Economic and Sociological Phenomena Related To Solar Activity and Influences*

by EDWARD R. DEWEY

ABSTRACT: A list of 47 cycles in economic and sociological phenomena that are alleged to fluctuate with the sunspot cycle (average length 11.11 years), or which are alleged to have periods of about 11 years, is presented. The history of the idea that sunspots have economic effects is outlined. Various subsidiary cycles have been alleged to exist in sunspot numbers. Some of these are listed and two are compared with corresponding economic cycles.

Sunspots with alternate cycles reversed (the double sunspot cycle with an average length of 22.22 years) are discussed. Fourteen economic and sociological phenomena that are alleged to have periods of about this length are listed. The results of a systematic period reconnaissance of the double sunspot cycle are presented. An example of a solar-economic correspondence is given. Allegations of direct influences of individual spots and other solar disturbances are considered. All the allegations of this sort that could be found are included.

As the length of the successive sunspot cycles varies considerably, comparisons of cycles in terrestrial phenomena with cycles in sunspots should use identical spans of time for both of the series being compared. Moreover, as there seem to be environmental forces of unknown origin having a great variety of period, the effect of such of these forces as have periods about 11 or 22 years long could easily be mistaken for the effects of sunspots. Finally, it is noted that advocates of solar-economic and solar-sociological interrelationships have not as yet explained how the association could operate.

CONCLUSIONS: There are sufficient allegations and hints of correlations so that the question of the effects of solar cycles, either direct or indirect, upon economic and sociological phenomena must remain open.

However, in spite of numerous allegations and partial correlations, no conclusive evidence has yet been developed to show that the so-called 11-year sunspot cycle, or the double sunspot cycle of 22 years, or any of the subsidiary solar cycles that have been alleged, have economic or sociological repercussions. In addition, evidence of such consequences from individual sunspots or solar eruptions is sketchy and lacks corroboration.

In spite of numerous allegations and widespread folklore, there is, as yet, no conclusive evidence that the dominant 11-year sunspot cycle, or the double sunspot cycle of 22 years, or any of the subsidiary solar cycles that have been alleged, have any economic or sociological repercussions. Evidence of economic or sociological consequences of individual solar eruptions is sketchy and lacks corroboration.

On the other hand, there are enough allegations, hints, and correlations so that a thorough, definitive, and final study should be made to answer, once and for all, the question, "Does the sun have direct or indirect economic and sociological effects in addition to the 24-hour cycle of the day and the 12-month cycle of the year?"

This paper presents the evidence for association, and attempts to evaluate it. The paper is divided into five parts dealing respectively with: I, the 11-year sunspot cycle itself; II, subsidiary sunspot cycles; III, the double 22-year cycle of sunspots with alternate cycles reversed; IV, subsidiary cycles of the double sunspot cycle; and V, individual solar eruptions.

The dominant 11-year cycle (See Figure 1) is of course the cycle of chief interest, but minor sunspot cycles have also been alleged. Moreover, study of the double or 22-year sunspot cycle is expanding, and interest in individual solar eruptions is also increasing.

I. THE 11-YEAR SUNSPOT CYCLE

The dominant cycle in sunspot numbers has averaged 11.11 years in length from 1527 through 1966,[44] although times between lows of individual cycles have ranged—during

* A paper delivered September 6, 1968, at the Second International Symposium on Solar-Terrestrial Relationship in Physical-Chemistry and in the Science of Life, Brussels, Belgium, September 1–7, 1968.

the last 19 cycles—from 8.67 to 13.92 years.[15] See Figure 1 for chart of sunspots, 1700–1967.

In view of the wide difference in length of different sunspot cycles (waves), measurement of the average length of this so-called 11-year cycle will range from 10.8 years to 11.4 years, or even over a greater range, depending upon the time over which the measurements are taken. Thus a terrestrial effect over one span of time might average one length; over another span of time it might average quite differently. For accurate comparisons, attempts to find correlations between the sunspot cycle and economic or sociological cycles must always be determined over the same span of time. However, this procedure is not always followed. Most people assume that the sunspot cycle has an average length of 11.11 years, regardless of the time span covered, but this is not so.

Table 1 below lists the chief economic and sociological cycles, or allegations of cycles, with periods (average wave lengths) in the general neighborhood of 11 years.

One should not put much weight upon the mere correspondence of period.[43,66] The fact that two phenomena fluctuate in cycles of about the same length is not too surprising, especially since so many cycles have been alleged. (The *Catalogue of Cycles, Part I–Economics*[105] lists nearly 1400 allegations of cycles in economics alone.) However, if the period of the cycles in two behaviors has been, or can be, measured so accurately that the values are practically identical, there is greater evidence of an interrelationship. If, in addition, the turning points of the two series come at the same time there is even more evidence of an association. (The current timing of the crest of the ideal* 11.11-year sunspot cycle is 1971.4).[44]

HISTORICAL

The idea that sunspots might have something to do with economic affairs was first advanced in 1801. In a paper read before the Royal Society of London in that year, Sir William Herschel, a German-British astronomer, called attention to an apparent relationship between sunspot activity and the price of wheat.[57] His studies covered six periods from 1650 to 1800. They were limited to mere correlation, without remark upon the rhythmic nature of the figures.

In 1838, and again in 1847, Dr. Hyde Clarke of England

* An *ideal* cycle is the average of all the waves of the given length. Its *timing* identifies the dates at which turning points of the various waves would come if they were all exactly of the determined average length (period). The *current* timing of the crest of the ideal cycle records the date of the crest of the ideal cycle (wave) nearest to the present time.

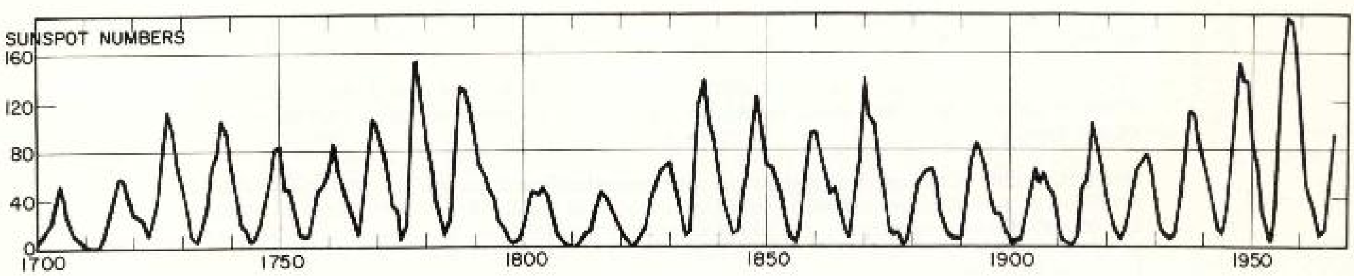

Fig. 1: SUNSPOT NUMBERS, BY YEARS, 1700–1967[12,98]

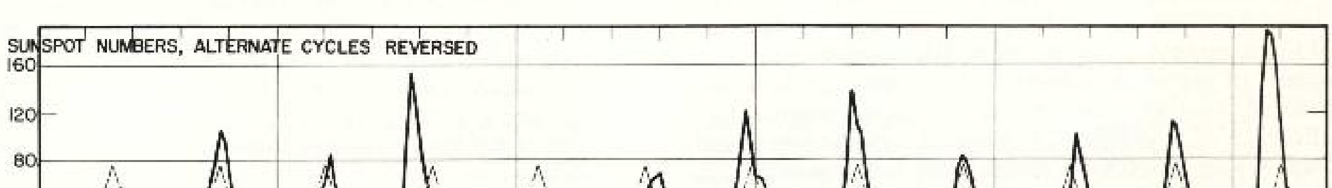

Fig. 2: THE DOUBLE SUNSPOT CYCLE

Sunspot Numbers, Alternate Cycles Reversed, by Years, 1700–1967, Together with the Ideal 22.22-Year Cycle.[45]

TABLE 1

LIST OF ECONOMIC AND SOCIOLOGICAL PHENOMENA
ALLEGED TO FLUCTUATE IN CYCLES ABOUT 11 YEARS LONG
(10.8 YEARS–11.4 YEARS)

No.	Phenomena	Span of Time in Years	Period in Years	Date of the Current Ideal Crest	Refer-ence	Notes
	COMMODITY PRICES					
1	Cotton Prices, U.S.A., 1821–1873	53	11	1968	5	2
2	Cotton Prices, U.S.A., 1731–1964	234	10.98	1971.83	99	1
3	Grain Prices, England, 1259–1400	142	11.11	—	63	3
4	Grain Prices, U.S.A., No Dates Given	—	SS	—	3	4
5	Pig Iron Prices, U.S.A., 1784–1951	168	11.1	—	26	1
6	Sheep Value, per Head, on Farms, U.S.A., 1867–1963	97	10.99	1972.10	99	1
7	Wheat Prices, England, 1650–1800	151	SS	—	57	5
8	Wheat Prices, Western and Central Europe, 1545–1869	325	11.000	1969.53	7	6
9	Wholesale Commodity Prices, Great Britain, Ireland, 1784–1869	86	SS	—	17	7
10	Wholesale Prices, All Commodities, U.S.A., 1720–1964	245	11.30	1972.75	99	1
	STOCK PRICES					
11	Combined Stock Prices, U.S.A., 1871–1958	88	10.83	1971.11	86	8
12	Industrial Stock Prices, U.S.A., 1871–1950	80	10.8	—	25	1
13	Stock Prices, U.S.A., 1871–1964	94	SS	—	15	9
	OTHER FINANCIAL					
14	Deposits in All Banks, U.S.A., 1834–1964	131	11.10	1977.91	99	1
15	Post Office Revenues, U.S.A., 1800–1964	165	11.000	1971.39	99	1
16	Reichsbank Clearings, Germany, 1884–1925	42	10.92	—	100	—
17	Residential Mortgage Loans, U.S.A., 1923–1942	20	SS	—	9	10
18	United States Steel Corporation Earnings, U.S.A., 1900–1948	49	11	—	95	—
	GENERAL BUSINESS					
19	Business Activity, U.S.A., 1855–1940	86	11.14	—	61	4
20	General Business Activity, U.S.A., 1750–1960	211	11	—	102	11
21	Non-Agricultural Business Activity, U.S.A., 1875–1931	57	11+	—	55	4
	AGRICULTURAL PRODUCTIVITY					
22	Corn Acreage Harvested, U.S.A., 1866–1964	99	10.99	1976.36	99	1
23	Corn Production, Iowa, U.S.A., No Dates Given	—	SS	—	109	5
24	Cotton Production, U.S.A., 1790–1964	175	11.38	1973.08	99	1
25	Crop Yields, Canada, 1898–1938	41	11	—	65	14, 5
26	Crop Yields, Wisconsin, U.S.A., 1866–1947 (Barley, Oats, Potatoes, Wheat, and Tame Hay)	82	11	—	72	10
27	Crop Yields, Wisconsin, U.S.A., 1866–1947 (Corn, Rye, and Tobacco)	82	11	—	72	5, 15
28	Crop Yields, U.S.A., 1792–1951	160	11	—	73	16
29	Grain and Field Pea Production, Canada, No Dates Given	—	SS	—	16	5
30	Wheat Yields, Eastern England, 1885–1906	22	11	1975	83	—
31	Wheat and Barley, Bumper Crops in the Near East, 1874–1940	67	10-12	—	18	12
	INDUSTRIAL PRODUCTION					
32	Automobile Production, U.S.A., 1925–1936	12	11	—	92	4
33	Lead Production, U.S.A., 1821–1964	144	10.81	1971.78	99	1

TABLE 1 — Continued

No.	Phenomena	Span of Time in Years	Period in Years	Date of the Current Ideal Crest	Reference	Notes
	INDUSTRIAL PRODUCTION — Continued					
34	Crude Petroleum Production, U.S.A., 1861–1964	104	11.19	1971.49	99	1
35	Physical Production of Manufacturing, U.S.A., 1863–1953	91	11.2	1972.2	27	—
36	Physical Production of Minerals, U.S.A., 1878–1927	50	11+	—	55	—
37	Pig Iron Production, U.S.A., 1844–1958	115	11.2	1972.2	85	—
	MISCELLANEOUS ECONOMICS					
38	Business Panics, U.S.A., 1877-78–1933-34	57	SS	—	71	—
39	Commercial Crises, France, England, 1793–1847	55	11	—	13	17
40	Economic Prosperity and International Crises, Worldwide, No Dates Given	—	SS	—	3	—
41	Sales of a Laxative, U.S.A., No Dates Given	—	11	—	76	18
42	Shipwrecks, Indian Ocean, No Dates Given	—	SS	—	62	19
43	Value of Fisheries, Canada, 1870–1917	48	SS	—	17	20
	SOCIOLOGICAL					
44	International Battles, 529 B.C.–A.D. 1900	2429	11.241	1970.7	20, 24	21
45	Mass Human Excitability, Worldwide, 500 B.C.–A.D. 1922	2422	11.11	—	96	22
46	Drought and Famine in South India, No Dates Given	—	11	—	4, 59	—
47	Marriage Rates in 15 Countries, in France, and in Austria, 1867–1912	46	SS	—	17	23

NOTES FOR TABLE 1

1. Hint of a cycle obtained by periodogram analysis.
2. Benner was the original discoverer of the 11-year cycle in cotton prices. He noted crests in 1825, 1836, 1847, 1858, 1869. Projecting his 11-year cycle to date would give a current crest at 1968.
3. The grains included wheat, barley, oats, beans, peas, vetches, and rye.
4. The author states that the figures seem to correlate with the sunspot cycle.
5. In inverse phase with sunspot cycle.
6. Periodogram analysis supplemented by careful study of the cycle in each section of the data. Beveridge says that the amplitude at 10.8 years over the whole sequence 1545 to 1852 is found to be much greater than at 11.2 and that if we insist on the best period to fit the figures, we get something like 10.93.
7. In inverse phase with sunspot cycles with lag of one year.
8. Originally (1951[22]) determined as 11.0 years.
9. The author shows that the greatest percentage decline in stock prices in each sunspot cycle occurs in the year when sunspots, going up, reach an annual average of 50, or shortly thereafter.
10. In phase with sunspot cycle.
11. Williams, using data from Silberling,[90] continued Silberling's work, 1940–1960, and reported that sunspot numbers and general business activity show a close relationship.
12. Bumper crops of wheat and barley coincide with excessive rainfall in the Near East. Excessive rainfall in this area recurs in cycles of 10-12 years (1883, 1893, 1906, 1917, 1929, 1938). These dates in turn coincide with times of sunspot maxima, he says.
13. Johnson felt that crop yields of wheat, oats, and barley in semi-arid regions of Alberta and Saskatchewan might be influenced by the sunspot cycle.
14. DeLury also claimed Canadian crop yields in wheat, oats, barley, and rye had an inverse relationship to sunspot cycles 1908–1929.[17]
15. The tobacco series started in 1869.
16. Crop yields have shown a direct correlation with high water levels in the Great Lakes which in turn have shown a correlation with the sunspot cycle.
17. Peaks 1793, 1804, 1815, 1837, 1847. Jevons assigned a period of 10.44 years for commercial crises in England, 1763–1857. This period also fitted approximately the crises of 1701, 1711, 1721, 1733, 1742, 1752, and the crises of 1866 and 1877-78. This cycle was not listed in Table 1 because its period is outside of the arbitrary limits of 10.8 years–11.4 years.
18. Sales preceded by the 11-year sunspot cycle.
19. Stewart quotes Henry Jeula of Lloyds and a Mr. Meldum, but without references. Jeula refers to shipwrecks in general. Meldum refers to those in the Indian Ocean.
20. DeLury states the value of fish cycle parallels the grain cycle, i.e., shows an inverse relationship to sunspots.
21. The 11-year cycle in war was first discovered in 1951 in data 1751–1943, a span of 193 years, and assigned a period of 11 1/7 years;[20] in 1952, in data 1751–1950, the period was revised to 11.2 years with an ideal crest at 1971.[24] Additional research using data 529 B.C.–A.D. 1900 shows average ideal period to be 11.241 years, ideal current crest at 1970.7 years.[47]
22. See also reference 36.
23. DeLury states that the mean cycle for 15 countries (Australia and 14 European countries) exhibits a positive phase with a lag of 3 years. The record for France is similar to that of the mean of the 15 countries, and is almost identical with the mean cycle for comparative wheat prices. The mean cycle in the marriage-rates of Austria is in perfect positive phase with the sunspot cycle.[17]

noted an 11-year cycle in trade and speculation and advanced the idea of a physical cause for this regularily.[13]

Our knowledge of Dr. Hyde Clarke comes to us chiefly from Professor W. S. Jevons, a British economist, who, in 1878, wrote as follows:[13]

> It is curious to notice the variety of the explanations offered by commercial writers concerning the cause of the present [1878] state of trade....
>
> It occurs to but few people to remember that what is happening now is but a mild repetition of what has previously happened time after time. ... All kinds of distinct reasons can thus be given why trade should be now inflated and again depressed and collapsed. But, so long as these causes are various and disconnected, nothing emerges to explain the remarkable appearance of regularity and periodicity which characterises these events.
>
> The periodicity of the earlier portion of the series is so remarkable that, even without the corroboration since received, it convinced scientific inquirers that there was some deep cause in action. Dr. Hyde Clarke, for instance, wrote, more than thirty years ago, a paper entitled "Physical Economy—a Preliminary Inquiry into the physical Laws governing the Periods of Famines and Panics." This paper was published in the *Railway Register* for 1847, and is well worth reading. In the commencement he remarks: "We have just gone through a time of busy industry, and are come upon sorrow and ill-fortune; but the same things have befallen us often within the knowledge of those now living. Of 1837, of 1827, of 1817, of 1806, of 1796, there are men among us who can remember the same things as we now see in 1847. A period of bustle, or of gambling, cut short in a trice and turned into a period of suffering and loss, is a phenomenon so often recorded, that what is most to be noticed is that it should excite any wonder." Dr. Hyde Clarke then proceeds to argue in a highly scientific spirit that events so regularly recurring cannot be attributed to accidental causes; there must, he thinks, be some physical groundwork, and he proposed to search this out by means of a science to be called Physical Economy. In the third page of his paper he tells us that he had previously written a paper on the laws of periodical or cyclical action, printed in Herapath's *Railway Magazine* for 1838. "At this time," he says, "it was my impression that the period of speculation was a period of ten years, but I was led also to look for a period of thirteen or fourteen years.... In the course of these inquiries I looked at the astronomical periods and the meteorological theories without finding anything at all available for my purposes."[*] A little below Dr. Hyde Clarke continues: "Still thinking that the interval was an interval of about ten years, I was, during the present famine, led to look for a larger period, which would contain the smaller periods, and as the present famine and distress seemed particularly severe, my attention was directed to the famine so strongly felt during the French Revolution. This gave a period of about fifty-four years, with five intervals of about ten or eleven years each, which I took thus: 1793, 1804, 1815, 1826, 1837, 1847."
>
> Dr. Hyde Clarke was by no means the only statist who adopted a theory of periodicity thirty or forty years ago....
>
> The peculiar interest of Dr. Hyde Clarke's speculations consists in the fact that he not only remarked the cycle of ten or eleven years, but sought to explain it as due to physical causes, although he had not succeeded in discovering any similar astronomical or meteorological variation with which to connect it. Writing as he did in 1838 and 1847, this failure is not to be wondered at.

* The periodicity of the sunspot cycle was not suggested until a paper by Samuel Heinrich Schwabe of Dessau, Germany in 1844.

Clarke's work was supplemented in 1863 by R. C. Carrington, F. R. S., an English astronomer.[11] Carrington, in that year, published a paper which charted the variations in frequency of sunspots and the imperial average price of wheat over the period 1750–1860. Carrington, comparing the two curves, called attention to the "general but imperfect correspondence between the two curves but warned that this correspondence was insufficient upon which to base any conclusions." On the other hand, he said, "they powerfully stimulate further inquiry with a view of ascertaining whether the discrepancy may admit of future explanation."

In 1875 Professor W. S. Jevons read a paper before the Bristol meeting of the British Association entitled "The Solar Period and the Price of Corn."[63] In this paper Jevons analyzed the prices of oats, wheat, barley, peas, beans, vetches, and rye for the period 1259 to 1400 by arranging them as nearly as possible in 11.11 year arrays, the assumed length of the sunspot cycle. For each grain and for all grains combined he found maximum strength in the same year of his arbitrary arrangement.

On August 19, 1878, Jevons read a second paper on this subject, this one before the Dublin meeting of the British Association.[64] This paper was called "The Periodicity of Commercial Crises and Its Physical Explanation." In it he withdrew his 1875 paper and admitted to no success in his attempts to discover a regular periodicity in the price of corn in Europe. However, he noted a well marked decennial periodicity of 10.444 years in commercial crises, 1763 to 1857. This fact, coupled with a new determination of the sunspot period of 10.45 years made by a Mr. J. A. Brown impressed Jevons greatly. He stated, "...it becomes highly probable that two periodic phenomena, varying so nearly in the same mean period, are connected as cause and effect."[64]

In 1881, the English astronomer, N. R. Pogson traced an intimate connection between sunspot frequency and grain prices in Madras, India.[79]

In 1919, Professor Ellsworth Huntington of Yale advanced the idea that variations in solar radiation had an effect upon human beings and thus in turn upon business conditions, instead of affecting business first and then human beings, as was commonly believed.[60]

In 1926, Professor A. L. Tchijevsky of Moscow, in a paper read at the annual meeting of the American Meteorological Society at Philadelphia,[96] presented an index of mass human excitability, 500 B.C.–A.D. 1922.[58] This index showed a consistent pattern of 9 waves of excitability per century over the entire span of 2422 years.

The index was compiled from "detailed statistical researches in the histories of 72 countries and nations of the world."[96] All available works and textbooks in modern and ancient languages were consulted.

Tchijevsky found not only that his index was characterized by 11.1-year cycles, but that the crests of these cycles tended to correlate with all the knowledge available to him of crests of sunspot cycles.

More particularily, Tchijevsky wrote:[96]

As soon as the sunspot activity approaches its maximum, the number of important mass historical events, taken as a whole, increases, approaching its maximum during the sunspot maximum and decreasing to its minimum during the periods of the sunspot minimum....

In the middle points of the cycle, the mass activity of all humanity, assuming the presence in human societies of economical, political, or military exciting factors, reaches the maximum tension, manifesting itself in psychomotoric pandemics, revolutions, insurrections, expeditions, migrations, etc.—thus creating new formations in the existing separate states and new historical epochs in the life of humanity. It is accompanied by an integration of the masses, a full expression of their activity and a form of government consisting of a majority.

In the extreme points of the cycle's course, the tension of the all human military-political activity falls to the minimum giving way to creative activity and is accompanied by a general decrease of military or political enthusiasm, by peace and peaceful creative work in the sphere of state organizations, international relations, science and art, with a pronounced tendency towards absolutism in the governing powers and a disintegration of the masses.

The maximum of human activities in correlation with the maximum of sunspot activity, expresses itself in the following:

a. The dissemination of different doctrines (political, religious, etc.), the spreading of heresies, religious riots, pilgrimages, etc.

b. The appearance of social, military and religious leaders, reformers, etc.

c. The formation of political, military and religious and commercial corporations, associations, unions, leagues, sects, companies, etc....

In 1934 Dr. Carlos Garcia-Mata and Dr. Felix I. Shaffner set out to prove, once and for all, that the idea of solar-economic relationships was completely untenable.[55] To their great surprise they found a very close correlation. Only, instead of a solar-crop correlation as suggested by Herschel and Jevons they found a solar-manufactures correlation. This correlation covered the period 1875–1931 and was very marked. However, the crests and troughs of the solar cycles came *after* the crests and troughs of manufacturing and of total production. (Figure 3.) To overcome this difficulty—because the supposed cause can hardly follow the result—they postulated that the causative factor was the *rate of change* of solar activity. When the rate of change (first differences) of sunspot areas and solar faculae were compared with manufactures and with mineral production, the comparison was dramatic indeed. Note, however, that they found little or no correlation with crops.

I have tried to get Dr. Garcia-Mata to bring his 1934 work up to date, but he says the task would be a big undertaking and would take more time than he has available at the moment.

In 1936, Loring B. Andrews, Harvard astronomer, called attention to the apparent correlation over the preceding 200 years between sunspot activity and wars, international crises, and economic distress.[3] He conjectured that the cause of these and other solar-terrestrial correlations might be due either to the intensity of solar radiation or to emanations of ultraviolet light. Both of these two solar phenomena are associated with sunspot activity. Andrews felt that variation in ultraviolet light is the more reasonable of the two possible explanations for the economic and sociological correlations.

In 1960, Dewey made an investigation in depth of Tchi-

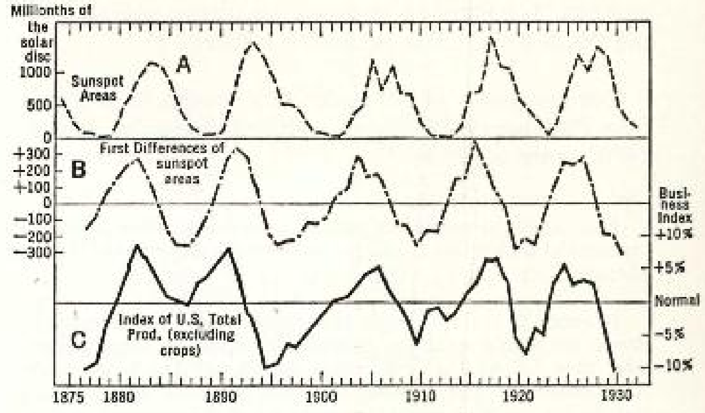

Fig. 3: SUNSPOTS AND MANUFACTURING

Sunspot areas and first differences of sunspot areas compared to manufacturing production, U. S. A., 1875—1931, all values smoothed by 4-year moving averages.

After Garcia-Mata and Shaffner.[55]

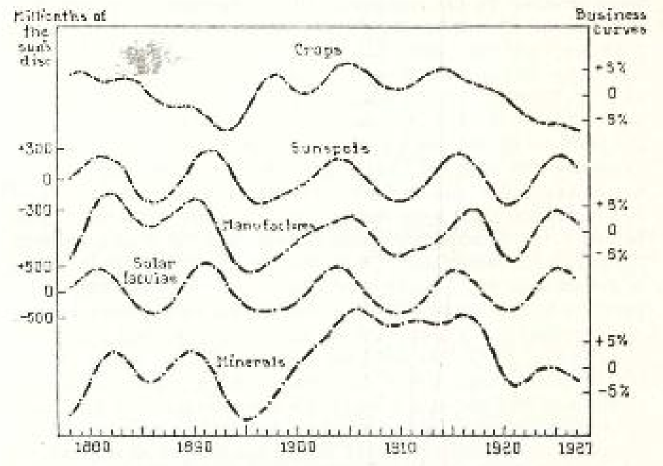

Fig. 4: SUNSPOTS, FACULAE, CROPS, MINERALS, AND MANUFACTURES

First differences of sunspots and solar faculae compared with manufactures, minerals, and crops, 1778—1928, all values smoothed.

After Garcia-Mata and Shaffner.[52]

jevsky's work, publishing the results in a paper called "Correspondence Between Tchijevsky's Index of Mass Human Excitability and Sunspot Maxima, 500 B.C.–A.D. 1922."[36] In this study he used dates of sunspot maxima derived by Schove[89] from old Chinese manuscripts and other sources which were not available to Tchijevsky.

Dewey found that when one compares all values of Tchijevsky's Index of Mass Human Excitability[58] with the years of sunspot maxima, the crests of the sunspot cycles *follow* the crests of the Index by about a year, on the average.

He concludes, "there probably is some response on the part of human beings to the sunspot cycle. However, this response would seem to be to the *cycle*, not to the spots themselves, for the maximum of mass human excitability precedes the maximum number of spots."[36]

In 1965, Charles G. Collins, an investment counselor, published "An Inquiry into the Effect of Sunspot Activity on the Stock Market."[15] In this article he showed that since 1871 (the date of the earliest good U.S.A. stock price figures) in each solar cycle, the largest percentage stock market decline has coincided with or followed the year in which average sunspot number counts have reached 50.

Was Jevons right in thinking that there is a 11.11-year cycle in British grain prices from 1259 to 1400? Has it continued? Are the *irregularities* of the sunspot period reflected in the *irregularities* of the economic data? If the period of the solar and economic cycles are identical, what are the mechanics whereby solar variations could affect human beings? Was Professor Huntington correct in thinking that it was somehow associated with the emission of ultraviolet light? Or is there some other explanation? No one yet knows, but we *should* know. There is no excuse for failure to make a full investigation of this subject.

II. SUBSIDIARY SUNSPOT CYCLES

Turning now to subsidiary sunspot cycles, we face much the same situation. Many such cycles have been alleged with varying degrees of credibility. (See Table 2.)

Many economic and sociological cycles have corresponding periods, but little effort has been made to see if these, in truth, do have identity of period, if they correspond in phase with the subsidiary sunspot cycles, and if their irregularities correspond also. In fact, even the minor sunspot cycles themselves have not as yet been thoroughly investigated. This investigation, and the relationship of solar cycles to similar cycles on earth, should be made at the earliest opportunity.

One provocative comparison, however, involving a shorter sunspot cycle, has been made. It suggests that an investigation in depth of minor sunspot cycles and economic phenomena might be very fruitful indeed. I refer to the cycle about 17 weeks long in daily sunspot numbers, first discovered in data for 1958, 1959, and 1960 and later found to continue backward throughout 1957, 1956, 1955, and 1954.[39] This 17-week cycle in sunspots has the same period, as closely as it can be measured in the data used, as a similar cycle in industrial common stock prices, present over the 63-year span, January 9, 1897–February 13, 1960.[37] The cycle on the sun was even clearer than the cycle in stock prices over the span of time studied. The cycle in stock prices was found to crest, ideally, at a fifth of a week into the week ending July 30, 1960. In sunspot numbers crests come on the average, 2 1/2 weeks after the ideal time of crest in stock prices. This behavior corresponds to the lag of sunspot timing as observed by Garcia-Mata and Shaffner in manufacturing and mineral production and by Dewey in Tchijevsky's Index of Mass Human Excitability.

Another similar example is the 42-year cycle in sunspot numbers discovered in 1954 by G. T. Lane.[69] This cycle in these figures was timed and was found to be present in each half of the series.[42] It is interesting that this cycle on the sun troughs ideally at 1970.25[42] just *after* a corresponding 42-year cycle in Arizona Tree Rings at 1969.06 and in inverse phase with Lord Beveridge's European wheat prices.[41] A similar cycle in cotton prices, U.S.A. 1731-32–1961-62 crests ideally even earlier, 1957.1.[40]

TABLE 2

SUBSIDIARY SUNSPOT CYCLES

Periods, in Years, of Subsidiary Cycles in Sunspot Numbers
As Variously Alleged

Scientist	Periods in Years										Reference
A. Schuster	4.8				8.4				11.13	13.5	82
K. Stumpff		5.6	7.3			8.8		10.0	11.13	12.9	94
A. E. Douglass					8.5			10.0	11.4	13.5	53
D. Alter			7.6	8.1		8.7		10.0	11.37		2
H. H. Clayton		5.6		8.1		8.94		9.9	11.17		14
G. T. Lane		5.625	7.60		8.36	8.76	9.3	9.93 & 10.59	11.25	13.0	69

III. SUNSPOT NUMBERS WITH ALTERNATE CYCLES REVERSED—THE DOUBLE SUNSPOT CYCLE

Automatically, by construction, the double sunspot cycle must be 22.22 years long if the single sunspot cycle is 11.11 years long.

The physical basis for the concept of the double sunspot cycle is as follows: As is generally known, sunspots are magnetized and normally occur in pairs. In one cycle (in the sun's northern hemisphere) North spots lead and South spots follow; in the next 11-year cycle, South spots lead and North spots follow. (In the sun's southern hemisphere the reverse behavior prevails.) These facts justify reversing alternate sunspot cycles to obtain a series of figures oscillating around an axis to create a cycle about 22 years in length. (See Figure 2.) A number of economic and sociological cycles have periods of about this length. (See Table 3.)

TABLE 3

LIST OF ECONOMIC AND SOCIOLOGICAL PHENOMENA ALLEGED TO FLUCTUATE IN CYCLES ABOUT 22 YEARS LONG (21.6 YEARS–22.8 YEARS)

No.	Phenomena	Span of Time in Years	Period in Years	Date of the Current Ideal Crest	Reference	Notes
	COMMODITY PRICES					
1	Cotton Prices, U.S.A., 1731-32–1939-40	209	21 3/4	—	23	1
2	Horse Prices, U.S.A., 1880–1937	58	22.5	1976.5	67	—
3	Wholesale Commodity Prices, U.S.A., 1790–1920	131	22	—	81	—
	FINANCIAL					
4	Combined Stock Prices, U.S.A., 1871–1956	86	22	1974.6	32	2
5	Post Office Revenues, U.S.A., 1800–1964	165	22.00	1970.93	48	1,3
	PRODUCTIVITY					
6	Wheat Yield, U.S.A., 1887–1944	58	22	—	8	4
7	Building Activity, Great Britain, No Dates Given	—	22	—	6	—
8	Pig Iron Production, U.S.A., 1854–1924	71	22	—	68	—
	MISCELLANEOUS ECONOMICS					
9	Dollar Sales of a Drug Co., U.S.A., 1884–1964	81	22	*1975	75	5
10	Advertising Effectiveness of a Drug Co., U.S.A., 1888–1950	63	22	*1973	77,78	—
	SOCIOLOGICAL					
11	Patents Issued, U.S.A., 1838–1957	120	22	—	34	—
12	Famine in North India, No Dates Given	—	22	—	4	—
13	International War Battles, 556 B.C.–A.D. 1900	2456	21.98	*1973.33	47	7
14	Suicide Rates of Males, New York City, 1866–1932	67	22-24	1976	10	6

*Trough

NOTES FOR TABLE 3

1. Hint of a cycle obtained by periodogram analysis.
2. A 22-24 year cycle in stock price lows, 1837–1949 is also alleged.[91]
3. A 22-year cycle in postal receipts in Milwaukee, Wisconsin, no dates given, is also alleged.[19]
4. The analysis is based on Kansas data for 1888–1909; Nebraska, Colorado, Kansas, and Texas data, 1906–1923; and Southern Plains data, 1927–1944.
5. Close correlations, 1884–1950, if sunspot numbers are advanced six years. Reverse correlation after about 1954.
6. The same cycle (22 years) is also alleged for suicides for males in Philadelphia 1900–1942, and males and females in Boston and Philadelphia, 1900–1942, all with crests similarly timed.[10]
7. Originally discovered in 1951 in data 1400–1943[21] and assigned a period of 22 1/7 years; investigated in 1956 in data 599 B.C.–A.D. 1950 and assigned a period of 21.95 years.[31] This period was later refined to 21.98 years.[47]

IV. SUBSIDIARY CYCLES OF THE DOUBLE SUNSPOT CYCLE

Sunspots with alternate cycles reversed, like sunspots themselves, evidence hints of minor cycles. The results of a systematic period reconnaissance of the double sunspot cycle show the periods of these hints. (Table 4.) Bear in mind that these periods are merely hints of lengths at or near which there may be real cycles.

As with the minor cycles of sunspots not reversed, there are occasional economic and sociological correspondences, but there is, as yet, no convincing evidence of relatedness—but, of course, there may be interrelationship, notwithstanding.

There are indications that some of the subsidiary cycles listed below are real,[52] but no studies have been made in respect to the significance of most of them. Moreover, there have been no studies to see the extent to which economic and sociological cycles of these periods exist; and, if they do exist, whether or not they synchronize with the solar behavior; and if they synchronize, what could be the mechanism of association.

However, a shorter cycle of 4.00 years, cresting ideally at 1954.25, that does have terrestrial correspondences has been isolated in sunspots with alternate cycles reversed, 1749–1954.[29] Four-year cycles have been found in many terrestrial phenomena, but they have not been measured accurately except for the 4-year cycle in the consumption of cheese, 1867–1953. The cheese consumption cycle crests ideally at 1954.0 and has a period of 4.0 years.[30] The correspondence is noteworthy because the ideal crests in the sunspot cycle come one-quarter year *after* the corresponding 4.0-year cheese cycle. This behavior is reminiscent of the findings of Garcia-Mata and Shaffner in respect to the 11.2-year manufacturing and mineral cycle, and the findings of Dewey in respect to both the 17 1/6-week stock price cycle and the 11.1-year Tchijevsky mass human excitability cycles referred to earlier.

This correspondence is provocative and suggests that an investigation in depth might be productive.

V. NON-CYCLIC CORRESPONDENCES

Sunspot cycles are measured in years, but if individual solar events have economic and sociological repercussions, these repercussions would have to be traced in daily figures. Almost any daily figures would be suitable, if based upon a large enough sample. For economic comparisons we might use bank clearings, stock and commodity prices, labor absenteeism, the number of telephone calls, the number of letters mailed, etc., etc.

For study of possible solar-sociological relationships we might use daily records of suicides, drunkenness, library withdrawals, disorderly conduct, want advertisements, riots, civil commotions, terrorist raids, minor front-line war engagements, accidents, and the like. However, relatively little study has been given to comparisons of this sort.

In the literature one comes across all sorts of references to the physiological effects of ultraviolet radiation or of magnetic variations of the sort that might be stimulated or triggered by the sun. In view of these physiological effects and correlations it would be natural to suppose the existence of economic and sociological repercussions, but as far as I have been able to discover, the subject has been almost completely ignored by investigators. In fact, I have been able to find but three persons who have given attention to this subject: Bernhard and Traute Düll of Germany and A. L. Tchijevsky of Russia.

Tchijevsky's work has already been referred to in connection with the 11-year cycle in his Index of Mass Human Excitability, which cycle he attributed to the effect of sun-

TABLE 4

CYCLE PERIODS,* 12 YEARS AND UP AT OR NEAR WHICH THERE MAY BE SIGNIFICANT CYCLES IN SUNSPOTS WITH ALTERNATE CYCLES REVERSED, 1700–1965

Period in Years	Date of Current Ideal Crest	Period in Years	Date of Current Ideal Crest	Period in Years	Date of Current Ideal Crest
204.615	2096.89	37.731	1964.67	19.777	1977.46
123.721	2087.58	32.048	1965.46	17.973	1975.41
80.606	2014.58	27.423	1985.01	15.647	1970.53
60.455	1995.04	25.333	1976.49	14.656	1970.52
52.157	2010.87	22.22	1982.86	13.782	1969.69
45.470	1975.94	21.452	1983.13	12.401	1968.21

*Obtained by systematic period reconnaissance of sunspot numbers with alternate cycles reversed,[52] after adjustment for the 22.22-year cycle (except, of course, for the 22.22-year cycle itself).[45]

spots. At the end of the paper in which he made this allegation he goes further and states:

> During the last War, the author made very interesting observations: the appearance of large sunspots was immediately followed by increased activities on different battle fronts simultaneously. The first observation was made in the middle of June 1915 when a large group of sunspots crossed the central meridian of the sun, and when the aurora borealis were exceedingly powerful in North America and Northern Europe, and magnetic storms were exceptionally strong and interfered with telegraph work. At the time of these phenomena, the hardest and bloodiest fights of the war were being fought by Germans, Russians, Austrians, Serbians, French, and English.
>
> These observations were the author's first impulse to begin his present research work.
>
> The Russian Revolution of February and October 1917, and the Revolutions in Germany and Austria also followed an exceptionally powerful rising of sunspots.
>
> There are indications that at the time of the maximum of the number of sunspots, the number of psychomotoric excesses greatly increases. For the purpose of finding out this dependence, the author made a special research which showed that the dates of the greatest agitations in the masses coincided in time with the dates of great perturbations in the matter of the sun.
>
> These coincidences, surprising in their significance, give such an amount of probability to the whole theory, that the author thinks they justify his assiduous and painstaking study of the subject.[96]

Tchijevsky included in his paper a diagram reproduced here as Figure 5 showing "coincidence of the episodic leaps in the sunspot activity and the outbursts of revolutionary activity in the masses on the territory of Russia during the period from 1 October 1905 until 1 April 1906 (strikes and meetings; bombs and attempts; immediate repression)."[96]

The work of the Dülls, mentioned above, had to do largely with physiological concomitants of solar outbreaks, but they did correlate suicides in Berlin, 1917–1919 and 1930–1932, and in Copenhagen, Frankfort am Main, Hamburg, and Zurich, 1928–1932, with days of maximum calcium flocculi on the sun's surface with the result shown in Figure 6.

Allegations exist of electric cable failures created by magnetic storms which in turn are created by sunspots, solar flares, etc.,[103,104] but it was felt that such failures are neither economic nor sociological phenomena and hence that they are outside the scope of this paper.

DISCUSSION

The attempt to deduce cause and effect from identity of period is complicated by the fact, not generally realized, that there seem to be a multitude of rhythmic (cyclic) forces that pervade our environment, and that it is these forces—not necessarily emanations from the sun—that may cause the observed behavior. For instance, a study in depth of Tchijevsky's work shows that his Index of Mass Human Excitability has two cycles in the 11-plus-year range. One, a weaker one with a period of 11.11 years corresponding to the period of the sunspot cycle; two, a stronger one of

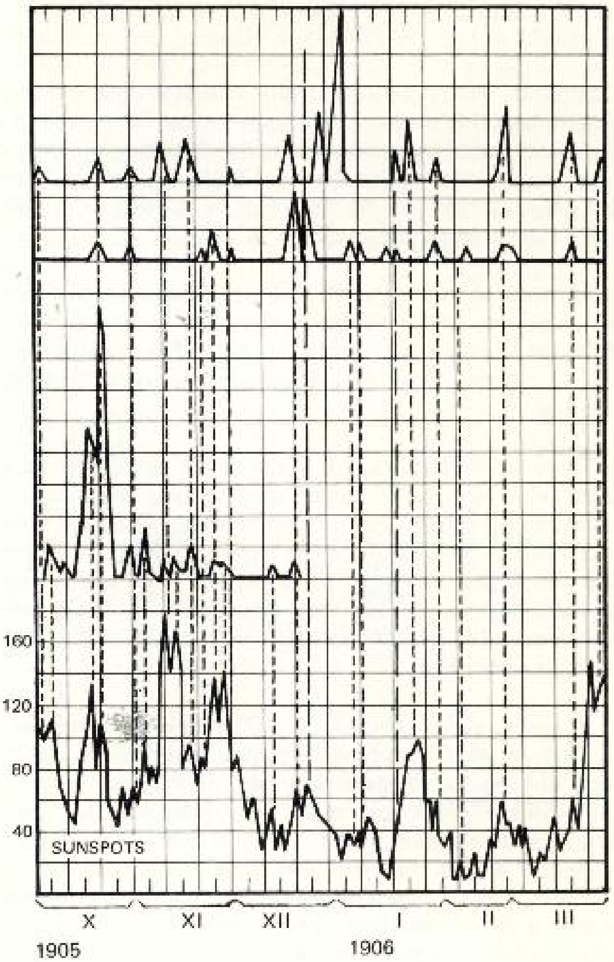

Fig. 5: SUNSPOTS AND REVOLUTION

Chart to show "coincidence of the episodic leaps in the sunspot activity and the outbursts of revolutionary activity in the masses on the territory of Russia during the period of 1 October 1905 until April 1906 (strikes and meetings; bombs and attempts; immediate repression)."

After Tchijevsky.[96]

11.15 years.[36] It is easy to see how confusion could arise unless cyclic determinations are very accurate indeed.

The statement—if it is true—that our space is prevaded by rhythmic forces of various periods is probably the most important contribution of this paper. It casts doubt upon all allegations of a solar cause of terrestrial cycles when these allegations are based merely on identity or approximate identity of period. This is true whether the allegations pertain to geophysical, physicochemical, climatological, biological, physiological, medical, economic, or sociological phenomena.

Perhaps sometime in the future we should have a con-

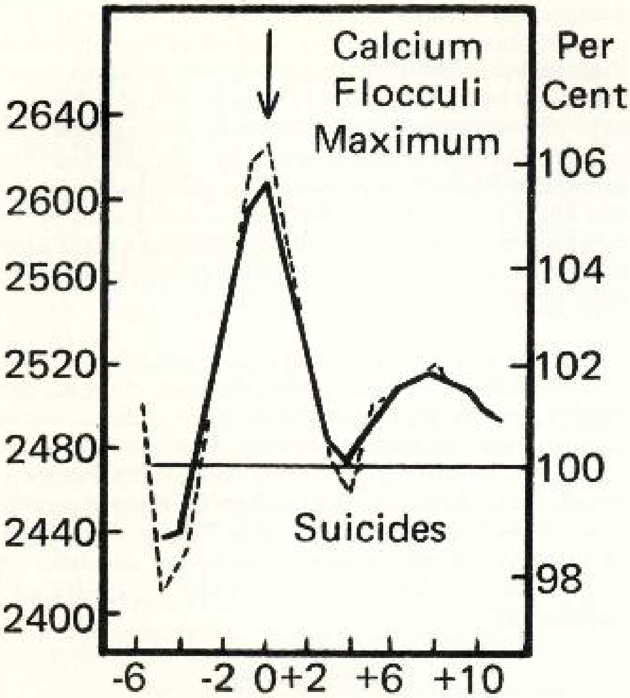

Fig. 6: SUNSPOTS AND SUICIDES

Suicides compared with heavy concentrations of calcium flocculi on the sun's surface. Suicides in Berlin, 1917–1919, 1930–1932; Copenhagen, Frankfurt-am-Main, Hamburg, and Zurich, 1928–1932.

After Düll and Huntington.[54]

ference similar to this one, but broad enough in scope to consider all extraterrestrial–terrestrial relationships. This suggestion is made on the assumption that the origin of the unknown forces that cause so many terrestrial cycles is indeed astronomical.

Over the years one reads a great many conjectures that sunspot cycles of various periods have economic, sociological, and other repercussions. Tables 1 and 3 give these allegations for the 11-year and 22-year economic and sociological correspondences only. My observation is that in general, regardless of period, the sunspot cycles turn *after* the corresponding earthly cycles they are supposed to create, whenever dates of turn in both series have been determined. This fact is illustrated quite clearly by the Garcia-Mata–Shaffner charts shown above (Figures 3 and 4).

There are several possible explanations for this apparent anomaly. First, we have the one suggested by Garcia-Mata and Shaffner themselves, namely that it is the rate of change of sunspot numbers rather than the actual number of spots that is the causative factor. Second, we might conjecture that whatever it is that causes the terrestrial behavior is the direct result of whatever it is that causes the sunspots–only, that the response of the sun takes longer. Third, we might evoke the principle of latitudinal passage. Insofar as the matter has been studied, it has been found that, on earth, cycles of the same period crest later and later as found from either pole, closer and closer to the equator.[106,107] In this they correspond to the behavior of sunspots which, at the beginning of a new cycle, appear at about 40° North and South Latitude. Then, as the cycle progresses, they occur closer and closer to the equator in the well-known butterfly pattern illustrated in Figure 7. On earth the passage, pole to equator, takes about 70% of the period of the cycle.[107] Thus, a 10-year cycle cresting ideally at the North Pole on January 1, 1960 would, if found in some other phenomenon at North Latitude 45° crest ideally 3 1/2 years later at mid-1963 (45/90 of 70% of 10.00 years). If found in some other phenomenon at the equator, it would crest ideally at January 1, 1967. As most terrestrial events with 11-year cycles lie 40° to 55° North Latitude and sunspots lie on the average at about 14° North and South Latitude, there would normally be a time lag if the two phenomena were the result of a common cause functioning in the observed way. This lag would amount to $\frac{40°\text{-}14°}{90}$ of 70% of 11.11 years to $\frac{55°\text{-}14°}{90}$ of 70% of 11.11 years. Thus, if latitudinal passage is a determining factor in the situation we might expect U.S.A. 11-year cycle crests to precede sunspot cycle crests by 2 1/4 years; British and European cycle crests to precede sunspot cycle crests by 3 1/2 years.

Another possible factor to take into account has been suggested by the late Professor DeLury, Astronomer Royal of Canada. DeLury found that precipitation in oceanic regions is greater at sunspot maxima (aquene response), while in inland regions precipitation is less at sunspot maxima (terrene response). Certain regions near the coast exhibit an intermediate or terraquene response in which aquene and terrene responses are blended in various ways.[17] C. G. Abbot, former Secretary of the Smithsonian Institution, also finds evidence of complex climatological association with sunspot

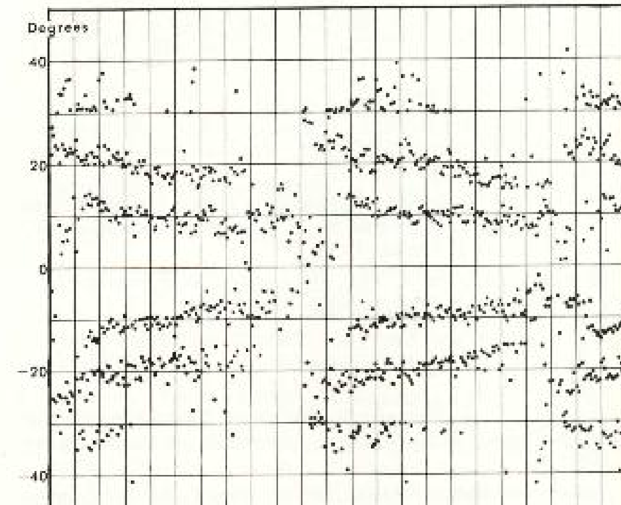

Fig. 7: SUNSPOTS BY LATITUDE, 1924–1947

Chart to show the characteristic "butterfly" or latitudinal passage behavior of sunspots.[93]

numbers.[1] Whether or not these complexities occur in solar-economic and solar-sociological correspondences is not yet known.

There is no evidence that I know of that the day-to-day variations of the surface of the sun have had economic repercussions. On the other hand, there are allegations of sociological repercussions. This whole subject of day-to-day economic and sociological relationship is one that deserves much further investigation. It needs to be put on a sound scientific basis.

If there are repercussions from individual solar events such as spots or ultraviolet emissions, it would seem reasonable to suppose that the effects would be greater at those times of the cycle when spots and emissions are generally more numerous. That is to say, economic and sociological behaviors might very well have 10-to-12-year cycles corresponding to and caused by similar cycles on the sun. There is some suggestion that they may, but it is by no means conclusive.

A PROGRAM

What should be done is this: First, each economic and sociological record where cycles in the 11-year or 22-year area have been alleged should be examined, tested, and evaluated by modern techniques. Second, we should compare with sunspot numbers (or with sunspot numbers with alternate cycles reversed, as the case may be) all such economic and sociological behaviors that withstand initial scrutiny. This comparison should be made over the same span of time. Third, we should examine, test, evaluate, and compare similarly the alleged economic and sociological behavior that might be thought to correspond to or be caused by the subsidiary solar cycles. Fourth, we should see if the irregularities of wave length of the earthly cycles correspond to those of the cycles on the sun.

In doing all of this we should keep in mind that, because of latitudinal passage or otherwise, the crests of the sunspot numbers may very well come *after* the crests of the associated economic and sociological behavior. Most particularly, we must remember that even if there is close correspondence of period, the earthly cycles—and perhaps the sunspot periods, also—may be the result of other forces. Finally, there should be extensive research relative to day-by-day association of economic and sociological phenomena with day-by-day solar disturbances.

CONCLUSION

The evidence in favor of solar-economic and solar-sociological relationship is provocative, but not yet conclusive.

REFERENCES

1 Abbot, Charles G. "Sunspots and Weather." *Smithsonian Miscellaneous Collection*, Vol. LXXXVII, No. 18. November 20, 1933.

2 Alter, Dinsmore. "A New Analysis of Sunspot Numbers." *Monthly Weather Review*, Vol. LVI, p. 399. October 1928, as quoted in H. H. Clayton. "The Sunspot Period." *Smithsonian Miscellaneous Collections*, Vol. XCVIII, No. 2, p. 16. March 27, 1939.

3 Andrews, Loring B. "The Earth, the Sun and Sunspots." *Harvard Alumni Bulletin*, Vol. XXXVIII, No. 28, pp. 928–934. May 1, 1936.

4 Archibald, E. D. "Droughts, Famines, and Forecasts in India." *Monthly Weather Review*, 1900, as quoted by I. R. Tannehill. *Drought, Its Causes and Effects*, p. 174. Princeton, New Jersey: Princeton University Press, 1947.

5 Benner, Samuel. *Benner's Prophecies of Future Ups and Downs in Prices.* 1875, Reprinted in the *Journal of Cycle Research*, Vol. VIII, No. 1. January 1959.

6 Beveridge, William H. *Full Employment in a Free Society*. New York: W. W. Norton and Co., Inc. 1945.

7 ———. "Wheat Prices and Rainfall in Western Europe." *Journal of the Royal Statistical Society*, Vol. LXXXV, London, 1922.

8 Bollinger, C. J. "The Cycle Pattern of Wheat Yields in the Great Plains." *Texas Geographic Magazine*, pp. 19–25. Spring 1947.

9 Bowerman, Walter. "Residential Mortgage Loans and Sunspot Numbers." *Popular Astronomy*, Vol. LII, No. 3. May 1944.

10 ———. "Three Correlations: A Statistical Survey." *Amer. Astr.*, December 1944-January 1945.

11 Carrington, R. C. *Observations of the Spots on the Sun from November 9th, 1853, to March 24th, 1861.* London: Williams and Norgate. 1863, as quoted in David Williams. "Business Cycle Forecasting." *Journal of Cycle Research*, Vol. VIII, No. 2, pp. 39–63. April 1959.

12 Chernosky, E. J. and M. P. Hagan. "The Zurich Sunspot Numbers and its Variations for 1700–1957." *Journal of Geophysical Research*, Vol. LXIII, No. 4, pp. 775–788. December 1958.

13 Clarke, Hyde. "Physical Economy—a Preliminary Inquiry into the physical Laws governing the Periods of Famines and Panics." *Railway Register*, London, 1847, as quoted in William S. Jevons. "Commercial Crises and Sunspots." *Nature*. Vol. XIX, pp. 33–37. November 14th, 1878, as reprinted in *Investigations in Currency and Finance*. London: MacMillan and Co. 1884; and New York: Augustus M. Kelley, Booksellers. 1964.

14 Clayton, H. H. "The Sunspot Period." *Smithsonian Miscellaneous Collections*, Vol. XCVIII, No. 2, p. 16. March 27, 1939.

15 Collins, Charles J. "Effect of Sunspot Activity on the Stock Market." *Financial Analysts Journal*, November-December 1965.

16 DeLury, Ralph E. *Matamek Conference on Biological Cycles: Full Proceedings*. p. 212, Canadian Labrador: Matamek Factory. 1932.

17 ———. "Sunspot Influences." *Journal of the Royal Astronomical Society of Canada*. March-April 1938.

18 DeTerra, Helmut. "Rainfall Periodicity in Relation to Malaria and Agriculture in the Near East." *Science*, Vol. CI, No. 2634, pp. 629–631. June 22, 1945.

19 Dewey, Edward R. "Cycles in Sunspots: The 22 1/5-Year Cycle in Relative Sunspot Numbers with Alternate Cycles Reversed, 1749–1949." *Cycles*, Vol. I, No. 1, pp. 8–11. June 1950.

20 ———. "Techniques Involved in the Determination of the Trend and the 57-Year Cycle in International Conflict." *Cycles*, Vol. II, No. 1, p. 12. January 1951.

21 ———. "The 22 1/7-Year Cycle in International War." *Cycles*, Vol. II, No. 2, pp. 43–46. February 1951.

22 ———. "Cycles in the Stock Market." *Cycles*, Vol. II, No. 3, pp. 83–88. March 1951.

23 ———. "Harmonic Analysis of Cotton Prices." *Cycles*, Vol. II, No. 4, pp. 140–142. April 1951.

24 ———. "The 11.2-Year Cycle in International War." *Cycles*, Vol. III, No. 4. pp. 135–141. April 1952.

25 ———. "Possible Cycles in Industrial Stock Prices, 1871–1950." *Cycles*, Vol. III, No. 6, pp. 166–179. June 1952.

26 ———. "Possible Cycles in Pig Iron Prices, 1784–1951." *Cycles*, Vol. III, No. 6, pp. 207–209. June 1952.

27 ———. "Manufacturing Production (Physical Production: 1810–1953)." *Cycles*, Vol. IV, No. 9, pp. 302–306. November 1953.

28 ———. "My Stock Market Forecast of 1944." *Cycles*, Vol. V, No. 6, pp. 215–226. June-July 1954.

29 ———. "The 4-Year Cycle in Sunspot Numbers Alternate Cycles Reversed 1749–1954." *Cycles*, Vol. VI, No. 6, pp. 186-187. June-July 1955.

30 ———. "The 4-Year Cycle in the Consumption of Cheese, 1867–1953." *Cycles*, Vol. VI, No. 6, pp. 188-189. June-July 1955.

31 ———. "The 22-Year Cycle in International Conflict, 599 B.C.–A.D. 1950." *Cycles*, Vol. VII, pp. 15-16. January 1956.

32 ———. "The 22-Year Cycle in Stock Prices." *Cycles*, Vol. VIII, No. 12, pp. 309–312. December 1957.

33 ———. "The 17-Week Cycle in Industrial Stock Prices–Continued." *Cycles*, Vol. IX, No. 10, pp. 263–265. October 1958.

34 ———. "Two Cycles and Trend in Patents Issued in U.S.A." *Cycles*, Vol. IX, No. 12, pp. 317–321. December 1958.

35 ———. "The 17-Week Cycle in Industrial Stocks." *Cycles*, Vol. X, No. 11, pp. 247-248. November 1959.

36 ———. "Correspondence Between Tchijevsky's Index of Mass Human Excitability and Sunspot Maxima 500 B.C.–A.D. 1922." *Journal of Cycle Research*, Vol. IX, No. 1. January 1960.

37 ———. "The 17.166-Week Cycle in the Dow-Jones Industrial Stock Prices Averages January 9, 1897–February 13, 1960." *Journal of Cycle Research*, Vol. IX, No. 3, pp. 87–116. July 1960.

38 ———. "The 17-Week Cycle in Stocks." *Cycles*, Vol. XI, No. 7, pp. 152-153. July 1960.

39 ———. "17-Week Cycle Found in Sunspots 1954–1960." *Cycles*, Vol. XI, No. 11, pp. 244-245. November 1960.

40 ———. "The 42-Year Cycle in Cotton Prices." *Cycles*, Vol. XIV, No. 5, pp. 125–127. May 1963.

41 ———. "The 42-Year Cycle in Tree-Rings." *Cycles*, Vol. XIV, No. 5, pp. 129–132. May 1963.

42 ———. "The 42-Year Cycle in Sunspot Numbers." *Cycles*, Vol. XIV, No. 6, pp. 145–147. June 1963.

43 ———. "Identity of Period." *Cycles*, Vol. XVII, No. 3, pp. 61–65. March 1966.

44 ———. "The Length of the So-Called 11-Year Cycle in Sunspot Numbers 1527–1966." *Cycles*, Vol. XVII, No. 10, p. 218. October 1966.

45 ———. "The 22-Year Cycle in Sunspot Numbers, Alternate Cycles Reversed." *Cycles*, Vol. XVII, No. 10, pp. 221–225. October 1966.

46 ———. "Reconnaissance for Secondary Cycles in Sunspot Numbers, Alternate Cycles Reversed." *Cycles*, Vol. XVII, No. 11, pp. 243–247. November 1966.

47 ———. "Systematic Reconnaissance of Cycles in War." *Cycles*, Vol. XVIII, No. 1, pp. 13–17. January 1967.

48 ———. "A Survey of Post Office Revenues." *Cycles*, Vol. XVIII, No. 3, pp. 64–66. March 1967.

49 ———. "The Case for Cycles." *Cycles*, Vol. XVIII, No. 7, July 1967.

50 ———. "Summary of Nine-Year to Ten-Year Cycles." *Cycles*, Vol. XVIII, No. 12. December 1967.

51 ———. "Solar and Economic Relationships, Continued 1934–1965." Unpublished Research 1968.

52 ———. "The Key to Sunspot-Planetary Relationships." To be published, 1968.

53 Douglass, A. E. *A Study of Cycles.* p. 129. Washington, D.C.: Carnegie Institution of Washington. 1936, as quoted in H. H. Clayton. "The Sunspot Period." *Smithsonian Miscellaneous Collections*, Vol. XCVIII, No. 2, p. 16. March 27, 1939.

54 Düll, Bernhard and Traute Düll. "Erd-und Sonnenphysikalische Vorgange in ihrer Bedeutung fur Krankheits-und Todauslosung." *Nosokomeion (Quart. Hospital Rev.)* Stuttgart. p. 108. 1938, as quoted by Ellsworth Huntington. *Mainsprings of Civilization.* pp. 518–522, New York: New American Library. 1945.

55 Garcia-Mata, Carlos and Felix I. Shaffner. "Solar and Economic Relationships, a Preliminary Report." *Quarterly Journal of Economics*, Vol. XLIX, November 1934. Reprinted as *Foundation Reprint No. 10.* Riverside, Connecticut: Foundation for the Study of Cycles. 1949.

56 Hanan, A., as quoted by Josef Hrase. "Cycles Economiques en Tchecoslovaquie." Societe Belge d'Etudes & d'Expansion No. 100.65. 1938.

57 Herschel, Sir William F. "Observations tending to investigate the Nature of the Sun, in order to find the Causes or Symptoms of its variable Emissions of Light and Heat, with Remarks on the Use that may possible be drawn from Solar Observations." *Philosophical Transactions of the Royal Society of London*, Vol. XCI, pp. 265–318. April 16, 1801.

58 Horner, S. L. "Tchijevsky's Index of Mass Human Excitability 500 B.C.–A.D. 1922." *Journal of Cycle Research*, Vol. IX, No. 1, p. 23. January 1960.

59 Hunter, W. W. as quoted in Balfour Stewart. "Suspected Relations Between the Sun and Earth." *Nature*, p. 45. May 17, 1877.

60 Huntington, Ellsworth. *World-Power and Evolution.* p. 29. New Haven: 1920, as quoted by Carlos Garcia-Mata and Felix I. Shaffner. "Solar and Economic Relationships, a Preliminary Report." *Quarterly Journal of Economics*, Vol. XLIX, November 1934. Reprinted as Foundation Reprint No. 10. Riverside, Connecticut: Foundation for the Study of Cycles. 1949.

61 Hutner, Simeon. "Business Activity's Complex Cyclical Pattern: The Three Component Forces, A Composite Curve Derived Therefrom, and a Composite Obtained by Substituting a Sunspot Curve for the 11.14-Year Cycle." *The Annalist.* June 13, 1940.

62 Jeula, Henry and Mr. Meldum. as quoted in Balfour Stewart. "Famines and Shipwrecks." *Nature*, pp. 461-462. September 27, 1877.

63 Jevons, William Stanley. "The Solar Period and the Price of Corn." A paper read at the meeting of the British Association, at Bristol in 1875, as quoted in *Investigations in Currency and Finance.* London: MacMillan and Co. 1884, as reprinted in New York: Augustus M. Kelley. 1964.

64 ———. "The Periodicity of Commercial Crises and Its Physical Explanation." A paper read at the meeting of the British Association, in Dublin on August 19th, 1878, as quoted in *Investigations in Currency and Finance.* London: MacMillan and Co. 1884, as reprinted in New York: Augustus M. Kelley. 1964.

65 Johnson, L. P. V. "Relation of Sunspot Periodicity to Precipitation, Temperature, and Crop Yields in Alberta and Saskatchewan." *Canadian Journal of Research*, Vol. XVIII, pp. 79–91. March 1940.

66 Kendall, M. G. "On the Analysis of Oscillatory Time Series." A paper read before the Royal Statistical Society on January

17, 1945, and published in the *Journal of The Royal Statistical Society*. Vol. CVIII, pp. 93–141.

67 King, Willford I. *The Causes of Economic Fluctuations: Possibilities of Anticipation and Control.* p. 230. New York: The Ronald Press Co., 1938.

68 Kuznets, Simon. *Secular Movements in Production and Prices.* p. 94. A Hart, Schaffner and Marx Prize Essay. Boston: Houghton Mifflin Co. 1930. See also: "Is the Long Cycle Why We Don't Grow?" *Business Week.* No. 1746, pp. 78–80. February 16. 1963.

69 Lane, G. T. "Cycles in Sunspot Numbers." *Journal of Cycle Research,* Vol. III, No. 1. Winter 1954.

70 Long, Clarence D. Jr. *Building Cycles and the Theory of Investment.* pp. 102–107. Princeton: Princeton University Press. 1940.

71 McGrath, Thomas Orrin. *Anticipating the Future.* p. 58. Los Angeles: Thomas Orrin McGrath. 1936.

72 Morris, William W. "Sunspot and Crop Production." Unpublished Manuscript, pp. 1–8. 1948.

73 Musham, Harry A. "Expert Peers into Lake and Sees Bad Crops." *Chicago Daily Tribune,* Part 1, p. 10 F, November 12, 1951. See also: Musham, Harry A. "The Practical Application of the Rhythmic Fluctuation of the Levels of the Great Lakes." *Journal of the Western Society of Engineers,* Vol. XLVII, No. 4, pp. 185–196. December 1943.

74 Nishioka, Hideo. *Long Warm Weather Cycle Ahead.* p. 6. New York: International Economic Research Bureau. 1957.

75 Pinkham, Charles H. "Dollar Sales of a Drug Co." *Cycles,* Vol. XVI, No. 5, pp. 110–113. May 1965.

76 ———. "Letters." *Cycles,* Vol. XVII, No. 7, p. 167. July 1966.

77 ———. As quoted in Edward R. Dewey. "The 22-Year Cycle in Advertising Efficiency of Lydia E. Pinkham Medicine Co." *Cycles,* Vol. II, No. 6, pp. 223-224. June 1951.

78 ———. As reported in Edward R. Dewey. "Construction of the Charles H. Pinkham Index of Advertising Efficiency." *Cycles,* Vol. II, No. 6, p. 234. June 1951.

79 Pogson, N. R. *Indian Famine Bluebook-1881,* as quoted in David Williams. "Business Cycle Forecasting." *Journal of Cycle Research,* Vol. VIII, No. 2, p. 46. April 1959.

80 Pokrowski, G. I. *Science,* Vol. LXVII, No. 397. 1928, as quoted in Ralph DeLury. "Sunspot Influences." *The Journal of Astronomical Society of Canada,* p. 48. March-April 1938.

81 Schumpeter, Joseph A. *Business Cycles, Vol. II,* p. 469. New York: McGraw-Hill Book Co., Inc. 1939.

82 Schuster, Sir Arthur. "On the Periodicities of Sunspots." *Philosophical Transactions of the Royal Society of London.* Vol. CCVI A, pp. 69–100. February 8, 1906.

83 Shaw, Sir William Napier. *Manual of Meteorology.* Cambridge: Cambridge University Press. 1928, Tabulation reprinted in *Cycles,* Vol. XV, No. 4, p. 83. April 1964.

84 Shirk, Gertrude. "The 17-Week Cycle in Industrial Stock Prices." *Cycles,* Vol. IX, No. 7, pp. 149–154. July 1958.

85 ———. "The 11.2-Year Cycle in Pig Iron Production." *Cycles,* Vol. X, No. 3, pp. 57–59. March 1959.

86 ———. "The Stock Market Projection: Audit of the 11-Year Cycle." *Cycles,* Vol. X, No. 8, pp. 173–175. August 1959.

87 ———. "The 17-Week Cycle in Stocks: How Good is It?" *Cycles,* Vol. XI, No. 8, pp. 174–177. August 1960.

88 ———. "The 17-Week Cycle." *Cycles,* Vol. XII, No. 9, p. 237. September 1961.

89 Shove, D. Justin. "Sunspot Maxima Since 649 B.C." *Journal of The British Astronomical Association,* Vol. LXVI, No. 2, pp. 59–61. 1956, as reprinted in the *Journal of Cycle Research,* Vol. V, No. 4, p. 111. October 1956.

90 Silberling, N. J. *The Dynamics of Business.* p. 562. New York: McGraw-Hill Book Company. 1943.

91 Smith, Edgar L. "Realistic View of 1950 Needed for Investor's Safety." *Brookmire Pioneer,* Vol. XXXVII, No. P8. December 15, 1949, as quoted in Hugh P. King. "Cycles in Financial Data." *Journal of Cycle Research,* Vol. VII, No. 1, pp. 3–40. January 1958.

92 Stetson, Harlan T. *Sunspots and Their Effects.* p. 71. York, Pennsylvania: Whittlesey House. 1937.

93 ———. *Sunspots in Action.* New York: The Ronald Press Company. 1947. See also: Dewey, Edward R. "Illustrations of Latitudinal Passage." *Journal of Cycle Research,* Vol. IX, No. 4, p. 172. October 1960 and Dewey, Edward R. "Cycles Timing Varies with Latitude." *Cycles,* Vol. IX, No. 11, p. 291. November 1958.

94 Stumpff, K. (1928), as quoted by H. Helm Clayton. "The Sunspot Period." *Smithsonian Miscellaneous Collections,* Vol. XCVIII, No. 2, p. 16. March 27, 1939.

95 Szatrowski, Zenon. "The Pattern of Changing Cycles in United States Steel Corporation Earnings per Share of Common Stock." *Economic Cycle Studies.* March 3, 1949.

96 Tchijevsky, A. L. "Physical Factors of the Historical Process." A paper read at the Annual Meeting of the American Meteorological Society, Philadelphia, Pennsylvania, December 30, 1926, as condensed and translated by Vladimir P. DeSmitt, and reprinted in *Journal of Cycle Research,* Vol. V, No. 4. October 1956.

97 U. S. Department of Agriculture. "Prices of Farm Products Graphically Presented." *U. S. D. A.–Yearbook of Agriculture, 1930.* p. 586. Washington, D. C. 1930, as quoted by Hadorn, Erwin T. *Cycles in Economic Data: A Digest,* Riverside, Connecticut: Foundation for the Study of Cycles. 1949.

98 U. S. Government Bureau of Standards. "Relative Sunspot Numbers." Boulder, Colorado, monthly releases.

99 Vaux, James E., Jr. "Results of General Program Analysis." Unpublished Research. March–June 1967.

100 Wardwell, Charles A. R. *An Investigation of Economic Data for Major Cycles.* Philadelphia: Westbrook Publishing Company. 1927. p. 76, as quoted in Hugh R. King. "Cycles in Financial Data." *Journal of Cycle Research,* Vol. VII, No. 1, pp. 34–39. January 1958.

101 Williams, David. "Business Cycle Forecasting." *Journal of Cycle Research,* Vol. VIII, No. 2, pp. 39–63. April 1959.

102 ———. "Sunspot Cycle Correlations." *Cycles,* Vol. XIII, No. 4, pp. 96-97. April 1962.

103 ———. "Predicting Power System Disturbances." A paper given to Power Group IEEE Group. Cleveland, Ohio. March 26, 1968.

104 ———. "Cosmic Influences on Man." A paper given at Bennington College, Bennington, Vermont. April 9, 1968.

105 Wilson, Louise L. *Catalogue of Cycles: Part I–Economics.* Pittsburgh: Foundation for the Study of Cycles. 1964.

106 Wing, Leonard W. "Global Pattern of 4.22-Year Cycle in Temperature." *Journal of Cycle Research,* Vol. III, No. 3, pp. 55–83. Summer 1954.

107 ———. "Latitudinal Passage Behavior." *Journal of Cycle Research,* Vol. VII, No. 3, pp. 67–78. July 1958.

108 Woytinsky, W. S. and E. S. Woytinsky. *Lessons of Recessions.* Washington, D. C.: Public Affairs Institute. 1959.

109 Wylie, Charles Clayton. *The Solar Cycle in Temperature and Crops.* Ames, Iowa: University of Iowa, 1948, as reported by William W. Morris. *Sunspot and Crop Production.* Unpublished Manuscript. 1948.

110 Yule, G. Udny. "On a Method of Investigating Periodicities in Disturbed Series with Special Reference to Wolfer's Sunspot Numbers." *Philosophical Transactions of Royal Society of London,* Vol. CCXXVI A, pp. 267–298. February 17, 1927.