Kondratieff's results (for iron and coal) may be an artifact of failing to carry the data sets back far enough in time.

Burns and *Mitchell* (1946:432) also criticize Kondratieff's approach to identifying long waves in production. They agree that wholesale prices tended historically to move in long upward or downward periods that correspond closely with Kondratieff's dating. But they question whether these price movements reflect overall economic growth as defined by their own NBER indicators.[51] Burns and Mitchell examine the shorter business cycles in the NBER data, asking whether those occurring during Kondratieff's (price) upswing differ from those during the downswing.[52] They find the business cycles to be similar during the two long wave phases, a negative result for the idea of long waves in production.

Klas Eklund (1980:398–99) says that by the end of the first wave of debate on long

51. Burns and Mitchell note that Kondratieff's data cover only 2 ½ long waves (since 1790) and that the NBER data go back only to the 1850s or 1870s, making a meaningful assessment of 50-year cycles impossible.

52. If a long wave exists, then "the position that an individual business cycle occupies in a 'long cycle' determines whether [the business cycle] is a mild movement . . . or a convulsive fluctuation" (p. 383).

waves, "a consensus of opinion seemed to emerge among economists, according to which the long waves were a monetary phenomenon, found in certain price and value series, but not in the entire economic sphere—or in the social and political spheres—the way Kondratieff had claimed." The view that "came to dominate among economists," according to Eklund, was that "long waves were a monetary phenomenon, exogenously determined" by wars and other noneconomic phenomena.

This did not end the debate on long waves in production, however. In the second round of interest in long waves, a number of new studies of this question have emerged, mostly from the capitalist crisis school.

Mandel's growth rates by phases for world trade and for industrial production in Great Britain, Germany, and the United States (Mandel 1980:3; from 1975:141) are reprinted in table 4.3. Growth rates clearly alternate between successive phases. Although his turning points for each variable correspond roughly with the base dating (the last part of which comes from Mandel), there is a slight problem with Mandel's practice of dating each variable's turning points on the basis of its own local peaks and troughs. Long waves should be defined as synchronous across variables and countries. It is easy to show alternating growth rates in successive phases by defining those phases as starting at some local peak (or trough) in the series and ending at some later local trough (or peak). But its ad hoc nature makes this a weak approach. The stronger test, which Mandel does not make, is whether growth rates alternate when a single dating scheme is imposed on all the countries and variables at once. Nonetheless, the turning points of Mandel's different series are close enough to each other that the degree of bias seems to be small.

Gordon (1978:24), also from the capitalist crisis school, presents data on physical output in the "advanced countries." Like Mandel, he presents average growth rates

Table 4.3. Mandel's Statistical Evidence for Long Waves

	Years	Percent
Annual compound rate of growth in world trade (at constant prices)	1820–1840	2.7
	1840–1870	5.5
	1870–1890	2.2
	1891–1913	3.7
	1914–1937	0.4
	1938–1967	4.8
Annual compound rate of growth of industrial output in Britain	1827–1847	3.2
	1848–1875	4.55[a]
	1876–1893	1.2
	1894–1913	2.2
	1914–1938	2.0
	1939–1967	3.0
Annual compound rate of growth of industrial output in Germany (after 1945: FRG)	1850–1874	4.5[b]
	1875–1892	2.5
	1893–1913	4.3
	1914–1938	2.2
	1939–1967	3.9
Annual compound rate of growth of industrial output in the United States	1849–1873	5.4
	1874–1893	4.9
	1894–1913	5.9
	1914–1938	2.0
	1939–1967	5.2

	Percent for 1947–1966	Percent for 1967–1975
Annual compound growth of industrial output after World War II		
United States	5.0	1.9
Original EEC six	8.9	4.6
Japan	9.6	7.9[c]
Britain	2.9	2.0

[a] Dr. J. J. Van Duijn, *De Lange Golf in de Economie* (Assen, 1979), p. 213, contests this figure. He appears to be right.
[b] R. Devleeshouwer ("Le Consulat et l'Empire, Période de 'takeoff' pour l'économie belge?" in *Revue de l'Histoire Moderne et Contemporaine, XVII*, 1970) gives the following annual compound rates of growth for the Belgian economy: 1858–1873: 6%; 1873–1893: 0.5%; 1893–1913: 4%.
[c] This was down to 7% for the 1967–79 period, and it will continue to slide down. *The Economist* (May 24, 1980) puts the annual rate of growth of Japan's GNP at 4.1% for the 1973–1979 period and estimates that it will decline to 3.5% for the 1979–1985 period.

Source: Mandel (1980: 3). Copyright Cambridge University Press. Reprinted by permission.

for each long wave phase using world production data from Dupriez (1947 2:567).[53] For comparison I include my base dating of phases:

	Gordon		Base dating scheme
Phase	Dating (Years)	Average annual growth in production per capita (%)	Corresponding phases (Years)
U	1865–1882	2.58	1848–1872
D	1880–1894	0.89	1872–1893
U	1895–1913	1.75	1893–1917
D	1913–1938	0.66	1917–1940

As with Mandel, Gordon selects the best local turning points based on the series itself. This problem is somewhat worse for Gordon than Mandel: he does not show largely convergent dating for a number of series, nor do his dates follow the base dating as closely (the first date differs by seventeen years).

Gordon supports these results using a different methodology—analysis of shorter business cycles (p. 26). He compares the ratio of total "expansion months" (short cycle trough to peak) to "contraction months" in business cycles on long wave upswing phases against those on downswing phases:

		Ratio of expansion to contraction months		
Phase	Years	U.S.	Great Britain	Germany
U	1848–1873	1.80	2.71	1.61
D	1873–1895	0.86	0.76	0.79
U	1895–1913	1.14	1.62	1.33
D	1919–1940	0.67	1.36	1.82

The methodological problem of ad hoc turning points recurs as above.[54] The differences do, nonetheless, seem fairly strong between the periods—and these periods now match the base dating scheme fairly closely.

Gordon's conclusions contradict those of Burns and Mitchell (discussed above), although Gordon uses Burns and Mitchell's general methodology and business cycle datings. This is one of several examples of different results produced by different schools.

Kleinknecht (1981a:689, 692–93) explicitly follows Mandel's methodology and examines data from additional countries. He gives the following estimates of average annual growth rates of real national product (constant prices) within long wave phases, using data from Mitchell (1980:779ff.):

53. "Annual cumulative rates of growth in physical output per capita, adjusting production indices for price changes and aggregating across countries" (p. 24).

54. The dates used for each country actually differ slightly from those shown above, based on the local turning points in the country's business cycles. War years are excluded, and certain other ad hoc adjustments are made.

Phase	Germany Years	(%)	Italy Years	(%)	Great Britain Years	(%)
U	1850–1873	2.77	1861–1873	0.91	1850–1873	3.02
D	1874–1893	1.92	1874–1893	0.68	1874–1893	1.42
U	1894–1913	2.95	1894–1913	2.48	1894–1913	2.01
D	1913–1938	1.77	1920–1938	1.83	1914–1938	0.75
U			1951–1969	6.50	1950–1969	2.74

Phase	Sweden Years	(%)	Denmark Years	(%)	Norway Years	(%)
U	1861–1873	3.29	1870–1873	4.46	1865–1873	2.30
D	1874–1893	1.55	1874–1893	2.63	1874–1893	1.50
U	1894–1913	3.61	1894–1913	3.87	1894–1913	2.67
D	1914–1938	2.60	1914–1938	2.88	(1914–1929	2.96
U			1950–1969	3.92	1930–1938	2.60)

Thus, except for the unusual dating for Norway since 1914 (enclosed in parentheses)—and acknowledging some minor discrepancies in turning points and the omission of World War II years—these data give further support to the alternation of higher and lower production growth rates on long wave upswings and downswings. The ad hoc selection of turning points for each series remains, however.

Bieshaar and *Kleinknecht* (1984) measure average growth rates for eleven national production series within predefined historical phase periods (using Mandel's datings) by fitting a trend line to logged data within the period.[55] The predefined phase periods minimize the ad hoc dating problem, but the mixed results show at best long waves only since 1890 (less than two waves) and not for Great Britain.

Kuczynski (1982:28) calculates the average annual growth rates of capitalist world industry as follows:

Phase	Kuczynski's dating Years	Average annual growth of world industry (%)	Corresponding dating from base scheme Years
D	(1830)–1847	4.16[a]	1814–1848
U	1847–1872	4.31	1848–1872
D	1872–1894	2.77	1872–1893
U	1894–1913	4.67	1893–1917
D	1913–1939	2.13	1917–1940
U	1939–1973	4.72	1940–1968
D	1973–(1980)	3.10 (unfinished)	1968–

[a]Kuczynski says too high because early downswing depression years around 1825 excluded.

55. The trend lines are constrained to intersect at turning points, and the methodology is rather complex.

Kuczynski (1978:86) gives the following average growth rates for the world economy (in constant prices). For each variable, the starting date of the long wave phase and the growth rate for that phase are shown:

	Total production		Industrial production		Industrial share of total		Agricultural production		Total exports	
Phase	Year	(%)	Year	(%)	Year	(%)	Year	(%)	Year	(%)
U	1850	2.3	1850	4.8	1850	2.2	1850	2.0	1850	5.7
D	1867	1.7	1867	3.3	1870	0.5	1881	1.2	1867	3.1
U	1894	2.8	1897	4.5	1897	1.4	1895	2.1	1894	3.5
D	1914	2.5	1914	2.3	1914	0.6	1916	1.2	1914	0.6
U	1951	4.5	1951	5.6	1951	1.1	1951		1950	
D	1967	3.5	1970	3.4	1967	0.5		{2.4}		{7.1}
	(1977)		(1977)		(1977)		(1977)		(1977)	

The dates are based on cluster analysis (grouping together years with similar data), so once again a bias is introduced by ad hoc dating of turning points for each series.

Screpanti (1984) continues in the same vein after reviewing the contributions of Mandel, Gordon, and Kleinknecht. Screpanti tabulates average annual compound growth rates of industrial output based on the data of Maddison (1977), for France, and for 16 OECD countries as a whole:[56]

	France		16 OECD Countries	
Phase	Years	(%)	Years	(%)
U	1846–1878	1.3		
D	1878–1894	0.9	1870–1894	2.1
U	1894–1914	1.5	1894–1913	2.8
D	1914–1938	1.0	1914–1950	1.9
U	1939–1967	3.7	1950–1970	4.9

From these results, and those of Mandel, Rostow, Kleinknecht, Gordon, Kondratieff, Dupriez, and Imbert, Screpanti concludes that "long waves in the growth rate of industrial output occurred in many advanced capitalist countries" and that "the timing of the long cycle is practically uniform throughout the center of the world capitalist system" (p. 519). He does, however, call attention to the "vagueness" of turning point datings that reflect both differences of opinion and actual differences in turning points between countries.

To summarize, six scholars—all from the capitalist crisis school of the theoretical debate—have attempted to show alternating patterns of rapid and slower growth in overall (national) production on alternating long wave phases. The results have been

56. The French figures apparently derive from another study by Gordon, Edwards, and Reich (1982).

consistently positive across a range of countries and data sources, although weakened somewhat by problems in dating turning points.

Other scholars from different theoretical schools have applied other methodologies to the production question with varied results. *Van der Zwan* (1980:192–97) analyzes time series data for production in the United States, United Kingdom, Germany, and the world and for U.K. income and world trade in primary products, covering various ranges of years around 1850–1940. He combines trend deviation and phase period methodologies—first fitting a time series to a long-term growth curve, then estimating the growth rates of the deviations from this curve in each long wave phase period.[57] Van der Zwan does not find significant differences in the growth rates across phases, however.[58] "The period 1874–1913 can be described nearly perfectly as one of constant growth" rather than stagnation followed by expansion. Van der Zwan's findings contradict those of the six capitalist crisis scholars just discussed, despite some methodological similarities.

Van Duijn (1980:224), however, disputes Van der Zwan's conclusions[59] and argues for a "business cycle" methodology for measuring long waves in production (see also Van Duijn 1979; 1983:165ff.). He divides a time series into short business cycles and defines the long wave as a group of four to six (typically five) such cycles (1980:226). Growth rates for each business cycle are determined by the difference from the peak of one business cycle to the peak of the next.[60] Van Duijn uses four long wave phases—prosperity, recession, depression, and recovery—but these phases are not always consistent with my base dating scheme,[61] and the dates of

57. The phase periods are predefined by price movements.

58. For example, he gives the following growth rates for U.S. production (index of production of manufactures), as estimated by linear trends in logged data:

Phase	Years	(%)
U	1861–1873	6.02
D	1874–1894	5.42
U	1896–1913	5.28

The British series are "completely inconsistent with the alleged long wave" (p. 193). German data, as well as world production and trade data, could support the long wave hypothesis but with "negligible" magnitude (p. 194).

59. Van Duijn (1980:224–26) criticizes both the quality of historical data and Van der Zwan's trend deviation method, which assumes a simple growth curve as the underlying trend about which production varies. Van Duijn would prefer an S curve as the underlying trend. Van Duijn echoes the early critics of Kondratieff in arguing that "the pattern of residuals is very sensitive to the trend assumptions one makes." Finally, Van Duijn objects to using price phases as a priori time periods in which to compare production growth rates. He argues that prices are not central to or even necessarily correlated with the long wave (as shown by the different histories of prices and production in the 20th c.).

60. Like Kondratieff's, this methodology aims to eliminate the effect of short business cycles on the measurement of long waves. It has the disadvantage of using only one (not necessarily representative) data point in each cycle (see chap. 8).

61. The "recession" phase sometimes falls late in the base dating upswing and sometimes early in the downswing, while "recovery" sometimes comes late in the downswing and sometimes early in the upswing. World War I is treated as a separate "war" phase, but World War II is included with "recovery."

Table 4.4. Results of Van Duijn's Analysis

*	Phase	Start of business cycle					Growth of Industrial Production Annual % Growth Rates				
		Brit.	Fr.	Ger.	U.S.	World	Brit.	Fr.	Ger.	U.S.	World
D	Prosperity	1782					4.8				
U	Prosperity	1792					2.4				
	(War)	1802					2.1				
D	Recession	1815	1815				3.9	1.4			
	Depression	1825	1824				3.7	0.5			
	Recovery	1836	1836				3.3	2.3			
U	Prosperity	1845	1847	1850			3.3	2.8	3.4		
	Prosperity	1857	1856	1857			2.1	0.6	3.9		
	Recession	1866	1866	1866	1864		3.6	2.1	5.9	6.2	
D	Depression	1873	1872	1872	1873	1873	2.0	1.9	1.2	5.8	3.1
	Recovery	1883	1882	1882	1882	1883	1.3	0.4	5.0	4.0	3.3
U	Prosperity	1890	1890	1890	1895	1892	1.3	1.6	3.8	6.4	4.2
	Prosperity	1903	1903	1903	1903	1903	2.6	3.5	4.4	5.3	4.0
D	(War)	1913	1913	1913	1913	1913	-1.4	-6.7	{1.1}	3.1	{2.8}
	Recession	1920	1920	1920	1920	1920	1.7	8.1		4.8	
	Depression	1929	1929	1929	1929	1929	2.7	-2.6	3.0	0.4	1.4
U	Recovery	1937	1937	1937	1937	1937	0.8	0.3	. . .	5.0	2.9
	Prosperity	1948	1948		1948	1950		6.6	15.4	4.4	
	Prosperity		1957	1957	1957			6.1	5.8	5.3	
D	Recession		1966	1966	1966			5.8	5.2	3.9	
	Depression		1973	1973	1973						

Source: These results have been reformatted from Van Duijn (1980: 228-230). Data sources vary; world production excluding USSR is from Lewis (1952). * = Grouping of Van Duijn's short cycles into my base dating scheme. Boxes indicate Van Duijn's "prosperity" phases.

business cycle turning points (which define long wave turning points in this approach) vary from country to country.

Van Duijn's (1980:228–30) results are summarized in table 4.4. I have grouped the business cycles by the base dating scheme as well as by Van Duijn's phases. Van Duijn concludes that the long wave in industrial production can be found (p. 231–32),[62] but my reading of his results is more skeptical. There is little apparent difference between growth on the (base dating) upswing phases and that on the downswings. Even using Van Duijn's own categorization of phases, the growth rates

62. He qualifies this with a series of ad hoc adjustments, taking into account the different courses of the business cycle and the long wave in different countries.

during "prosperity" phases (marked in boxes on table 4.4) are not higher than in the other phases for any of the four countries.[63]

Van Duijn later (1983:156–57) gives the following growth rates of industrial production by phases, as summarized by Thompson (1984:15a):[64]

Phase	Years	Great Britain (%)	U.S. (%)	Germany (%)	France (%)	Japan (%)
U	1840s–1870s	3.0	6.2	4.3	1.7	
D	1870s–1890s	1.7	4.7	2.9	1.3	
U	1890s–1913	2.0	5.3	4.1	2.5	2.4
	1920–1929	2.8	4.8	?	8.1	3.4
D	1929–1948	2.1	3.1	?	−0.9	−0.2
U	1948–1973	3.2	4.7	9.1	6.1	9.4

Van Duijn's methodology, variables, countries, and results resemble those of Gordon (1978:26), yet Van Duijn (1980; 1983) does not cite Gordon—another illustration of the problematical communication between schools.

Delbeke (1982b) follows Van Duijn in criticizing the use of trend deviation methods and in using a business-cycle methodology.[65] He tries to identify leading sectors in Belgian economic development (1831–1913) based on production growth rates analyzed by industry. Delbeke (p. 21) gives the following figures for the average annual growth of Belgian industrial production as a whole (as with Van Duijn I have separated the base dating scheme periods):

Phase[a]	Delbeke's phase	Start of business cycle	Growth rate (%)
D	(Depression)	1831	5.6
	Recovery	1837	1.0
U	Prosperity	1847	3.6
	Prosperity	1858	4.2
	Recession	1866	3.0
D	Depression	1875	1.3
	Recovery	1884	2.1
U	Prosperity	1893	3.3
	Prosperity	1900	3.4
	(Recession)	1908	3.5
D	Depression	1913	

[a]Dating of upswings and downswings by base dating scheme.

63. For the world total, the boxed growth rates are higher, but those data cover only 77 years (and only one prosperity period, 1892–1913).

64. Note that World War I years (but not World War II) are omitted and that the 1920s, a downswing in the base dating scheme, shows high growth and is included with the upswing here. Years vary between countries on the first three turning points. Japanese data are for total (not industrial) production.

65. "The long wave, in fact, can only be observed through the business cycles" (Delbeke, p. 19).

Delbeke's results, like Van Duijn's, are inconsistent, and he resorts to various ad hoc interpretations in order to reconcile them with the long wave theory.

Kuczynski (1978) (from the capitalist crisis school) uses spectral analysis to look for long waves in world agricultural production, total exports, inventions, innovations, industrial production, and total production for 1850–1976.[66] Kuczynski's results "seem to corroborate" the hypothesis of a long wave in these data (p. 81). The sixty-year cycle has a large bandwidth, however, due to the shortness of the time series. Also, Kuczynski notes that long waves account for only about one-sixth to one-fourth of the residual variance in production and trade series, and a much smaller porportion in the innovation and invention series. Kuczynski concludes that "we cannot exclude the possibility that the 60-year-cycle . . . is a random cycle" (p. 82).

Van Ewijk (1982), who claimed to show long waves in prices using spectral analysis (see above), applies the same methodology to real variables (British industrial production, GNP, investment, exports, and imports; French industrial production; and U.S. GNP) in the period since about 1800.[67] His results are even more negative than Kuczynski's: "With respect . . . to real economic variables, the analysis yields not even a trace of a long wave" (p. 495). Cross-spectral analysis indicates that "price-movements correspond badly to movements in industrial production" (p. 490).

Several works on production variables are methodological "outliers" from the main body of empirical work. *Metz*'s (1984a) "long waves" in production variables parallel his price waves, discussed earlier. These are irregular, smoothed, upward and downward trends that do not match the long waves of other scholars. *Bossier* and *Huge* (1981) look for long waves in Belgian real variables—industrial production, zinc and lead production, railroad traffic—from 1840 to 1978. They use a trend deviation methodology that involves three filters for stationarity and, depending on the filter used, find different cycles, none of which exceeds twenty-four years in length. *Keen* (1965) uses a method similar to Kondratieff's—trend deviation filters plus moving averages—for Japanese real variables from 1890 to 1938.[68]

Sterman (1984:35–37), from Forrester's group, compares historical data on U.S. GNP against the simulation produced by the system dynamics model (see fig. 4.2). While the model does indeed generate regular long waves of production, the historical data do not match this pattern very closely (my conclusion, not Sterman's).

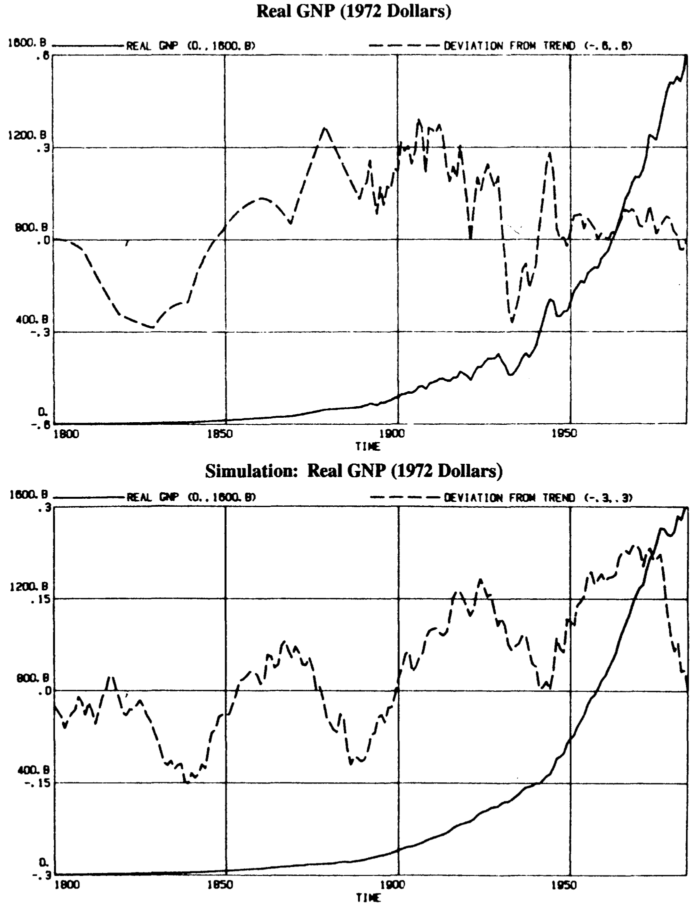
To summarize, the empirical studies of long waves in production fall into two groups, generally dividing the Marxist capitalist crisis approaches from the other schools. In the former group, six scholars applied the same methodology—estimating growth rates by phase period—and found consistent results showing alternating growth patterns on successive long wave phases. Among the second group of

66. Data are listed in Kuczynski (1980:309–12).

67. Because of nonstationarity in the real series (p. 477), the residuals from a loglinear trend were used (p. 478).

68. Keen tries to find the sequence of leads and lags among variables to infer possible causality; however, his study is flawed by the problems discussed above with trend deviations and moving averages plus the problem of an extremely short time span.

Figure 4.2. Sterman's Actual and Simulated U.S. GNP



Source: Sterman (1986: 90,92)

studies, however, only weak support for long waves in production variables was found. This contrasts sharply with the strong support for long waves in *prices* found by some of those same researchers.[69]

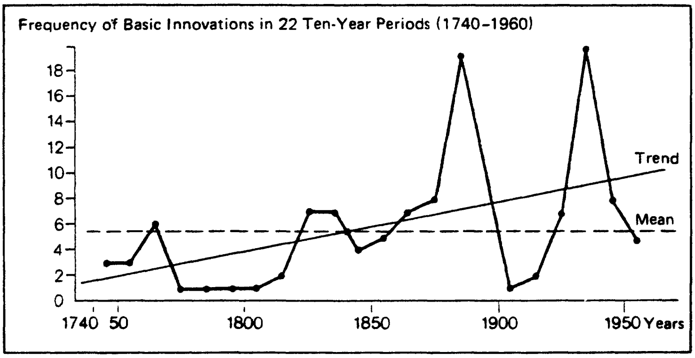
Innovation

There is no consensus on how to measure innovation.[70] Studies rely either on such proxy variables as patent applications (whose meaning may not be clear) or on lists of

69. Eklund's (1980:412) review of empirical studies concludes that "wave-like fluctuations in prices . . . have been found—but these are quite compatible with explanations based exclusively on exogenous factors. In physical time series of production . . . there has been no evidence of long waves."

70. Innovation generally is taken to mean putting an invention or discovery into commercial application, sometimes many years after the initial invention or discovery.

Figure 4.3. Mensch's Swells of Basic Innovations



Source: Mensch (1979: 130). From Mensch's *Stalemate In Technology: Innovations Overcome The Depression*, Copyright 1975 by Umschau Verlag, Frankfurt. Reprinted by permission from the Ballinger Publishing Company.

innovations put together by authors based on their own criteria. The different methods of counting innovations (and "basic" innovations as a subset) account for the different results of various researchers. After deciding what to count, most studies have tried to calculate the annual innovation rate during successive long wave phases. But, as with studies reviewed above, there are problems defining and dating phase periods (inconsistent or ad hoc datings).

As discussed in chapter 3, the innovation school contains an important subdebate between scholars who correlate innovative surges with the long wave downswing phase (for example, Mensch) and those who correlate innovative surges with the early upswing phase (for example, Freeman et al.). The empirical evidence bearing on this debate comes from Mensch and Freeman (innovation school), Van Duijn and Kleinknecht (hybrid theories), and Hartman/Wheeler and Kuczynski (outside the innovation school).

Mensch (1979:123) presents data on the frequency of innovations dated according to when the newly discovered material or technique is put into production (or the new product marketed) for the first time. These are graphed in figure 4.3. Mensch concludes that "there are innovative surges in which swarms of technical innovations do emerge in close formation. However, in between these surges, there are long dry spells in which there is scarcely any movement in the basic innovative process" (p. 119). He dates periods of "technology stalemate" around 1825, 1873, and 1929 (p. 4) and swarms of innovation around pre-1787, 1815–27, 1871–85, and 1926–38 (p. 132).[71] Thus Mensch's evidence supports the hypothesis that innovation rises on

71. These correspond in the base dating scheme with the downswings of 1762–90, 1814–48, 1872–93, and 1917–40.

the stagnation phase of the long wave. Other researchers, however, have questioned Mensch's methods and findings.[72]

Clark, Freeman, and *Soete* (1981) examine U.S. patents, "significant inventions" in Great Britain, the innovations corresponding to those inventions, and innovations in the plastics industry specifically. These data show some clustering but with no clear relationship to the overall level of economic activity.

Much of the dispute revolves around what list of innovations to use. Clark et al. (1981) criticize Mensch's list of forty-one inventions and the corresponding innovations taken from Jewkes, Sawers, and Stillerman's list of sixty-one inventions (p. 313). They point to the "high degree of ambiguity" in dating innovations based on arbitrary and subjective standards. Their own dating of the same set of innovations (developed after first resolving differences among themselves!) differs substantially from Mensch's. Whereas Mensch's data seemed to show that during the depression lead times from invention to innovation were reduced (the acceleration hypothesis) and more innovations occurred (the bunching hypothesis), Clark et al. find no support for these conclusions in their revised data (p. 316). While some bunching did occur in the 1930s, they note, most innovations fall in the period of recovery, and the rest do not seem to have been induced by economic conditions.

There are two ways to resolve the Freeman-Mensch dispute on what innovations to include, suggests Kleinknecht (1981b). The size of the sample can be increased by including more cases of basic innovations (as Van Duijn does)—but this does not guarantee a reduction in selection bias. Or, as Kleinknecht does, one can "evaluate other random samples from independent sources."

Van Duijn (1981:24–30) tests Mensch's innovation hypothesis with an expanded set of cases—eighty "major innovations that shaped the lives of 13 twentieth-century growth sectors." The list is based on the judgments of "various experts." Van Duijn finds that "a simple match between long-wave phase and innovation life cycle phase does not exist." Innovations between 1921 and 1957 are grouped as follows:

Phase	Years	Innovations
Recession	1921–1929	5
Depression	1930–1937	11
Recovery	1938–1948	15
Prosperity	1949–1957	9

Van Duijn, in contrast to Mensch, emphasizes the "recovery phase as the period during which major product innovations are most likely to be introduced" (p. 30). Van Duijn's 1983 study likewise finds the evidence unsupportive of Mensch's

72. Mansfield (1983:141) criticizes Mensch's dating of innovations (e.g., the diesel locomotive innovation in 1934 rather than Mansfield's suggestion of 1913) and his distinction of "basic" from other innovations. "For example, Mensch does not include the electronic computer or the birth control pill as basic innovations, but does include the zipper. Moreover, the reasons for excluding the many important, but not basic, innovations are not obvious."

depression-trigger explanation and somewhat supportive of the opposite recovery-stimulus explanation.

Kleinknecht (1981b) tests Mensch's hypothesis against a list of innovations derived from a second (independent) source.[73] Kleinknecht groups the 120 cases into three categories: scientific instruments, improvement and process innovations, and product innovations. He hypothesizes that improvement and process innovations cluster on the upswing and product innovations cluster on the downswing. Relying on visual inspection of the data and simple statistical tests, Kleinknecht finds support for this hypothesis. The evidence "confirms the depression-trigger hypothesis" of Mensch as applied to product innovations (basic innovations) but "does not contradict the prosperity-pull position" of Freeman for the less basic "improvement and process" innovations (Kleinknecht 1981b:303).

Hartman and *Wheeler* (1979:60–65) investigate innovation in Britain and the United States for 1760–1974 and 1873–1974, respectively.[74] Annual patent data support the hypothesis that "downswing periods . . . are all characterized by significant innovative activity":

	Great Britain		United States	
Phase	Starting date	Increase in patents sealed (%)	Starting date	Increase in patent applications (%)
D	1760	438		
U	1790	56		
D	1813	472		
U	1849	51		
D	1873	341	1873	120
U	1896	20	1896	52
D	1920	40	1917	8
U	1938		1940	50
			1974	

However, this correlation seems to apply only to British, not American, patents.

Kuczynski (1978:86) calculates the average annual rates for basic innovations from 1878 to 1955, developed from his own list of innovations:

Phase	Period starting date	Annual innovations
D	1878	1.48
U	1899	0.13
D	1922	1.48
U	1943	(0.69)
	(1956)	

73. Mahdavi (1972), who investigated innovations for reasons unconnected with long waves and whose list may therefore be less biased than those of Mensch and Van Duijn.

74. They also study indicators of infrastructural development, including the length of canals, railroads, highways, and air routes opened and the number of commercial vehicles. These data on infrastructure are too spotty to be of much use, however.

Although there is an ad hoc dating problem,[75] Kuczynski's dates correspond *roughly* to the base dating scheme, which supports the idea of increased innovation on downswing phases.

Kuczynski (1978) also investigates the temporal relationship of innovation and production (as well as trade) using cross-spectral analysis (spectral analysis between two time series). Kuczynski claims that industrial production leads in the long wave sequence and that innovation follows.[76] "It is obvious that industrial production predominates over all the other economic activities" (p. 82).[77]

To summarize, the empirical evidence for long waves in innovation is mixed. Several studies (Mensch, Kleinknecht, Hartman and Wheeler, and Kuczynski) show innovation clustering on the downswing, but others (Freeman, Clark, and Soete; Van Duijn) question these findings and the data and methods behind them.

Other Variables

Several empirical studies have examined other variables, although most attention has been on prices, production, and innovation. Several of the variables of interest listed at the beginning of this chapter—capital investment, wages and protests, and trade—have been addressed by almost no empirical work, and only spotty evidence can be found.[78]

Two studies of production—Cleary and Hobbs, and Van Ewijk—also include *capital investment* data, but neither finds long waves in either capital investment or production.

Kondratieff and Oparin look at *wages*—disagreeing on the presence of long waves. Little has been done since then. The study of long waves of protest has been more interpretive than quantitative and has not used wage data.

Trade is touched on by several scholars, but none distinguishes patterns in trade from those in production. Kondratieff, Mandel, and Kuczynski find long waves in both production and trade, while Oparin, Van der Zwan, and Van Ewijk find long waves in neither production nor trade.

75. As with Kuczynski's production analysis, above, the same data are used both to determine turning points and then to estimate growth rates between those points. Kuczynski's datings are based on cluster analysis, in which similar years are grouped together.

76. His long wave sequence begins with changes in the ratio of industrial to total production, followed by changes in the level of industrial production, in the export/production ratio and the export level, in innovation and invention, and finally in the level of agricultural production and the ratio of agricultural to total production. My own reading of Kuczynski's evidence leaves me skeptical of these claims, although as I will show in chapter 10, I arrive at certain similar results when using Kuczynski's data.

77. Kuczynski suggests that "one could say—in contrast to Mensch—that economic recessions *generate* innovating activities, and innovating activities *generate* inventive activities." However, because of methodological difficulties, Kuczynski says only that the empirical data do not conflict with such an interpretation. Kuczynski's timing actually supports that of Mensch; but he sees economic downswings as causing innovation upswings, rather than innovation upswings causing economic upswings (the two are not incompatible). While the liberal innovation school sees innovation (individual human creativity) as driving economic evolution, Kuczynski's Marxist argument stresses that economic/social conditions shape individual creativity.

78. A few empirical studies connecting the last variable, war, with long waves will be reviewed in chap. 5.

Several other empirical studies have been made of less common variables. Dupriez (1951:247) measures the connection between *central bank note issue* and long waves. For six countries—Great Britain, France, Germany, Belgium, the Netherlands, and the United States—he gives the following data on the annual increment of the note issue:

Phase	Starting date	Growth rate (%)
U	1791	5.15
D	1818	1.18
U	1843/44	6.97
D	1873	1.83
U	1898	4.30
D	1913	(stationary?)

Gordon, Weisskopf, and Bowles (1983) use the short business cycle methodology to study U.S. *labor costs* as a long wave variable. They classify business cycles as either "reproductive" cycles, in which the business cycle recession cuts labor costs and restores profits, or "nonreproductive" cycles, in which labor costs rise during the business cycle recession (p. 154). Gordon et al.'s results "indicate alternating periods of nonreproductive and reproductive cycles," with nonreproductive periods in 1890 to 1903, 1926 to 1937, and 1969 to the present. These periods correspond roughly (but only roughly) with the downswings of the base dating scheme. The results (with datings based on NBER business cycles except for minor ad hoc adjustments) are as follows:

Business cycle recession (peak→trough) Years	Average annual change in labor costs[a] (%)	Business cycle recession (peak→trough) Years	Average annual change in labor costs (%)
1890–1891	0.78	1926–1928	0.97
1892–1894	4.54	1929–1933	0.15
1895–1897	2.30	1937–1939	−1.32
1899–1901	0.58	1944–1947	−1.60
1903–1905	−3.48	1948–1950	−0.54
1907–1909	−5.91	1953–1955	−1.77
1910–1912	−1.61	1957–1959	−0.56
1913–1915	−7.97	1960–1962	−0.34
1919–1922[b]	−4.96	1969–1971	0.16
1923–1925	−4.02	1973–1976	0.10
		1979–1981	0.39

[a]Labor cost data source not indicated.

[b]Changed from NBER dating of business cycle.

Gordon et al.'s dating diverges from the long wave base dating scheme (as does Gordon's, discussed above), and they make ad hoc adjustments to the NBER data. But overall their results provide some evidence of long waves in labor costs.

Sau (1982:574–75), although not addressing long waves primarily, attempts to relate *profits* to the long wave in a Marxist framework. His study, however, is limited to a single turning point in the period since 1960. The data show gross profit rates peaking out as a percentage of assets in 1965 (United States), 1966 (Great Britain), and 1969 (France, West Germany, and Japan). This would support the (Marxist) declining rate of profit theory of the onset of economic decline.

Conclusions Regarding the Empirical Evidence

Quantitative empirical studies of long waves over the past sixty years have produced some areas of convergent results and other areas of unresolved dispute.

The overall dating schemes of researchers associated with all theoretical schools of the long wave debate showed very strong convergence. With few exceptions, dating schemes of thirty-three scholars showed a one-to-one correspondence with my base dating scheme, despite minor differences in dating particular turning points. With regard to price data since 1790, there was strong consensus on the existence of long waves, manifested as higher and lower inflation rates in successive historical periods. Only the conceptualization of the long wave in terms of fixed periodicities yielded weak or negative results in the post-1790 period. For prices before 1790, the results are similar but less conclusive, partly because of the smaller number of studies and the lower quality of data.

In the production variables (since 1790), by contrast, there is a strong division between the results of different theoretical schools. Studies by six Marxists, using similar methodologies based on phase-period growth rates, all found that production (especially industrial production) consistently grows more rapidly on long wave upswings. However, studies by scholars from other theoretical schools using different methodologies either failed to confirm this finding or provided only weak evidence in its support.

As regards innovation, there was modest (and disputed) evidence of a clustering of basic innovations on the economic downswing. Several other variables—labor costs, profit rates, and central bank note issue—showed some evidence of alternating growth rates on successive long wave phases.

These results will be taken up further in chapter 7, which (among other tasks) will sort out the theoretical and empirical arguments of the long wave debate from a philosophy of science perspective, framing the alternative hypotheses of different researchers. The process of sifting, weighing, and testing long wave hypotheses will then lead into Part Two (chapters 8–12), in which I will present my statistical analyses of time series data in support of the development of a long wave theory. First, however, I will take up the separate but related debate on cycles of war and hegemony.