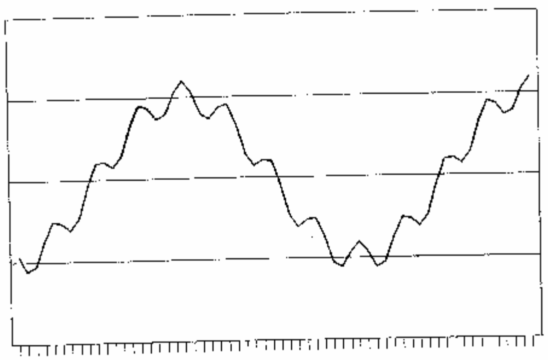

FIG. 2. Synthesis of a short cycle and a longer cycle, which served as the trendline for the shorter cycle.

in spectral analysis, but the analyst should experiment. This technique tends to create ragged data series, which might need additional smoothing. Also, one data point will be lost at the beginning and one at the end of the data. First differences can be easily computed with the CAP III program — especially in spectral analysis — or in a spreadsheet.

3. Cycle Subtraction

This method of detrending cannot easily be done without a computer, although the principle is simple. Any cycle with a length that is approximately the length of the data series can be subtracted from the series. In most cases, this will successfully detrend the data. The Spectral Analysis program in CAP III can be used to easily identify the cycle to be subtracted.

4. Departures

Departures are probably the best way to completely detrend data. A centered moving average is taken of the original time series. This moving average is then subtracted from the original data. The result is a new time series composed of the departures, or residuals of the moving average.

The data will be completely detrended, but only in regard to the length of the moving average. For example, a 41-month departure will detrend the data only for cycles within about 10-15% of the length of the moving average. Therefore, only cycles from 35 to 47 months should be sought with this departure series. Thus, the analyst will have to do many different analyses in order to conduct a complete analysis on any one time series. This is why so many analysts ignore this method.

Prior to taking departures, all other transformations — such as logs and simple moving averages — should be made to smooth out randoms. Then a spectral analysis, or a visual scan with a cycle finder such as the Ehrlich Cycle finder, can find the important cycles to be tested. From this point, moving-average departure files for the various cycle lengths should be created and the testing begun. The Foundation's CAP III program is specifically designed to create departure files and then analyze the data.

Adding Back the Trend

Once the data has been detrended and the cycle analysis is complete, the trend should be added back into the data. This can be done in one of several ways:

1. Take antilogs of the log data and convert the data back to the number represented by the logarithm.

2. Add the moving average used in the departures back into the original data.

3. Find a long cycle that approximates the trend and sum it with the cycles. (This is one of the best methods.)

4. Compute the long-term trend and add this trend to the cycle projection.

When adding trend to cycles, be cautious. The historical trend can change, and counter-trend corrections or rallies often can distort the long-term trend. Therefore, be very careful. Examine the important long cycles. If they are near an important turn, the trend should be added only with great care.

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The Effect of Sunspot Activity on the Stock Market

by Charles J. Collins

Solar phenomena have been a source of scientific interest and investigation since Sir William Herschel, in 1801, found a correlation between sunspot activity and terrestrial phenomena. Herschel observed that periods of low sunspot activity correspond with sparse crops, while bountiful sunspot activity had a like effect on agricultural yield. On the basis of his studies, Herschel then correctly predicted, during a drought year, a number of ensuing years of agricultural plenty for Britain.

Subsequently, the periodicity of the sunspot cycle was announced, and Schwabe, in 1844, estimated the average length to be approximately ten years. Further observations and investigations have disclosed other facets — such as the relation between sunspot phenomena and atmospheric conditions on earth, and the electromagnetic nature of sunspots and its disturbance of the earth's magnetic field, with consequent interference with radio communication.

Modern science is giving considerable attention to solar phenomena in relation to disruption of the earth's magnetic field, to human health, and to weather, including rainfall, temperature, and cyclone frequency. The security analyst's interest is more directly concerned with the effect of solar phenomena on business, and on speculation as evidenced by the ebb and flow of prices over our stock exchanges. Here we must turn to W. Stanley Jevons as the first to give prominence to a correspondence between sunspot variation and the business cycle.

Before consulting Jevons and others who have followed up Jevons' initial hypothesis, it might be well to have some knowledge of sunspot activity itself. Table 1 lists data covering the 19 cycles that have taken place since Rudolph Wolf, using old observations of the sun from 1749 to 1849, began publishing the figures in the last named year. These data have been released since 1849 by the astronomers of the Zurich Observatory (Wolf, Wolfer, Brunner, and Waldmeier) in the Observatory's *Astronomische Mitteilungen*.

The observations are taken daily, and are averaged for the month as well as the year. The observed numbers, which are more immediately available month by month, are subsequently smoothed. It is the observed rather than the smoothed count that is given in Table 1. Of minor interest, but accounting for the fractional values, the monthly sunspot number is the mean of the daily values of the relative sunspot number, R. The relative sunspot number is $R = K(10g + s)$ where g is the number of sunspot groups and s is the total number of distinct spots. K is a scale factor that depends on the observer and is intended to effect the conversion to the

TABLE 1.

THE LAST 19 SUNSPOT CYCLES (Based on observed Wolf Numbers)

No.	Beginning Count	Date	Peak Count	Date	Closing Count	Date	Cycle Length**
1	0.0	6-1755	107.2	5-1761	3.0	6-1766	11.0
2	3.0	6-1766	158.2	10-1769	0.0	2-1775	8.8
3	0.0	2-1775	238.9	5-1778	6.0	7-1784	9.5
4	6.0	7-1784	174.0	12-1787	0.0	6-1798	13.11
5	0.0	6-1798	62.3	10-1804	0.0	8-1810	12.2
6	0.0	8-1810	73.7	3-1816	0.0	4-1823	12.8
7	0.0	4-1823	107.1	4-1830	1.0	6-1833	10.2
8	1.0	6-1833	206.2	12-1836	3.5	2-1843	9.8
9	3.5	2-1843	159.9	12-1848	0.0	5-1856	13.3
10	0.0	5-1856	116.7	7-1860	0.0	1-1867	10.8
11	0.0	1-1867	176.0	5-1870	0.0	3-1879	12.2
12	0.0	3-1879	91.5	1-1884	0.2	11-1889	10.8
13	0.2	11-1889	129.2	8-1893	0.0	4-1902	12.5
14	0.0	4-1902	108.2	2-1907	0.0	6-1913	11.2
15	0.0	6-1913	154.5	8-1917	0.5	8-1923	10.2
16	0.5	8-1923	98.0	7-1928	0.2	8-1933	10.0
17	0.2	8-1933	165.3	7-1938	0.3	4-1944	10.8
18	0.3	4-1944	201.3	5-1947	0.2	1-1954	9.9
19	0.2	1-1954	253.8	10-1957	3.4*	7-1964*	

** Low point to date (February 1965)*

*** Fractions are in months, or twelfths, rather than tenths.*

In order to obtain cycle duration, this series (unlike Tables 2, 3, and 4) uses monthly rather than yearly means of the sunspot count.

Charles J. Collins is the well-known financial analyst who brought R.N. Elliott and the Elliott Wave to the attention of the public in the 1930s.

scale originated by Wolf. A sunspot cycle is often measured from low point to low point, or minimum to minimum.

It will be seen from Table 1 that the sunspot count recedes, once a peak has been passed, to a figure of under ten to zero. Peaks, on the other hand, have varied from as low as 62.3 to as high as 253.8, this latter figure characterizing the cycle that is now concluding or may have concluded. Of greater interest is the cycle's duration, running from around nine to 14 years. The average length of the 18 completed cycles listed in Table 1 is 11 years—and, if extremes be struck out to obtain modal length, the length varies, but in the mean it is 10 years 7 months.

A rather interesting feature of sunspots is their behavior, as discussed in a paper by Drs. Garcia-Mata and Shaffner, to which study later reference will be made. At the beginning of the cycle, the spots are distributed in two belts, between 20° and 40° latitude on both sides of the sun's equator. As the cycle progresses, they appear each year nearer the equator, and at the end of the period are centered around the equator at about 60° on either side.

Then the new cycle is suddenly announced by new spots (with reversed magnetic polarity) at about 40° latitude and, as the spots of the old cycle that are near the equator disappear, the two belts of the new cycle are again formed in the greater latitudes. Because of the reversal of magnetic polarity with each successive sunspot cycle—that is, from the southern solar hemisphere to the northern solar hemisphere, then vice versa—some investigators feel that the complete solar cycle is around twenty-two and one-quarter years in length, or a combination of two successive cycles as given in Table 1.

Studying industrial crises between 1721 and 1867, Jevons obtained an average of 10.43 years between them. He could see no reason why the human mind "in its own spontaneous action" should select so exact a period to vary in—and, having noted a somewhat similar interval for the sunspot cycle, he attributed the industrial waves to some outside, or extraterrestrial, phenomena related to the solar period.

Jevons reasoned that variation in the number of sunspots produced corresponding variation in crops, and that, through this channel, business cycles were brought about. Later studies, particularly those of Dr. C.G. Abbot of the Smithsonian Institution, have demonstrated that variations of the sun's emission of radiation, which variation is tied in with sunspot activity, are associated with weather changes. Weather, in turn, affects crops.

Dr. Warren M. Persons, however, following detailed statistical analysis, demonstrated, so far as the United States was concerned, that the correlation between physical crop production and total values is almost nil. Under the law of supply and demand, redundant crops lower prices, short crops raise them. Thus, yield and total value are not synonymous. Persons' findings tend to vitiate Jevon's view as to variation in agricultural yield causing similar variation in general industrial activity; but Jevon's question still remains as to why these periodic variations in industrial phenomena seem to correspond with the solar cycle.

That there is a correspondence between solar activity and general industrial production has been demonstrated by Garcia-Mata and Shaffner [*Quarterly Journal of Economics*, November 1934]. Pointing out that Persons' index of industrial production of manufacturers in the United States, smoothed for year-to-year fluctuations, showed that five cycles appeared clearly between the actual bottoms of 1876 and 1932, making an average of 11.2 years, they also found that the average of the last five sunspot cycles was 11.16 years.

They further indicated that a graphic correlation of both the sunspot and business curves should be *inverse*—that is, an increase in sunspots correlates with a decrease in business. A graphic comparison with the solar curve inverted showed that, to obtain a high correlation through agreements of tops and bottoms, a lag of three or more years was required—that is, the inverted solar curve plotted three or more years ahead of the business curve.

Garcia-Mata and Shaffner made various other tests of solar phenomena and business—such as comparisons of business activity with the yearly changes of the areas of solar faculae, and also with the effect of sunspots according to the latitude from which they emanated—and, in each instance, found a correspondence. One graph comparing their sunspot studies with secular swings in industrial production is shown in Figure 1.

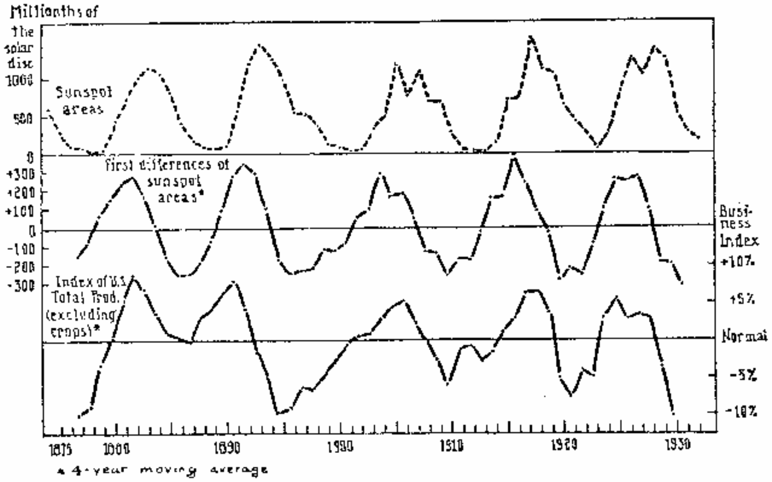

FIG. 1. Comparison of sunspot studies with secular swings in industrial production. By Garcia-Mata and Shaffner.

One particularly interesting aspect of the Garcia-Mata/Shaffner comparisons of yearly changes of the total area of solar faculae with the index of physical production (excluding crops) in the United States over the 1875 to 1932 interval was the appearance of two short, though sharp, business panics (those of 1903-04 and 1913-14) that showed no relationship to the solar curve.

The solar curve, at the time, called for normal to above-normal business (See Figure 2). These periods were preceded by two great volcanic eruptions—Mount Pele in Antilles in 1902, and Katmai in Alaska 1912—each of which cast into the atmosphere thousands of tons of volcanic dust. Distributed within a few months around the earth by atmospheric winds, the dust remained aloft for a number of years, forming a sort of envelope around the globe and reducing considerably, on earth's surface, the radiation that was being produced by the sun. In other words, the normal influence on earth of solar phenomena for the years in question was mitigated by a screen of volcanic ash.

Their findings were summarized by Garcia-Mata and Shaffner as follows:

> Summing up, we can say that, *from a statistical point of view*, there appears to be a clear correlation between the major cycles of nonagricultural business activity in the United States and the solar cycle of 11+ years; but, so far, we have been unable to determine whether the best correlation is with the curve of the total amount of the solar disturbances with a lag of several years, or with the cycle formed by the yearly increase or decrease in disturbances in the solar surface (spots, faculae, etc.), or whether the existence or absence of spots pointing directly to the earth in the solar central zone, or through some other feature of the solar cycle. *From a logical point of view*, all of the evidence accumulated seems to show that it is hardly possible to believe that the relations revealed are wholly accidental.

Someone has stated that, if a delivery truck is seen to arrive every morning between nine and ten at a certain corner on Mondays for 26 consecutive weeks, there can be no assurance that it will appear again on the morning of the 27th week. But if the observer, seeking the cause of this phenomenon, finds that this is the delivery of a certain chemical needed weekly to operate a machine in a plant that runs year-in and year-out, he may then predict for the 27th Monday with some degree of certitude.

In seeking a working hypothesis for the statistical relationship between solar activity and business, Garcia-Mata and Shaffner referred to one of the many competing theories of business fluctuations—the one that attributes such changes to psychological cause. Professor Pigou of Cambridge

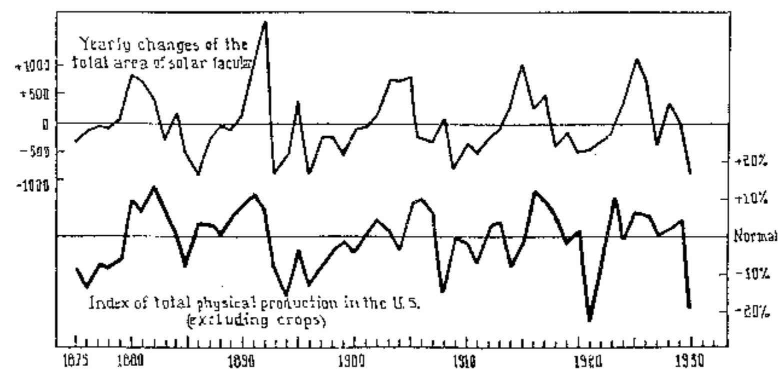

FIG. 2. Yearly changes of the total area of solar faculae compared with the index of physical production (excluding crops) in the United States, 1875-1932.

has been one of the leading more recent protagonists of this theory, which is to the effect that a cumulative error of optimism on the part of the interdependent business community leads to over-expansion, or boom. As awareness of the excess occurs, a cumulative error of pessimism develops and overcontraction, or recession, ensues. Thus the psychological cycle repeats, ad infinitum.

To reconcile the psychological theory of the business cycle with their findings, Garcia-Mata and Shaffner added, "We need, then, to assume that the variations of solar activity affect directly, or through some terrestrial mechanism, the psychological reactions of human beings."

Among the propositions set forth in demonstration of this relationship were certain harmonious biological phenomena, such as the death rate cycle, the birth rate cycle as predetermined by the curve of conception, and sudden changes in the course of chronic illness. As possible mechanisms of the relationship, reference was made to the wide variations in ultraviolet light received by the earth from the sun, and the known effect of solar variation on the magnetic activity of the earth and an ensuing direct electrical effect upon human beings.

If solar phenomena have a direct or indirect influence on human psychology, it then is logical to assume that the solar-human relationship will show up in the fluctuations in stock prices. While changes in human psychology from pessimism to optimism, and the reverse, will be registered in the business curve, the change cannot be so sudden or so violent as in the stock market. This is because business commitments often take months to be processed, or consummated physically, while stock market commitments are registered fully in the price structure on the day they are made. In this connection, no one who lived through the September-November 1929 break in the American stock market will ever question the dramatic way in which reversed psychology can affect prices.

In the aforementioned monograph on solar and economic relationships, Garcia-Mata and Shaffner dealt with the stock market, but only with respect to turning points in the 1929 and the 1932 periods. Throughout these two hectic intervals — which included the turn-about to major decline and the turn-about to major advance — a high degree of correlation was demonstrated between solar phenomena and New York Stock Exchange prices.

Subsequent to the Garcia-Mata/Shaffner study, Edgar Lawrence Smith has been one of the more prominent protagonists in the further development of sunspot-economic theory. Bearing in mind, however, that sunspot activity as a causative agent affecting business and production cycles is still a highly controversial subject among scientists, it might be well to revert, for a moment, to Jevons, whose inquiring mind more than a century ago gave first prominence to the matter.

William Stanley Jevons, a prolific and brilliant writer, was born in Liverpool in 1835 and, at the time of his death in 1882, occupied the foremost position in England, both as a logician and as an economist. His *Elementary Lessons in Logic* became the most widely read basic textbook in logic in the English language. Other of his principal works were the *Theory of Political Economy* and the *Principles of Science*.

Jevons' speculations on the connection between commercial crises and the incidence of sunspot activity are found in his work, *Investigations in Currency and Finance*. It is from the position taken by Jevons in this particular theoretical digression that the matter has been further developed in the writings of others.

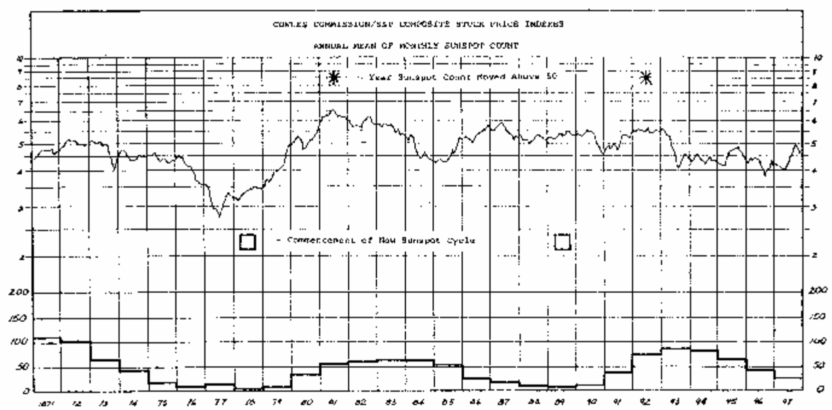

FIG. 3. Stock market activity compared with sunspots, 1871-1897. Squares designate the beginning (low point) of each new sunspot cycle; asterisks (*) indicate the year in each new cycle that the mean sunspot count first moved above 50.

Edgar Lawrence Smith, whose *Common Stocks as Long Term Investments* (1924) has been one of the most widely read books in the investment field, has devoted considerable attention to solar phenomena and stock market fluctuation. Smith's studies are given in detail in two books, *Tides in the Affairs of Men* (1939) and *Common Stocks and Business Cycles* (1959).

Smith points out that nearly all observers from Jevons on have recognized the element of mass psychology as a large factor in the upsurge of business and expansion of credit and prices, until they reach extremes from which they fall, sometimes precipitously, in an atmosphere of panic. He adds, however, that one school of thought held that it was the movement of business and prices that caused the feeling of optimism or pessimism, while another school felt that it was change in the "public temper" that initiated the upturns or downturns.

At this point, Smith cites a number of authorities who, as had he, observed that, in each decade in its like years (as 1905, 1915, 1925, 1935, 1945, 1955, for illustration), many commercial phases were almost alike. He goes on to mention Dr. William F. Petersen's investigations, given in his books, *The Patient and the Weather* and *Man, Weather, Sun*, which record in great detail the many physical and psychological changes that occur in human organisms as they coincide with changes in their immediate environment, usually recorded by the Weather Bureau.

On the basis of his own and others' observations, Smith arrived at the following solar-economic hypothesis which, he states, can only be preliminary, its final definition awaiting "cooperative study by groups conversant with the several divisions of science involved and, in all probability, [it] must await further research in each of these divisions." Smith states:

> 1. All changes in quantity, content, and angle of solar radiation (radiation is used here to include all classes of solar emanation, not merely light and heat) reaching the earth's atmosphere cause relative changes in this atmosphere, and hence in the environment of man.
>
> 2. A preponderance of these atmospheric changes are recorded proportionately in changing types of weather, over shorter or longer periods, on a worldwide basis, and are recorded in relative weather data at widely separated weather stations.
>
> 3. The activities, health, and mental outlook of populations are affected by changes in environmental conditions, and these effects are measurable in records of man's behavior — notably in certain basic economic series.
>
> 4. Because of these relationships, at different points on the earth's surface it is possible to find weather data that can be used as an index of probable human response to total environmental change.

Putting this hypothesis to the test, Smith combined rainfall and temperature readings as weather data for a clue to probable changes in mass psychology and consequent economic changes, some of which are recorded in intermittent swings in the common stock price level. In commenting on his rainfall-temperature method of measurement, Smith added:

> I have no single measurement for 'total environment' and remain uncertain as to the particular element in the environment that may have a dominating effect upon mass psychology. Is it related more closely to changing electrical stimulants, or to temperature or rainfall changes, or even to the changing content of solar radiation itself? Any or all of these may be involved, but as they are to greater or lesser extent interrelated with each other, I have made my experiments with the more easily obtainable data, i.e.,

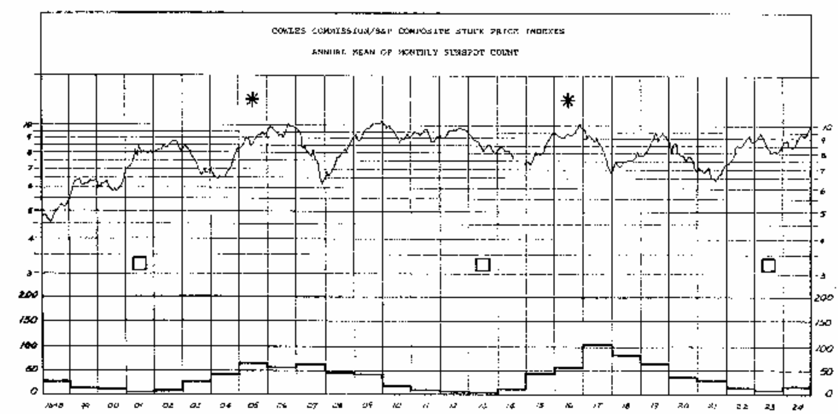

FIG. 4. Stock market activity compared with sunspots, 1898-1924. Squares designate the beginning (low point) of each new sunspot cycle; asterisks (*) indicate the year in each new cycle that the mean sunspot count first moved above 50.