CHAPTER ELEVEN

Data Analysis 3: War

A Measuring War

As I mentioned in chapter 8, high quality data on war covering the past five centuries have been lacking until a few years ago, when Levy (1983a) extended the approach of the Correlates of War project from 1815–1975 to cover the period 1495–1975.[1] With one minor exception,[2] this chapter relies entirely on Levy's data.[3] Levy's list of great powers is shown in table 11.1. Membership in the great power system changes over time, with old powers like Spain and Turkey dropping out and new ones like the United States and Japan joining. Table 11.2 lists the wars in Levy's data set.

While there is only one data set, there are several ways to cut into the data. I looked at the war data from a variety of angles generated by the combination of three dimensions: (1) different classes of wars, (2) different indicators of war, and (3) different methods for analyzing those indicators and correlating them with phase periods. While the same methodological tools are used as in the past two chapters, they are supplemented by other methods oriented to the distinct qualities of war and of the war data, which are not shared by the economic time series.

Classes of Wars

What is a war, and what wars are of interest? Many arguments have taken place concerning the proper definition and measurement of war. As a practical matter I have accepted Levy's definitions deriving from the COW approach (see chapter 6). Levy's data include only wars involving the "great powers," so I am limited to investigating these wars at the core of the world system. But from the list of such wars, six overlapping classes of wars may be distinguished:

1. All wars on Levy's list: 119 wars in which "great powers" fought, either against each other or against less powerful, more peripheral countries.
2. Great power wars:[4] 64 wars *between* great powers—that is, with one or more

1. The COW data are a standard data set on war. For the period since 1815, Levy's data set is essentially the same as the COW data.

2. A tangential investigation into Sorokin's data for the pre-1495 period.

3. Levy's work is reviewed in chap. 6. His data are shaped by his realist approach to international relations (see Levy 1985a), emphasizing "Great Power" politics.

4. The categorization of wars as great power wars is Levy's, not my own.

Table 11.1. Membership in Levy's "Great Power System"

Country	Years
France	1495-1975
England/Great Britain	1495-1975
Austrian Hapsburgs/Austria/ Austria-Hungary	1495-1519; 1556-1918
Spain	1495-1519; 1556-1808
Ottoman Empire	1495-1699
United Hapsburgs	1519-1556
The Netherlands	1609-1713
Sweden	1617-1721
Russia/Soviet Union	1721-1975
Prussia/Germany/West Germany	1740-1975
Italy	1861-1943
United States	1898-1975
Japan	1905-1945
China	1949-1975

Source: Levy (1983a).

great powers participating on each side. This class is, along with the first, the most relevant to the *core* of the world system.

3. Core-periphery wars: the 55 wars not in class 2—that is, those with a great power on one side only, fighting against a non-great-power country.
4. Great power wars *except* wars of European powers against Turkey. This class is largely similar to class 2 but in the earliest centuries conceives of Turkey as external to the European system. This class thus includes only wars within the emergent *European* core.
5. All wars involving Britain. This represents the total war effort of Britain whether directed against other great powers or less powerful countries.
6. All wars involving France. France and Britain were examined because they were the longest-standing central actors in the great power system.

War Indicators

A variety of indicators of war may be used to examine each class of war. My primary measure is battle fatalities, which Levy (after Singer and Co.) refers to as the *severity* of war. It is an indicator of the scale of violence, getting at the dimension of "how big" a war is. Several secondary indicators are also used. One of these is what the COW project, and Levy, call *intensity*—the ratio of battle fatalities to the European population. This might be more appropriate than total fatalities in measuring war's impact on society or on society's ability to make war. In practice, the results turned out largely similar to severity and I have reported the severity results since it is a simpler and more straightforward indicator. Another indicator is the *incidence* of war—the presence or absence of wars of a certain type in the system in a given year. I

Table 11.2. Levy's List of Wars

#	GP?	Name	Years	#GPs	Sev.	Country	Int.
1	*	War of the League of Venice	1495-1497	3	8	F SA	119
2		Polish-Turkish War	1497-1498	1	3	T	45
3		Venetian-Turkish War	1499-1503	1	4	T	60
4		First Milanese War	1499-1500	1	2	F	29
5	*	Neapolitan War	1501-1504	2	18	F S	269
6		War of the Cambrian League	1508-1509	3	10	F SA	145
7	*	War of the Holy League	1511-1514	4	18	FESA	261
8	*	Austro-Turkish War	1512-1519	2	24	AT	343
9		Scottish War	1513-1515	1	4	E	57
10	*	Second Milanese War	1515-1515	3	3	F SA	43
11	*	First War of Charles V	1521-1526	3	30	FE H	420
12	*	Ottoman War	1521-1531	2	68	TH	958
13		Scottish War	1522-1523	1	3	E	41
14	*	Second War of Charles V	1526-1529	3	18	FE H	249
15	*	Ottoman War	1532-1535	2	28	TH	384
16		Scottish War	1532-1534	1	4	E	55
17	*	Third War of Charles V	1536-1538	2	32	F H	438
18	*	Ottoman War	1537-1547	2	97	TH	1329
19		Scottish War	1542-1550	1	13	E	176
20	*	Fourth War of Charles V	1542-1544	2	47	F H	629
21	*	Siege of Boulogne	1544-1546	2	8	FE	107
22	*	Arundel's Rebellion	1549-1550	2	6	FE	79
23	*	Ottoman War	1551-1556	2	44	TH	578
24	*	Fifth War of Charles V	1552-1556	2	51	F H	668
25	*	Austro-Turkish War	1556-1562	2	52	AT	676
26	*	Franco-Spanish War	1556-1559	3	24	FES	316
27	*	Scottish War	1559-1560	2	6	FE	78
28	*	Spanish-Turkish War	1559-1564	2	24	S T	310
29	*	First Huguenot War	1562-1564	2	6	FE	77
30	*	Austro-Turkish War	1565-1568	2	24	AT	306
31	*	Spanish-Turkish War	1569-1580	2	48	S T	608
32	*	Austro-Turkish War	1576-1583	2	48	AT	600
33		Spanish-Portuguese War	1579-1581	1	4	S	50
34		Polish-Turkish War	1583-1590	1	17	T	210
35	*	War of the Armada	1585-1604	2	48	ES	588
36		Austro-Polish War	1587-1588	1	4	A	49
37	*	War of the Three Henries	1589-1598	2	16	F S	195
38	*	Austro-Turkish War	1593-1606	2	90	AT	1086
39		Franco-Savoian War	1600-1601	1	2	F	24
40	*	Spanish-Turkish War	1610-1614	2	15	S T	175
41		Austro-Venitian War	1615-1618	1	6	A	70
42		Spanish-Savoian War	1615-1617	1	2	S	23
43		Spanish-Venetian War	1617-1621	1	5	S	58
44	*	Spanish-Turkish War	1618-1619	2	6	S T	69
45		Polish-Turkish War	1618-1621	1	15	T	173
46	*	Thirty Years' War-Bohemian	1618-1625	4	304	ESA N	3535
47	*	Thirty Years' War-Danish	1625-1630	6	302	FESA NW	3432
48	*	Thirty Years' War-Swedish	1630-1635	4	314	SA NW	3568
49	*	Thirty Years' War-Swedish/French	1635-1648	5	1151	F SA NW	12933
50		Spanish-Portuguese War	1642-1668	1	80	S	882
51		Turkish-Venetian War	1645-1664	1	72	T	791
52	*	Franco-Spanish War	1648-1659	2	108	F S	1187
53		Scottish War	1650-1651	1	2	E	22
54	*	Anglo-Dutch Naval War	1652-1655	2	26	E N	282
55	*	Great Northern War	1654-1660	3	22	A NW	238
56	*	English-Spanish War	1656-1659	2	15	ES	161
57		Dutch-Portuguese War	1657-1661	1	4	N	43
58	*	Ottoman War	1657-1664	3	109	F AT	1170
59		Sweden-Bremen War	1665-1666	1	2	W	11
60	*	Anglo-Dutch Naval War	1665-1667	3	37	FE N	392
61	*	Devolutionary War	1667-1668	2	4	F S	42
62	*	Dutch War of Louis XIV	1672-1678	6	342	FESA NW	3580
63		Turkish-Polish War	1672-1676	1	5	T	52
64		Russo-Turkish War	1677-1681	1	12	T	125
65	*	Ottoman War	1682-1699	2	384	AT	3954
66	*	Franco-Spanish War	1683-1684	2	5	F S	51
67	*	War of the League of Augsburg	1688-1697	5	680	FESA N	6939

#	GP?	Name	Years	#GPs	Sev.	Country	Int.
68	*	Second Northern War	1700-1721	2	64	E W	640
69	*	War of the Spanish Succession	1701-1713	5	1251	FESA N	12490
70		Ottoman War	1716-1718	1	10	A	98
71	*	War of the Quadruple Alliance	1718-1720	4	25	FESA	245
72	*	British-Spanish War	1726-1729	2	15	ES	144
73	*	War of the Polish Succession	1733-1738	4	88	F SA R	836
74		Ottoman War	1736-1739	2	38	A R	359
75	*	War of the Austrian Succession	1739-1748	6	359	FESA RG	3379
76		Russo-Swedish War	1741-1743	1	10	R	94
77	*	Seven Years' War	1755-1763	6	992	FESA RG	9118
78		Russo-Turkish War	1768-1774	1	14	R	127
79		Confederation of Bar	1768-1772	1	14	R	149
80	*	War of the Bavarian Succession	1778-1779	2	0.3	A G	3
81	*	War of the American Revolution	1778-1784	3	34	FES	304
82		Ottoman War	1787-1792	2	192	A R	1685
83		Russo-Swedish War	1788-1790	1	3	R	26
84	*	French Revolutionary Wars	1792-1802	6	663	FESA RG	5816
85	*	Napoleonic Wars	1803-1815	6	1869	FESA RG	16112
86		Russo-Turkish War	1806-1812	2	45	E R	388
87		Russo-Swedish War	1808-1809	1	6	R	51
88		War of 1812	1812-1814	1	4	E	34
89		Neapolitan War	1815-1815	1	2	A	17
90		Franco-Spanish War	1823-1823	1	.4	F	3
91		Navarino Bay	1827-1827	3	.2	FE R	2
92		Russo-Turkish War	1828-1829	1	50	R	415
93		Austro-Sardinian War	1848-1849	1	5.6	A	45
94		First Schleswig-Holstein War	1849-1849	1	2.5	G	20
95		Roman Republic War	1849-1849	2	.6	F A	4
96	*	Crimean War	1853-1856	3	217	FE R	1743
97		Anglo-Persian War	1856-1857	1	.5	E	4
98	*	War of Italian Unification	1859-1859	2	20	F A	159
99		Franco-Mexican War	1862-1867	1	8	F	64
100		Second Schleswig-Holstein War	1864-1864	2	1.5	A G	12
101	*	Austro-Prussian War	1866-1866	3	34	A GI	270
102	*	Franco-Prussian War	1870-1871	2	180	F G	1415
103		Russo-Turkish War	1877-1878	1	120	R	935
104		Sino-French War	1884-1885	1	2.1	F	16
105		Russo-Japanese War	1904-1905	1	45	R	339
106		Italo-Turkish War	1911-1912	1	6	I	45
107	*	World War I	1914-1918	8	7734	FE A RGIUJ	57616
108	*	Russian Civil War	1918-1921	5	5	FE R UJ	37
109		Manchurian War	1931-1933	1	10	J	73
110		Italo-Ethiopian War	1935-1936	1	4	I	29
111		Sino-Japanese War	1937-1941	1	250	J	1813
112	*	Russo-Japanese War	1939-1939	2	16	R J	116
113	*	World War II	1939-1945	7	12948	FE RGIUJ	93665
114		Russo-Finnish War	1939-1940	1	50	R	362
115	*	Korean War	1950-1953	4	955	FE U C	6821
116		Russo-Hungarian War	1956-1956	1	7	R	50
117		Sinai War	1956-1956	2	0	FE	0
118		Sino-Indian War	1962-1962	1	.5	C	1
119		Vietnam War	1965-1973	1	56	U	90

Legend:

GP? * indicates a "great power war" (between greatpowers).
#GPs Number of great powers participating in war.
Sev Severity of war -- total battle fatalities sufferedby great powers, in thousands.
Int Intensity of war -- Battle fatalities suffered by great powers, per million European population.

Countries (letter indicates participation in war):

F = France
E = England
S = Spain
A = Austria-Hungary
T = Turkey
H = United Hapsburgs
N = Netherlands
W = Sweden
R = Russia
G = Germany
I = Italy
U = United States
J = Japan
C = China

Source: Levy (1983a)

measure war incidence at three levels by determining whether average annual battle fatalities per million European population (intensity) from great power wars exceed zero, one hundred, or five hundred in a given year.[5] The final indicator is the number of wars occurring in a given period—that is, the *frequency* of wars in a given class. Each of these war indicators provides different information about the pattern of war at the core of the world system—how often wars occur, how big they are (absolutely and relative to population), and how long they last.

Methods

Several methods are used to analyze these indicators of war. Some use *time series* of annual battle fatalities (severity), which I calculate from Levy's data. Since the fatality data are given only by war, not by year within a war, I distribute each war's fatalities among the years spanned by the war—giving the first and last years half the fatalities of the intermediate years since on average wars begin and end in the middle of a year.[6]

This severity time series has extreme variation and nonstationarity in later centuries with the abrupt high-fatality wars between great powers. To control the nonstationarity somewhat (and thus avoid having the twentieth century overwhelm the earlier centuries), I generally use the *logged* time series. The logged series used the following scale:[7]

Annual fatalities:	0	1,000	10,000	100,000	1,000,000	10,000,000
Logged scale:	0.0	0.5	1.5	2.5	3.5	4.5

The main war time series are listed in Appendix B.

To get at the correlation of war with long wave phase periods, two methods of counting or averaging wars by phase period are used. The first is to treat the war time series like the economic time series, segmenting the series at each turning point and calculating averages within phases.[8] I refer to this as fatalities "strictly" within a phase period.[9] The second method is to place each war in the phase period that it

5. The first level, 0, indicates whether any war involving a great power is in progress, 100 excludes the very minor wars, and 500 includes only the most major wars.

6. If the beginning and ending years were allocated a full year's share of the fatalities, then the time series would seem to jump to twice the fatality rate whenever one war gave way to another in the same year, even though they never actually overlapped (this happens, e.g., when Levy distinguishes phases of a conflict as separate wars).

7. Since the years with no fatalities cannot be logged (the log of 0 is negative infinity), such years were set to an arbitrary low number: −0.5 on the log scale in which 0 equals 1,000 annual fatalities, 1 equals 10,000, and so on. The −0.5 value translates to 316 fatalities a year, which is close enough to 0 to represent a "peace" year adequately. However, having negative numbers in the series is problematical in certain applications, so 0.5 was added to the above series, creating a new series defined as shown: original series in 1,000s, logged, +0.5, and 0 in original set to 0.

8. Averages rather than growth rates are taken as the most appropriate measure to test hypotheses of higher *levels* of war on upswing phases.

9. Of course, without data on the annual distribution of fatalities within a war, I cannot actually say how many fatalities really occurred in one phase period or the other when a war overlaps a turning point.

"mainly" fell into.[10] A few wars that fall on the turning points do not qualify for inclusion in either period. By including wars in the period they mainly fall in, this method is less sensitive to the particular dating of turning points than the first method (counting overlapping war years in the phase they overlap into). The comparison of both methods is useful in finding out how sensitive the war results are to the particular turning points used.[11]

Finally, I examine time series graphs showing the continuous behavior of war and economic variables over the entire five centuries, which help to identify both dynamic patterns in the data and relationships between different variables. Log scales are used to bring out the ups and downs of the series in spite of long-term upward secular trends.

War Cycles

The great power war[12] severity times series (fig. 11.1) strongly suggests fifty-year cycles.[13] In the middle years of the graph, around 1600–1800, are four regularly recurring war peaks (marked "WP"). Each is a sustained, high-fatality war that ends a series of wars of escalating severity. These peaks are spaced about fifty years apart and are followed by two more peaks (around 1870 and around 1915), also spaced about fifty years apart, though of shorter duration and not preceded by a series of escalating wars. Only the final peak, World War II, does not fit the pattern, following too closely after the World War I peak. Going back to the years before 1600, three more peaks are visible, although much more weakly in the first two cases, which have similar though slightly shorter spacing.

Furthermore, there is a dramatic one-to-one correspondence between the recurring war peaks shown on the graph and the long wave peaks (from the base dating scheme), which are indicated on the figure by small arrows at the top. For nine successive long waves, until 1918, each war peak occurs near the end of an upswing phase period.[14] From this, I date ten war cycles since 1495 (table 11.3).

10. This is defined as at least 60% of the war years falling within the period and no more than three war years falling in a different period.

11. In both cases, results are expressed in terms of average annual levels within a phase period to equalize for the varying lengths of historical phases.

12. Great power wars, excluding wars against Turkey. A log scale is used to condense the upward trend in fatalities.

13. Again, this is only an average annual rate within each war, not a truly annual series. In reading this and later graphs of war data, remember that the first and last years of a war have half the annual fatalities as the middle years, creating a pattern in the graph like this (see, e.g., pattern at World Wars I and II in the figure):

The lower points for the first and last years should not be mistaken for separate wars.

14. Note that the economic peak in 1720 (from Frank's dating for England) could be moved to about 1713—the end of the war peak—and would then fit international prices as well as war better. Prices appear to fall in 1713–20. This might resolve the problem with prices in the downswing of 1720–46, noted earlier for several series (chap. 9).

Figure 11.1. Great Power War Severity, 1495-1975

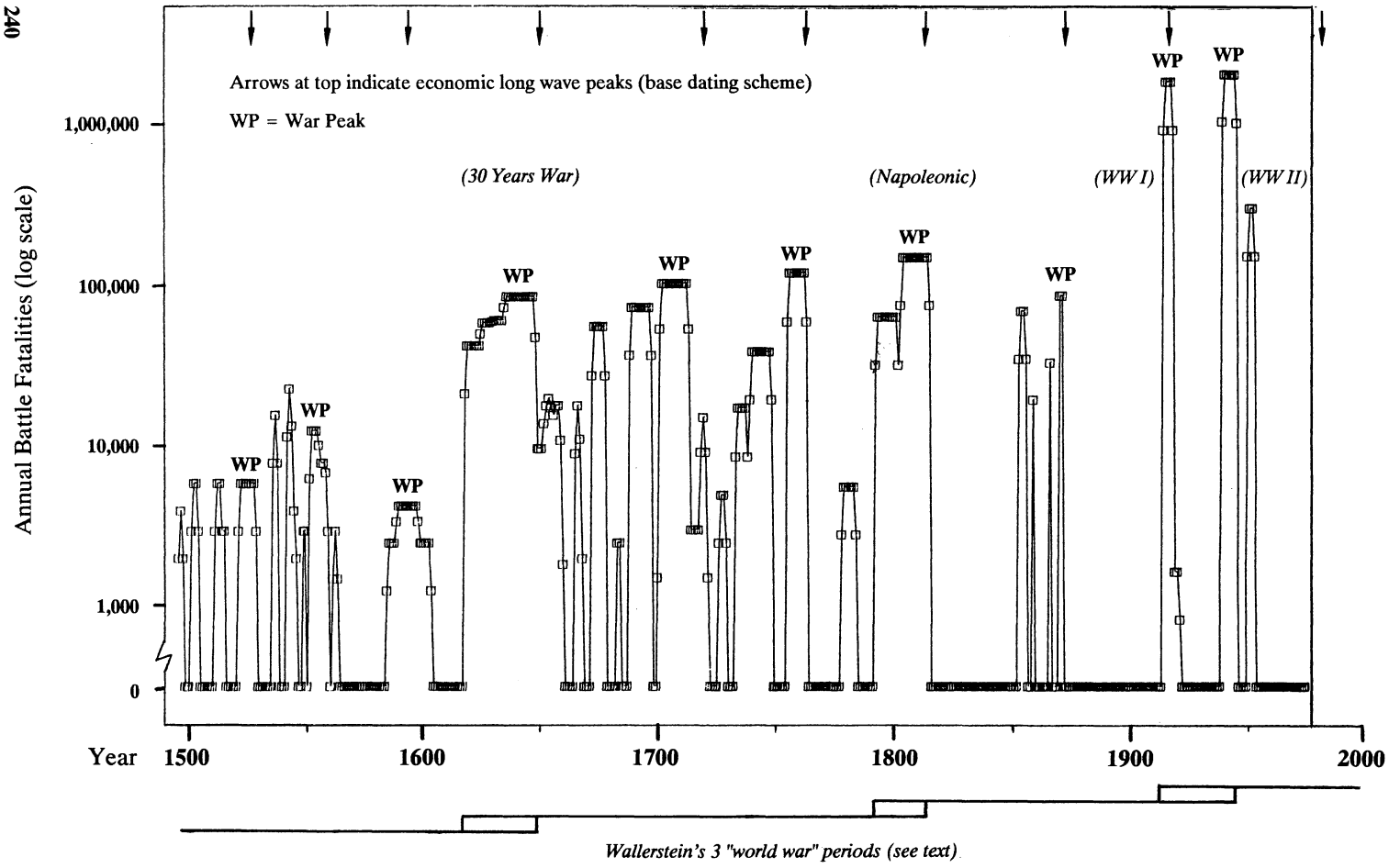


Table 11.3. Dating of Long War Cycles, 1495-1975

Cycle	Starting date of war cycle	Peak war years	Length (years)	Ending date of corresponding long wave phase period
1	(1495)	1521-1529	(35)	1528
2	1530	1552-1556	28	1558
3	1558	1593-1604	47	1594
4	1605	1635-1648	44	1649
5	1649	1701-1713	65	1719
6	1714	1755-1763	50	1761
7	1764	1803-1815	52	1813
8	1816	1870-1871	56	1871
9	1872	1914-1918	47	1917
10	1919	1939-1945?	(27)	(1968/80?)

Cycle	Peak wars	Annual fatality rate at peak *(thousands)*
1	First and Second Wars of Charles V; (Ottoman War v. Hapsburgs) [a]	13
2	Fifth War of Charles V; (Ottoman War v. Hapsburgs) [a]	22
3	War of the Armada; (Austro-Turkish War) [a]	11
4	Thirty Years' War: Swedish/French Phase	88
5	War of the Spanish Succession	107
6	Seven Years' War	124
7	Napoleonic Wars	156
8	Franco-Prussian War	90
9	World War I	1,934
10	World War II	2,158

[a] Dating of war peaks in cycles 1-3 based primarily on intra-European wars rather than those against Turkey. Wars against Turkey are included in the statistics, however, and are shown above in parentheses.

Three Eras

In describing the war cycles in fig. 11.1, I find it helpful to look at the war pattern as evolving and passing through successive stages of development, which I call "eras." In each successive era, the recurring pattern of war severity resembles the previous era in some ways but differs in others:

1. From 1495 until about 1618/1648, great power wars fluctuate up and down around a level of about ten thousand fatalities per year (from 1511 to 1606 there are only three "peace" years out of ninety-four). Three war peaks, albeit weak ones, can be picked out on the basis of sustained, high-fatality wars: 1521–29, 1552–56, and 1593–1604.[15]

2. From about 1618/1648 to 1793/1815, there is a repeating pattern, or "signature," of great power war, in which a series of wars of escalating severity culminates in a high-fatality war and a relatively peaceful period follows. This pattern repeats four times, the war peaks ending respectively in 1648, 1713, 1763, and 1815. The fatality levels of these war peaks are an order of magnitude higher than in the previous era—about one hundred thousand annually—and rise steadily during the two centuries. In these centuries a trend toward more peace years breaking up the years of great power war is observable.

3. From about 1793/1815 to 1914/1945, the peace years become predominant and the pattern of escalating wars within a long wave is replaced by one or more peaks of short duration. In this era the wars are shorter and, in the case of World Wars I and II, more severe by an order of magnitude (about two million battle fatalities per year).

I hypothesize that a fourth era may have begun around 1945 in which even fewer great power wars will occur, but any that do will be of even greater severity and shorter duration.

Note that Wallerstein's (1983) three "world war" periods (fig. 11.1, bottom), each followed by the start of a new hegemony (see chapter 6), seem to correlate with the eras just described. These issues will be taken up further in the discussion of hegemony cycles in chapter 13.

World War II: An Anomaly

World War II is anomalous, coming at the beginning rather than the end of a long wave upswing.[16] World War I marks the end of one upswing, and World War II the beginning of the next, with a downswing of economic stagnation and reduced war in between. The timing of World War II at the start of an upswing might be explained in

15. The peak at 1552–56 is higher but shorter than 1521–29, while 1593–1604 is again lower but longer; 1576–80 (not considered a peak) is both lower and shorter than the neighboring peaks. George Modelski has suggested to me that the Dutch-Spanish war of around 1585–1609 be added to Levy's data set (Levy did not consider it a great power war). Doing so does not change the war curve in fig. 11.1 in any important way, although it does change the first "peace" years in that period to 1615–17 rather than 1607–9, and it increases fatalities on the downswing of 1595–1620 (fig. 11.3).

16. It is not bad to have one anomalous case out of ten; but when it is the most recent case there is no way to know whether it is a single deviant case or the start of a new pattern. These issues are taken up in chap. 15.

part by the unusual irresolution that resulted from World War I. The costs of that war were far above any previous experience, constituting a severe shock to the world economic and political system.[17] World War I ended in mutual exhaustion without resolving the issue of hegemony (particularly since the rising powers, Russia and America, withdrew into revolution and isolationism after that war). Only at the outset of the next long wave upswing (production having turned upward sometime around 1933), could hegemonic war resume. The upswing thus began at a high level of war severity instead of war building up to a peak late in the upswing as in previous long waves.

But once World War II occurred, how could the world economy sustain a continued upswing phase instead of being driven into a long downswing as in previous war peaks? Here the answer may be the expansion of the core of the world economy. By the time of World War II, the United States had become the world's largest industrial power, Soviet industrialization had proceeded at a rapid pace, and Japan had also industrialized rapidly and benefited from sitting out World War I. This expanded core could support another hegemonic war before Europe alone could have. The increased severity of World War I, coupled with the extension of the European system to a global one (Barraclough 1964:268), thus created the conditions for World War II to occur early rather than late in the upswing phase.[18]

The rest of the 1940–80 upswing phase saw continuing war, but not directly between great powers. Three "Pacific" wars—World War II, Korea, and Vietnam—go together on this upswing (see chapter 14). The upswing ended with an unusually small war, Vietnam (although it did take its toll on the world economy), as it had begun with an unusually large one.

Singer, Levy, and War Cycles

Given the evidence of cycles in Levy's war data, I became curious why Levy, who was aware of the debate on fifty-year cycles in war, had concluded that no cycles could be found in his data.[19] The answer seems to be a combination of two factors. First, Levy used visual inspection to look for cycles in the data and did not find them evident. Second, Levy (1983a:137) did not search for cycles statistically, since he did not spot them in visual inspection of his own data and since past research had not shown evidence of cycles. On the latter point he specifically cites (in addition to Sorokin) Singer and Small's (1972:206) negative findings using spectral analysis. Levy concludes that "it is very unlikely that sophisticated statistical techniques could uncover any patterns that are sufficiently strong to have any substantive significance. For this reason these tests are not applied here."[20]

17. See Carnegie 1940; Kindleberger 1973; Bogart 1920, 1921; Dickinson 1934, 1940; Jeze 1926; Kohn and Meyendorff 1932; Seligman 1919; and Berger 1928.

18. While this "explains" the anomaly, I recognize it is an ad hoc explanation.

19. Levy (1983a:137) writes that "there are no hints of any cyclical pattern in either the occurrence of war or in any of its other dimensions." Periods of war and peace "appear to be scattered at random."

20. This is a good illustration of the power of a research paradigm to shape what one looks for—and hence what one finds or does not find.

Ironically, Levy's data *would* have allowed even the methodology of Singer and company to identify long waves in great power war. To illustrate this, I use the type of methodology applied by the Correlates of War—a methodology based on fixed periodicities—even though I think it is inappropriate for social cycles. The Auto-Correlation Function (ACF) is a function expressed in terms of lags in a time series. For a given lag n, the value of the ACF is the correlation of all the data points in the series with the corresponding set of data points n years earlier.[21] The set of such correlations for sequential lags makes up the ACF.[22] In an autoregressive time series,[23] the ACF starts out high but generally falls rapidly in the first few lags to a statistically insignificant level. If there are cycles in the data (periodic in calendar time), the ACF will then rise again in a bump centered somewhere around the cycle length.

The top part of figure 11.2 shows something like what David Singer and the COW project must have looked at—the ACF for war severity for the period after *1815* (the data available to the COW project before Levy extended them). In this ACF no fifty-year cycle is visible. A weak twenty-six year cycle is visible, but this derives entirely from the single case of World War I followed by World War II. And indeed these are exactly the conclusions that Singer and Cusack (1981:413) reported, which in turn discouraged Levy from searching statistically for cycles in his data.

But the bottom part of the figure—the ACF for great power war severity from *1495* on—reveals a different pattern. There is a clear bulge in the ACF peaking around fifty to sixty years. Depending on the exact formulation,[24] the peak is either just barely, or not quite, significant at the .05 level. Thus even methods based on fixed periodicity are able to pick up the long wave in Levy's five centuries of war data.

For no economic variable—even the best price series—can I find a peak at around fifty years on its ACF.[25] The peak in the ACF for war severity thus indicates that the war cycle is more periodic in calendar time than are economic movements. This is consistent with the hypothesis that sociopolitical dynamics, such as a generation cycle in war, help to stabilize the temporal recurrence of economic long waves.

War and Long Wave Phases

The connection between economic phase periods and wars is investigated in several ways. Levy's "great power wars" (class 2, above) are

21. As the number of lags increases, the degrees of freedom decreases (terminal years are lopped off), so it takes a larger value of the ACF at high lags to make the ACF statistically significant at a given confidence level. The confidence limits in a graph of an ACF therefore curve outward as they move to the right.

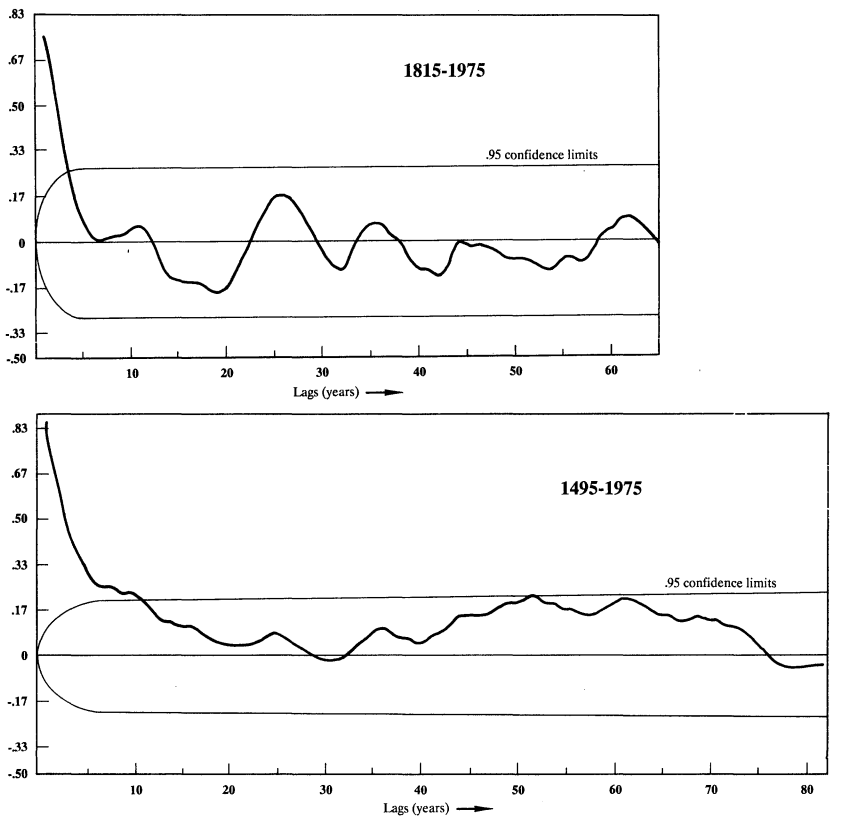
22. My "lag structures"—relative to a scheme of alternating phases of uneven length—get at somewhat the same thing as an ACF but in cycle time rather than calendar time.

23. The value of one year's data point is correlated with the value in the previous year.

24. Whether the series is logged or not, and so on.

25. I tried a variety of different data treatments, such as logging the series and transforming them to differences and to growth rates—all with little effect.

Figure 11.2. ACFs for War Severity, 1815 on and 1495 on



categorized (table 11.4) according to the economic phase period in which the war "mainly" fell (see definitions above, p. 239). Thirty-one wars occurred during upswings, twenty-seven during downswings, and six seriously overlapped phase periods (see also table 11.5, column 7). Thus hardly any *more* wars occurred on the upswing phases than the downswings. But in total battle fatalities (severity), except for the 1575–94 upswing, there is a clear alternation between upswing and downswing phases. More severe wars occurred during upswing phases.

I have tabulated six war indicators by phase period (table 11.5).[26] The first indicator (col. 3) derives from the list of fatalities (table 11.4), here expressed as an average annual fatality rate in each phase.[27] This indicator is also displayed as a bar chart in figure 11.3. With the exception of the (low-fatality) upswing of 1575–94, fatalities follow the pattern of upswings and downswings throughout the 481-year

26. Note that 1968, not 1980, is used here as the date of the last turning point, because these analyses were done while using the unmodified dating from Mandel. The categorization of those twelve years makes no substantial difference in any reported results, so I have not recalculated them with 1980.

27. To compensate for the different lengths of phases.

Table 11.4. Great Power Wars by Phase Period

Period	*Fatalities ('000)*		*Great power wars mainly in period*
	Upswings	*Downswings*	
(1495)–1508		26	League of Venice; Neapolitan War
1509–1528	161		Holy League; Austro-Turkish; Second Milanese; Ottoman War; 1st and 2nd Wars of Charles V
1529–1538		60	Ottoman War; 3rd War of Charles V
1539–1558	227		Ottoman; 4th of Charles V; Siege of Boulogne; Arundel's Rebellion; Ottoman; 5th of Charles V; Franco-Spanish
1559–1574		60	Scottish; Spanish-Turkish; 1st Huguenot; Austro-Turkish
1575–1594	48		Austro-Turkish
1595–1620		111	Austro-Turkish; (2) Spanish-Turkish
1621–1649	1 767		Thirty Years' War: Danish; Swedish; Swedish-French
1650–1688		668	Franco-Spanish; Anglo-Dutch Naval; Great Northern; English-Spanish; Ottoman; Anglo-Dutch Naval; Devolutionary War; Dutch War of Louis XIV; Franco-Spanish
1689–1719	2 020		League of Augsburg; 2nd Northern War; Spanish Succession; Quadruple Alliance
1720–1746		462	British-Spanish; Polish Succession; Austrian Succession
1747–1761	992		Seven Years' War
1762–1789		34	Bavarian Succession; American Revolution
1790–1813	2 532		French Revolutionary; Napoleonic Wars
1814–1847		0	—
1848–1871	451		Crimean; Italian Unification; Austro-Prussian; Franco-Prussian
1872–1892		0	—
1893–1916	7 734		World War I
1917–1939		21	Russian Civil War; Russo-Japanese War
1940–1967	13 903		World War II; Korean War
1968–(1975)		(0)	—

Note: Wars not categorizable by phase period: Austro-Turkish (1556–1562); Spanish-Turkish (1569–1580); War of Armada (1585–1604); War of the Three Henries (1589–1598); Thirty Years' War/Bohemian (1618–1625); Ottoman War (1682–1699). Total fatalities in these wars: 852,000.

Source: Goldstein (1985: 438).

span of the data. Up through 1892, the average annual fatality rate was six times higher on upswings than on downswings; if the twentieth century is included, it is twenty-one times higher on upswings than downswings.

Categorizing the same fatality data "strictly" by phase period (col. 4),[28] in conjunction with the method just discussed, points to sensitivities to the exact dating of turning points. Not surprisingly, the main effect is on the twentieth century's two world wars, each overlapping one to two years into an adjacent phase. The results also show the weakest correlation to be in the period 1495–1620. Nonetheless, the fatality rate on upswings is still more than four times higher than on downswings for

28. As explained above, a war that overlaps slightly into another phase period then has a proportion of its fatalities allocated to the other period (relative to the percentage of years in each period).

Table 11.5. Selected War Indicators by Phase Period

Phase period (1) (2)	Great power wars: Avg. ann. fatal. — Mainly in period (3)	Great power wars: Avg. ann. fatal. — Strictly in period (4)	Great power wars: Percent war years — All GP wars (5)	Great power wars: Percent war years — Above 500 ann. fatalities per 10^6 Euro. pop. (6)	Great power wars: No. of wars mainly in period (7)	Other wars: Avg. ann. fatalities mainly in period (8)
1495–1508 D	1.9	1.9	50	0	2	0.6
1509–1528 U	8.0	7.0	85	0	6	0.4
1529–1538 D	6.0	9.5	100	0	2	0.4
1539–1558 U	13.8	14.0	95	0	7	0.6
1559–1574 D	3.8	7.4	100	0	4	0
1575–1594 U	2.3	5.8	95	0	1	1.2
1595–1620 D	4.3	9.2	77	8	3	1.2
1621–1649 U	60.9	68.2	100	97	3	0
1650–1688 D	17.1	21.5	85	13	9	0.6
1689–1719 U	63.1	71.2	100	71	4	0.3
1720–1746 D	17.1	15.3	74	0	3	1.8
1747–1761 U	66.1	57.7	60	47	1	0
1762–1789 D	1.2	7.9	32	7	2	1.0
1790–1813 U	105.5	95.8	92	83	2	10.4
1814–1847 D	0	6.9	6	6	0	1.6
1848–1871 U	18.8	18.8	33	17	4	0.8
1872–1892 D	0	0	0	0	0	5.8
1893–1916 U	322.2	201.4	12	12	1	2.1
1917–1939 D	0.9	173.9	26	13	2	11.5
1940–1967 U	496.5	458.0	36	36	2	0.3
1968–1975 D	0	0	0	0	0	7.0
1495 to 1975:						
All downs	5.9	26.0	50	6	27	2.6
All ups	126.6	110.6	71	40	31	1.6
Between	—	0	0	0	6	—
Total[a]	65.1	66.9	60	22	64	2.1
1495 to 1892 only:[b]						
All downs	7.3	9.6	60	6	25	1.5
All ups	44.8	45.6	84	44	28	1.8
Between	—	0	0	0	6	0
Total[a]	25.6	27.8	72	24	59	1.6

Explanation of columns:

1. Dates of economic phase period (from literature).
2. Nominal type of period (D = downswing; U = upswing).
3. Average annual fatalities over period, from great power wars falling primarily during the phase period [see bar chart]; excludes six wars not definable as mainly in either phase period.
4. Average annual fatalities from great power wars during phase period based on time series and including overlap from wars falling primarily in an adjacent period.
5. Percent of years in phase period in which any great power wars were in progress.
6. Percent of years in phase period in which time series of annual average fatalities per million European population exceeded 500.
7. Number of great power wars (GP on both sides) falling primarily during the phase period.
8. Average annual fatalities over period, from non-great power wars (GP on one side only) falling primarily during the phase period.

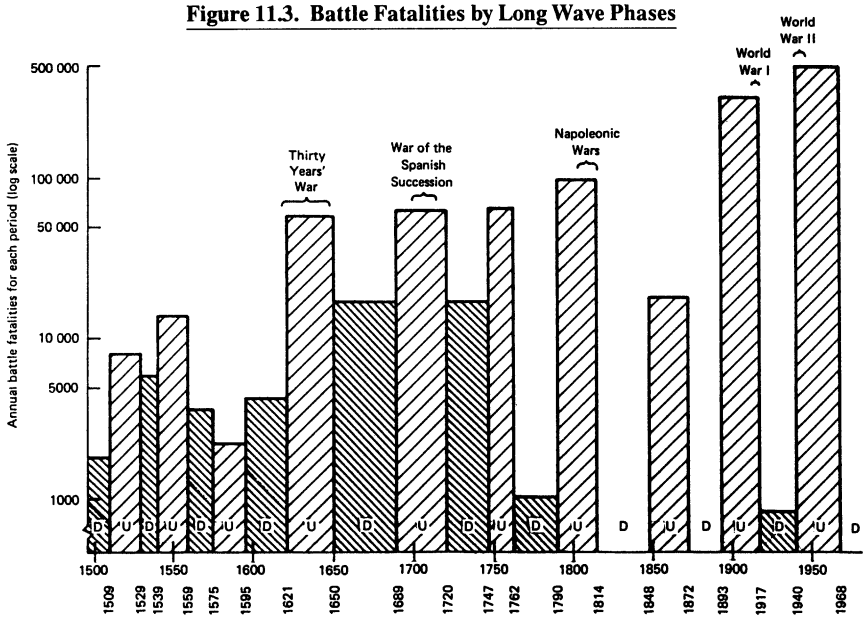
Note: 'Fatalities' refers to battle fatalities only.

[a]Totals exclude wars falling between periods for variables categorized as 'mainly in period' (Variables 3 and 8).

b Twentieth century omitted because 2 turning points fall during extremely severe wars, making results sensitive to dating.

Source: Goldstein (1985: 423).

Figure 11.3. Battle Fatalities by Long Wave Phases



Battle fatalities from great power war in each economic phase period, 1495–1975. U = economic upswing; D = economic downswing. (Wars with over one million total fatalities are noted.)

Source: Reprinted from Goldstein (1985: 422).

both 1495–1892 and 1495–1975. The greater severity of war on long wave upswings, then, is a very strong and consistent correlation.[29]

The years in which any great power war was in progress (col. 5) match the upswing/downswing pattern from 1595 on except for two periods (1747–61 and 1917–39). Overall, 71 percent of the upswing years saw great power wars in progress, as compared with 50 percent of the downswing years. This reflects only a weak correlation with phase periods. Counting only years in which very major wars were in progress produces a stronger correlation (col. 6). There were no wars this severe before 1595, but after 1595 the upswing/downswing pattern matches the ups and downs of war incidence with only one exception (1917–39 slightly above 1893–1916). Of the upswing years, 40 percent saw a very major great power war in progress, as compared with only 6 percent of the downswing years.

The frequency of wars (col. 7) does not correlate with the phase periods; roughly equal numbers of wars took place on downswings as on upswings.

These results for great power wars indicate that the long wave upswing periods are characterized neither by *more* wars than on the downswings nor by wars that last much *longer,* but by much *bigger* wars—roughly one order of magnitude bigger.[30]

29. The severity data also show a strong secular increase over the past five centuries. Particularly strong jumps in the fatality rate occurred with the Thirty Years' war (1618–48) and World War I (1914–18).

30. Orders of magnitude refer to numbers ten times as large, as 10, 100, 1,000, and so on.

These bigger wars are more costly, more destructive, and have greater political and economic impact.

In wars involving great powers on *one side only,* fighting lesser powers (col. 8), there is weak evidence of an inverse correlation to long wave phases from 1600 on (with the exception of 1790–1813).[31] Such a pattern would suggest a displacement of war from core-core conflicts during the upswing to core-periphery wars during the downswing. While this possibility remains intriguing, the evidence thus far is weak.[32] For the other classes of war listed in chapter 8, any cyclical patterns seem to result only from their overlap with the great power war class.

War and Inflation

From the seventeenth century on, most of the major inflationary periods appear to be connected to wars. This pattern is evident in fig. 11.4, a graph of the fluctuations of war severity and of the most central price indexes along with long wave phase periods (shown by vertical lines). Beginning in 1621 each upswing phase in the price series is dominated by a period (or two periods in the case of 1848–71) of major inflation lasting from three to twenty years. These periods of major inflation (identified by visual inspection) are labeled on figure 11.4 ("MI") and listed in table 11.6. Each major inflation period is associated with the later, high-fatality stages of the escalatory war upswing (though not always the final war peak). In all but two cases, 1755 and 1914, the increase in great power war precedes the price increase (see table 11.6).[33] But these relationships are somewhat irregular. Not every war escalation is inflationary; price deflation does not always follow the end of great power wars; and prices sometimes drift downward after an inflationary period while war continues.

Granger Causality: War and Prices

As a supplementary test of the relationship between war and prices, I used Granger causality analysis (J. Freeman 1983). This methodology can help to identify lagged correlations between two time series, indicating temporal precedence of one variable relative to another and hence possible causality. Given two times series x and y,[34] Granger causality asks whether, once the past behavior of series x itself is taken into account, the past behavior of series y still has a significant effect on x. The same

31. The high-fatality upswing of 1790–1813 results from the spillover of the great power Napoleonic wars into Turkey, which was no longer considered a great power.

32. Overall the rate is only slightly higher on downswings than upswings, and even this disappears if 20th-c. data are excluded. Visual inspection of a time graph of these wars showed no clear pattern in relation to the phase periods.

33. In 1755, the price increase precedes the war onset by one year, but most of the price rise in the 1754–60 inflation period follows the onset of war. In 1914, mild inflation had been underway since 1898, but sharper inflation was triggered by the onset of war. A similar pattern occurs in 1939 (mild inflation underway since 1933/36).

34. The raw data are logged and then differenced to ensure stationary and to control variance; Granger causality is preserved across these transformations (J. Freeman 1983).

Figure 11.4. Great Power War, Prices, and Phase Periods

- Great power war fatalities
- English Industrial Price Index
- English Producers' Price Index
- British Wholesale Price Index
- French Wholesale Price Index
- German Wholesale Price Index
- US Wholesale Price Index

All variables plotted on log scales.

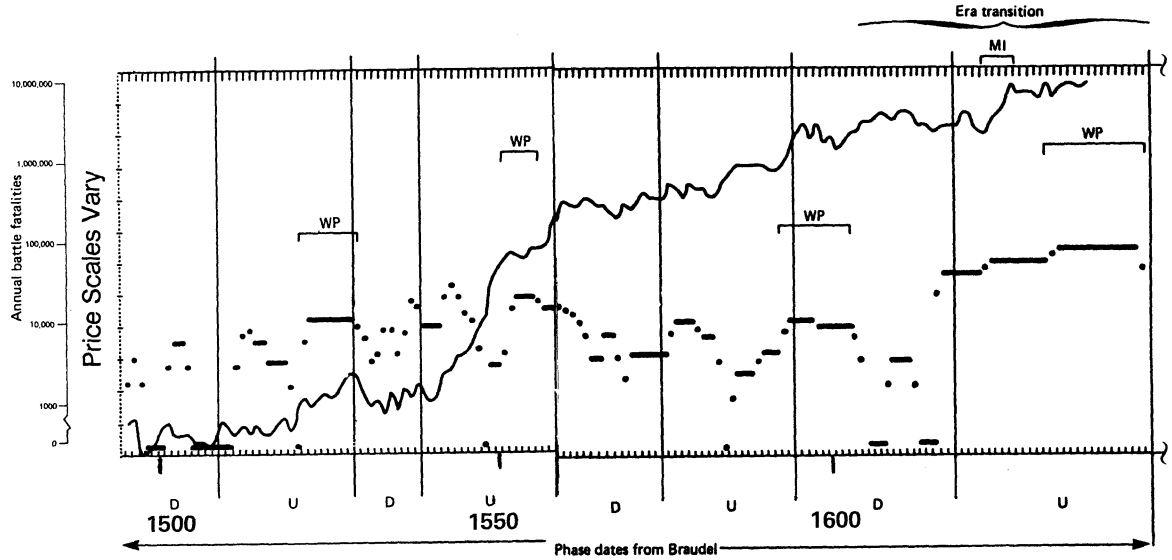
WP = War peak at end of each war cycle

MI = Major inflation period of upswing

D = Nominal Downswing ; U = Upswing

Note: Three segments of graph overlap. Price indexes are plotted on log scales to compensate for long-term upward trends. The graph has been drawn to bring out trends in each variable. Scales are different, and arbitrary, for each price index, so one variable should not be compared against another on an absolute scale.

Source: Goldstein (1985: 424-9).



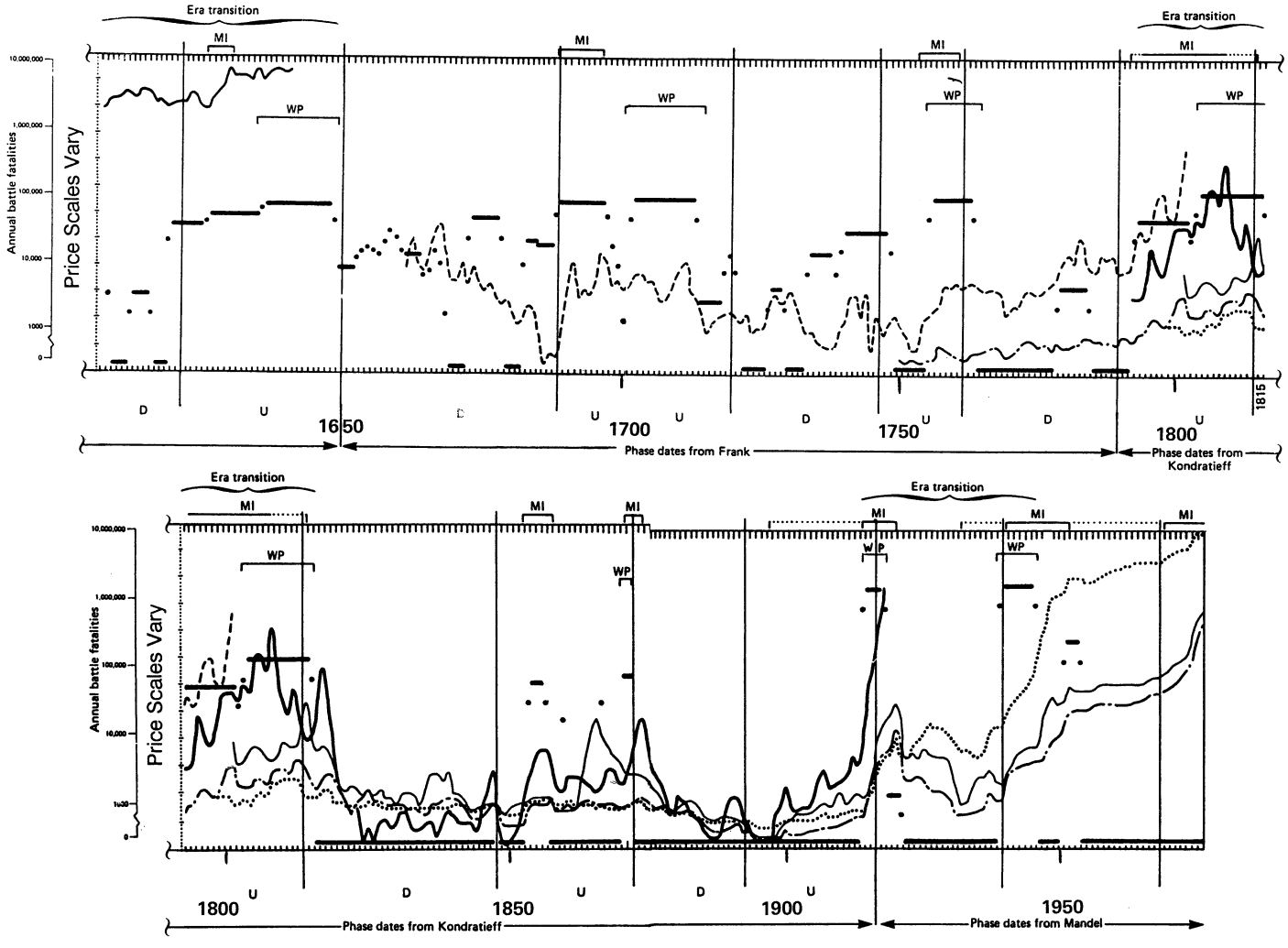

Era transition
MI
WP
Annual battle fatalities
Price Scales Vary
D
U
1650
1700
1750
1800
1815
Phase dates from Frank
Phase dates from Kondratieff
1850
1900
1950
Phase dates from Mandel

Table 11.6. Major Inflation Periods and Associated Wars

Inflationary period	Great power war occurrence
1626-29	Escalation of Thirty Years' War, 1625
1689-96	Onset of War of League of Augsburg, 1688
1754-60	Onset of Seven Years' War, 1755
1792/94-1808/14	Onset of French Revolutionary wars, 1792
1851-55 Germany only	–
1853-57 Britain, France	Onset of Crimean War, 1853
1862-65 U.S. only	(U.S. Civil War)
1871-73	Onset of Franco-Prussian War, 1870
1898-1914 (mild)	–
1915-1920 (steep)	Onset of World War I, 1914
1933/36-1939 (mild)	–
1940-51 (steep)	Onset of World War II, 1939
1952-68 (mild)	–
1969-80 (steep)	(Vietnam?)

question is asked of the effect of x on y. This is done by regressing each variable on its own past values and the past values of the other variable in a two-equation system and testing for the joint significance of the other variable's coefficients.[35]

There are methodological problems with Granger causality in this application—chiefly the extreme autocorrelation of the war time series. In long periods of "peace," and during certain prolonged wars, the series remains constant for long time periods (longer than the eight lags included in the equation). When changes do occur, they are very abrupt. The economic time series, by contrast, fluctuate from year to year. Nonetheless, a statistically significant result in this application would very likely reflect actual temporal precedence of war and prices, since the autocorrelation problem would not account for such a result.

The results of this analysis, shown in table 11.7, demonstrate consistently significant Granger causality from war to prices, but not vice versa, in the era *since 1790.* The three series in which this relationship is statistically significant at a level of less than .01 are the British commodity price index, French wholesale price index, and German wholesale price index. In all the post-1790 series, the evidence is strong that wars play a major role in the price wave.

The period *1648–1815* shows evidence of Granger causality from war to prices, but the relationship is weaker than in the nineteenth and twentieth centuries. For the period *before 1648,* the Granger-causal relationships are not statistically significant.

35. These are estimated with ordinary-least-squares as "seemingly unrelated regressions." Only a limited number of past lags can be included when estimating the equation. I estimated each equation twice, once with eight lags of the first variable and four lags of the second variable, then with eight and ten lags included respectively. Results reported are for the latter.

Table 11.7. Granger Causality Results for War and Prices

1495-1648:

Period	Variable 1	Dir./ sign	Variable 2	Sig. Lags	Significance
1496-1788	GP War		French Wheat Prices		–
1496-1788	French Wars	<–	French Wheat Prices	5*	–
	French Wars	–>	French Wheat Prices	8*	–
1496-1640	GP War		English Ag. Prices		–
1496-1640	British Wars	< +	English Ag. Prices	7*	–
1496-1640	GP War		English Ind. Prices		–
1496-1640	British Wars	<–	English Ind. Prices	2,9*	–

1618-1815:

Period	Variable 1	Dir./ sign	Variable 2	Sig. Lags	Significance
1631-1817	GP War	+ >	English Wheat Prices	1*	–
1631-1817	British Wars	+ >	English Wheat Prices	8*	*

1790-1945:

Period	Variable 1	Dir./ sign	Variable 2	Sig. Lags	Significance
1781-1922	GP War	+ >	British Kondratieff Prices	1-4**	**
1802-1922	GP War	+ >	U.S. Kondratieff Prices	2,3**	*
	GP War	< m	U.S. Kondratieff Prices	2,3*	*
1802-1975	GP War	+ >	U.S. Wholesale Prices	2**	*
1751-1975	GP War	+ >	British Wholesale Prices	1-3,6*	*
1799-1975	GP War	+ >	French Wholesale Prices	2,6**;8,9*	**
	GP War	< m	French Wholesale Price	2,8*	*
1793-1918	GP War	+ >	German Wholesale Prices	1-4**;5-7*	**

Notes: Variable 1 = 1st variable of Granger analysis; Variable 2 = 2d variable of Granger analysis. Dir./sign = direction of Granger causality and sign of coefficients (m = mixed signs on different lags);
Sig. Lags = Particular lags found significant in the equation. Significance = Overall significance level: * < .05 ; ** < .01. Results shown are for 8 lags by 10 lags.

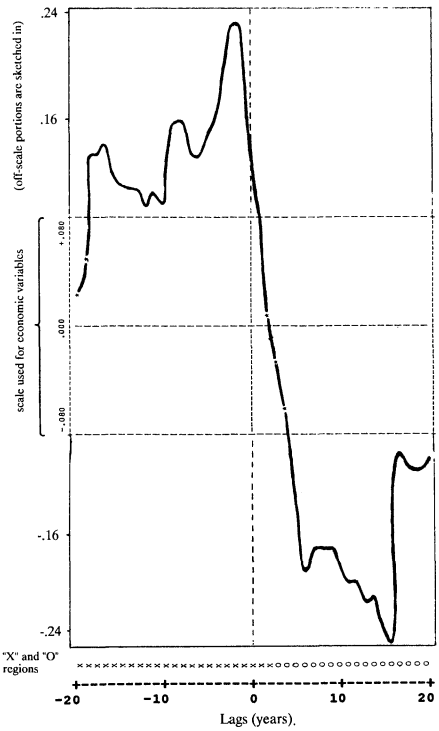
In that period, either wars had less impact on prices (wars were less sharply defined in that period), or data are simply of lower quality.

Lag Structure for War

If wars do lead prices, this should be evident in the lag structure for the war severity time series.[36] In the lag structure of war severity relative to the nominal (price) long wave phases (fig. 11.5), note that the "fit" is much stronger than in the economic series and that I have therefore extended the scale threefold at both the top and bottom. The structure is robust, although the shift from "X" to "O" regions is quite abrupt. The "X" region is from at least −20 lags to +2, and the "O" region from

36. The scale of the series was described earlier. The logged series was used to control the extreme variance of the series, particularly in the 20th c. (sudden jumps to extreme severity levels would overwhelm data from the previous four centuries).

Figure 11.5. Lag Structure, War Severity



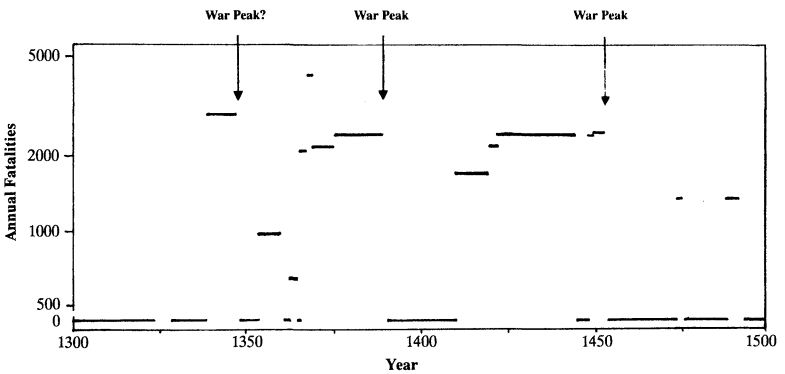
+3 to at least +20. The peak comes near the end of the "X" region, −1 to −2 lags, and the trough at +16 lags. This structure indicates that war *leads* prices, by about one to five years (for the strongest correlation). This of course implies that war *lags* production by about ten years.

War Cycles before 1495?

It is really outside the scope of this project to consider war cycles before 1495 in any serious way. Nonetheless, Sorokin (1957) provides some fatality data going back well before 1495, and Imbert (1959) gives datings of claimed long wave phase periods back to 1286,[37] so I checked whether the two match up. But I can find no strong correlation between Imbert's economic phases and Sorokin's war data. For instance, for Imbert's French phases for all wars involving France, the upswing phases contain 550 battle fatalities annually on average, while the downswing phases contain 440 annually (610 annually during transition years between phases as given by Imbert). In English-French wars, categorized by English phase periods (a dif-

37. Unfortunately, Imbert's datings are quite different for different countries (England and France).

Figure 11.6. English-French Battle Deaths, 1300-1500



Note: Data, converted to time series and graphed on log scale, are from Sorokin (1957: appendix).

ferent dating scheme), the average annual fatalities are 600 on the upswings and 1180 on the downswings (950 in transition years).

The only intriguing results came not from Imbert's data but from graphing the Sorokin fatalities alone. One series—English-French wars, essentially battle fatalities from the Hundred Years' War (1339–1453)[38]—seemed to show fifty-year cycles at least weakly (fig. 11.6). A series of three war peaks seem to exist in 1347, 1389, and 1444 (the peaks are separated by forty-two and fifty-five years, respectively). The data for other countries—Austria-Hungary, Russia, and Poland—did not follow these patterns, however, nor did fatalities for Europe as a whole.

A long wave in the Hundred Years' War might point to the centrality of Britain and France at a very early point in the development of the "core" in Europe, but the evidence here is much too weak to support that conclusion. Future research into long waves before 1495, however, might pay particular attention to England and France.

Hypotheses of War and the Long Wave

The results reported in this chapter bear directly on the long wave hypotheses dealing with war. The existence of long waves of war is corroborated and provisionally accepted, while the contrary hypothesis may now be rejected:

Long waves exist in war and related political phenomena. [A]
(Kondratieff, Wright, Väyrynen, Craig and Watt)

Long waves of war do not exist. [R]
(Sorokin)

---

38. This class was perhaps the closest thing to great power wars that existed before 1495.

The hypothesis connecting higher levels of war with the long wave upswing has been strongly corroborated, and the opposite timing rejected:

War concentrations occur on long wave upswings. [A]
(Kondratieff, Åkerman, Rose, Wright, Craig and Watt, Väyrynen)

War clusters early in the downswing.[39] [R]
(Mensch)

And more exact statements can now be made about the timing of war relative to the long wave phases. This hypothesis:

Price upswings precede major wars. [R]
(Rostow, Thompson and Zuk)

is true only if interpreted as referring to changes in the *rate* of price increases and the *level* of war.[40] Major wars tend to occur late in the price upswing, before the price peak. But, overall, changes in war precede changes in prices.

Summary of Empirical Analysis

Chapters 9–11 have presented the results of my empirical analysis on long waves in economic variables and in war. This analysis began from a conception of long waves as alternating historical phase periods in which cycle time rather than calendar time is the appropriate statistical framework. I defined these phase periods, a priori, by a single base dating scheme that applies across the board to all the time series studied.

Fifty-five economic time series and several war series were assembled into a coherent data base, which was analyzed to find whether the behavior of the series in fact alternates in successive phase periods. The analysis consistently identified synchronous long waves in a variety of price series from different core countries as well as in the two (English) real wage series. The analysis of time-shifted correlations further identified long waves in production, innovation, and capital investment—although the paucity of data, especially for capital investment, makes this conclusion quite tentative. The production variables lead prices by about ten to fifteen years, allowing a new interpretation of the "stagflation" of the 1970s as the start of a production downswing and the end of a price upswing. Innovation seems to lead

39. This timing is off by only ¼ cycle, not ½, since it refers to levels of war, not rates. Clusters occur late in the upswing phase.

40. The difference between rates and levels can appear as a roughly ¼-cycle shift in timing (see chap. 8).

prices, inversely, by about five years, and capital investment seems to lead prices by about ten years. Long waves in trade are not evident. The severity of great power war correlates strongly with the long wave, leading prices by about one to five years. The pattern of recurring war, while remaining fairly synchronous with the long wave, passes through several different eras over the course of five centuries.

The lagged correlations of the different classes of variables suggests the following *sequence* of the long wave, which I adduce as most plausible given all empirical evidence:

−15 lags	
	Upturn in production
−10	Upturn in capital investment
−5	Downturn in innovation
	Upturn in war severity
0	Upturn in prices; downturn in wages

These results form the starting point for the next chapter, in which I develop a theory of the long wave, building on both the empirical analysis of chapters 9–11 and the theoretical debates of Part One.

While the results arrived at in chapters 9–11 are in many places tentative, and the data supporting them often fragmentary, I have nonetheless tried to piece together the most coherent picture possible—admittedly, only a "rough sketch"—from the available information. This effort does not "prove" anything about long waves but helps to build theory consistent with available evidence. Further research into one or another class of variable may well turn up contradictory evidence at some later point, forcing a revision of theory (or resolving an unsolved puzzle, such as the British-U.S. patent mystery). But for now, the picture described in chapters 9–11 is the most consistent and supportable interpretation that can be made of the available evidence.

In closing, I note that the competing long wave hypotheses tested in the preceding chapters may be seen as the bottom level of a hierarchy of hypotheses. At the upper levels, the results corroborate three metahypotheses:

1. The existence of a world system—corroborated by the international synchrony of political-economic movements.
2. The unity of economics and politics in that system—corroborated by the strong correlations among political and economic variables.
3. The existence of long waves of political economy within the world system—corroborated by the alternating growth rates in the data series.