Economic Cycles and Changes in the Earth's Geomagnetic Field

BY BRYAN J. WALSH

The relationship between changes in solar activity and events on earth has been the subject of much analysis and controversy since sunspots were first systematically recorded. A number of researchers have noted similarities between patterns observed in sunspot cycles and a variety of economic and financial cycles.

The scientific establishment usually denigrated such similarities as the result of either chance occurrence or poor analysis. However, despite the poor standing of this field of research, it has endured for the last fifty years.

Dewey (1968) summarized the apparent relationships he and other researchers had uncovered between solar activity and economic phenomena. He described 43 activities alleged to fluctuate with an 11-year cycle, including commodity prices, stock prices, banking activity, business activity, industrial production, and agricultural productivity. However, many of these cycles appeared to reach their maximum *prior* to the solar cycle peak to which they supposedly were responding.

Garcia-Mata and Shaffner (1934) found that solar activity as measured by sunspot number lagged U.S. manufacturing production. However, a marked correlation was noted when the rate of change in sunspot area was calculated (Figure 1).

Collins (1965) noted a relationship between rising sunspot activity and a subsequent fall in U.S. stock prices. He found that, when the mean monthly sunspot number first rose to above 50, a decline in the stock market followed. If the year in which the mean *monthly* sunspot number first exceeds 50 is substituted for the year in which the *annual* sunspot number exceeds 50, the relationship noted by Collins is enhanced. The most recent example of this phenomena occurred in October 1987, when the mean monthly sunspot number rose to 55.8—the first time it topped 50 since the cycle began in 1986.

Niemira (1990) noted the curious occurrence of recessions around the turn of a new decade. As chronicled by the National Bureau of Economic Research, recessions have occurred around the turn of a new decade 77% of the time during the past 130 years (Figure 2).

Discovery of the cause of this phenomena would improve our understanding of the role astrophysical phenomena play in economic activity, and improve our ability to forecast economic developments.

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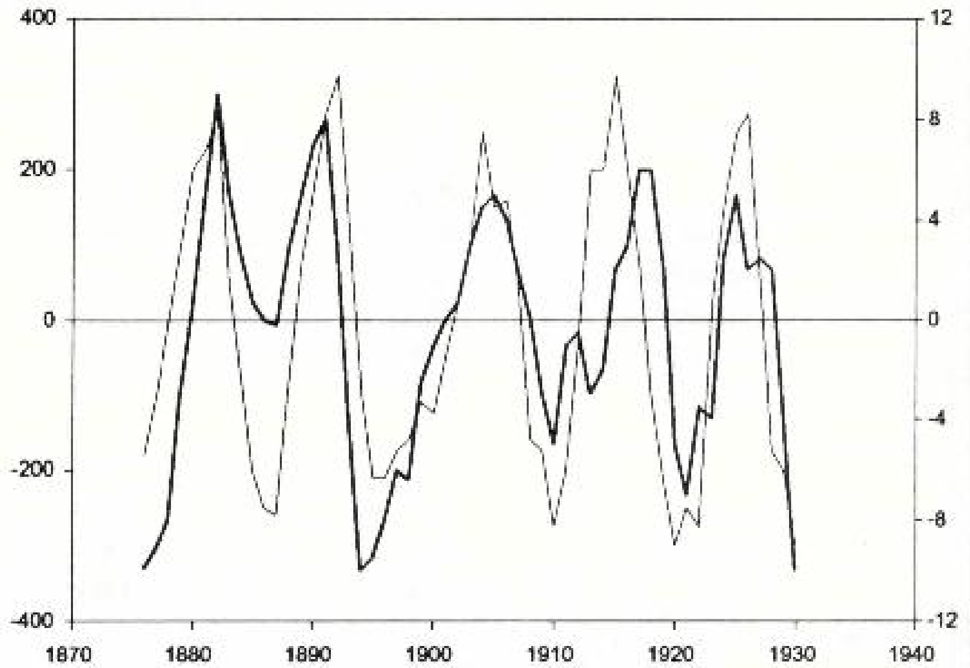

Figure 1. U.S. manufacturing production (bold, right scale), % change in index, and sunspot areas (light, left scale), first differences, 1875-1935. *After Garcia-Mata and Shaffner.*

The Geomagnetic Field

The sun's energy output fluctuates throughout the sunspot cycle as solar particulate, ultra-violet, x-ray, electron, visible light, and other portions of the solar output spectrum vary along with sunspot activity. Depending on which portion of the solar spectrum is measured, the range between maximum and minimum can vary by as much as 1000% for EUV radiation during the course of one 11-year cycle (Roble 1987). On the other hand, total luminescence seems to vary by only 0.1% during a typical solar cycle (Foukal and Lean 1991).

The flow of this energy into interplanetary space is accompanied by strong magnetic fields, which pinch back the earth's ambient magnetic field in a direction away from the sun and into the shape of an elongated tear drop. This magnetic environment is the earth's magnetosphere. Solar plasma and particulate flow (the solar wind) interact with these complex magnetic fields and can become trapped in the earth's magnetosphere.

In turn, the differential flow of ions and electrons in the magnetosphere and ionosphere form currents that seem to be the primary cause of intensity variations in earth's magnetic field. The magnitude of this effect is proportional to the square root of the solar wind dynamic pressure (Le and Russell 1993).

The net effect is to create a natural magnetic resonating cavity in which a variety of extremely low frequency (ELF) and very low frequency (VLF) electromagnetic waves are created (Al'pert 1990). A variety of acoustic and ion-cyclotronicc waves also are created (Rees 1989). Moreover, solar flares enhance the ELF and VLF radio spectrum by altering the ionospheric D-region, which improves the transmissibility of ELF and VLF electromagnetic waves.

The magnetic resonating cavity created is further modulated by lunar atmospheric gravitational effects, as well as diurnal and seasonal solar radiation effects. When combined with this modulation, the frequency distribution and amplitude of the electromagnetic fields responds to the solar cycle by producing such well known effects as the aurora and the electrojet, as well as a host of ELF and VLF effects on a variety of terrestrial systems.

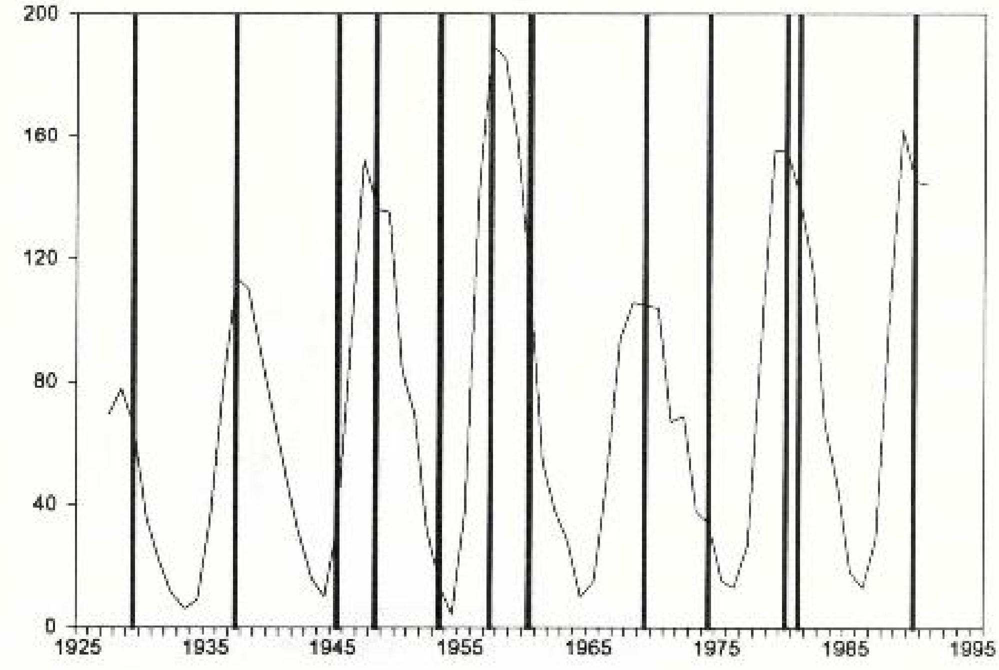

Figure 2. Mean annual sunspot number (curve, left scale) and year of recession onset (bars), 1920-1990.

To determine the net amplitude of these effects, a network of 11 recording stations located between 46° and 63° north and south was established about fifty years ago. These stations systematically measure and record various characteristics of the earth's magnetic field.

A number of magnetic variation indices are produced from these observations. The two indices most commonly used by researchers are the Kp and Ap indices. The Kp index measures the magnetic field's horizontal field component; the Ap index converts the Kp index into a linear scale that ranges from 0 to 400. The geomagnetic field amplitude as measured by the Ap index fluctuates with the solar cycle, but with significant leads and lags (Figure 3).

ELF Fields and Biological Effects

Studies of the effects of ELF and VLF electric and magnetic field on humans, animals, and *in vitro* preparations now number in the hundreds (Florig 1992). Researchers have uncovered relationships between extremely weak ELF and VLF magnetic fields and changes in a

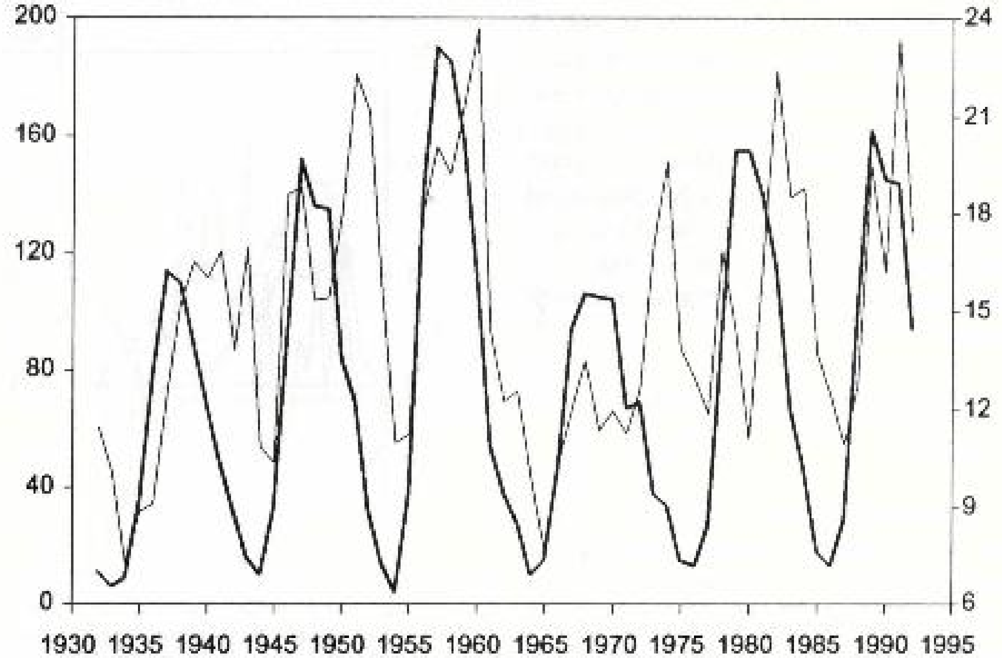

Figure 3. Mean annual sunspot number (bold, left scale) and mean annual Ap geomagnetic index (light, right scale), 1932-1992.

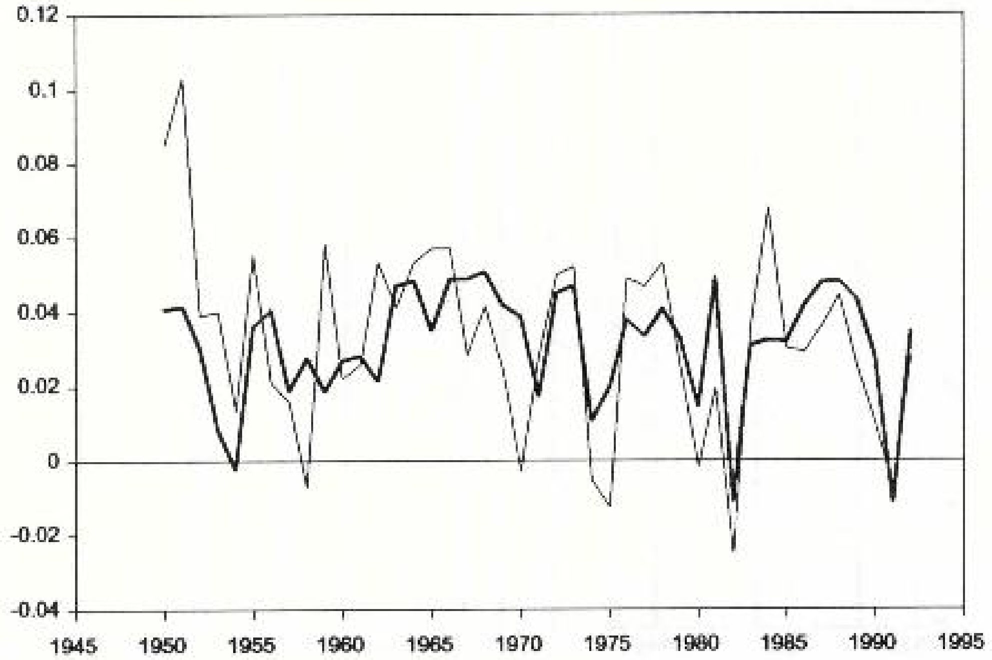

Figure 4. Annual rate of change in real U.S. GNP (bold) and Ap change projected value (light).

wide variety of biological systems. *In vitro* studies point to ELF sensitivities in cellular signaling (Luben et al. 1982), ionic flow rates (Blackman 1985), DNA synthesis (Liboff 1984), RNA transcription (Goodman and Henderson 1988), systemic responsiveness to hormones and neurotransmitters (Lyle et al. 1988), animal passivity (Thomas et al. 1986), human reaction time (Friedman et al. 1963), and behavior (Lovely 1988).

The popular press has focused attention on the potential cancer-causing role of ELF fields produced by high-voltage power lines and electric blankets. However, the less dramatic but real effects of ELF fields on brain chemistry and body metabolism are in the early stages of exploration. Based on research to date, the frequency and rate of change in the field intensity–not the *level* of intensity–seems to create the effects observed (Lednev 1991). Apparently, biological systems cannot adapt to rapid changes in frequency and intensity as readily as they can to a steady but higher intensity magnetic field.

ELF Fields and the Solar Cycle

Geomagnetic field strength varies constantly in response to changes in solar particulate flow and overall levels of solar radiation. The field produces a broad spectrum of ELF and VLF electromagnetic radiation of changing amplitude, as noted earlier. While the typical amplitude is quite small, these ELF fields can be readily detected with tuned radio receiver circuits.

Because their intensity fluctuates with changes in the solar cycle, these weak ELF fields likely produce changes in neurotransmitter levels and cellular responsiveness similar to those observed by laboratory researchers. A number of field studies point to just such a connection (Becker 1990).

Thus, solar cycle activity and human economic activity may be linked to the effects of the ELF and VLF fields created by changing levels of solar energy output. If such a connection exists, it should be possible to relate changes in the geomagnetic field to changes in human activity on every scale, including economic activity and financial market behavior.

Economic Cycles and the Geomagnetic Field

The first step to identify possible relationships between changes in the geomagnetic field and human activity was to compute the rate of change in the geomagnetic field, as measured by the Ap index, over a number of years. The change rate was estimated using the following equation

$$\text{Rate} = K_1 + K_2 * \exp((P_1 / P_2)$$

where K_i are the scaling constants and P_i are the averaged mean daily Ap indices for selected periods.

The annual rate of change for several measures of economic and financial performance also was computed for similar time periods. Changes in field strength then were regressed against annual change rates in economic and financial variables. Geomagnetic field changes led economic changes by six to twelve months (Table 1).

The Ap rate of change models correctly anticipated the timing of increases and decreases in economic and financial activity more than 65% of the time. In

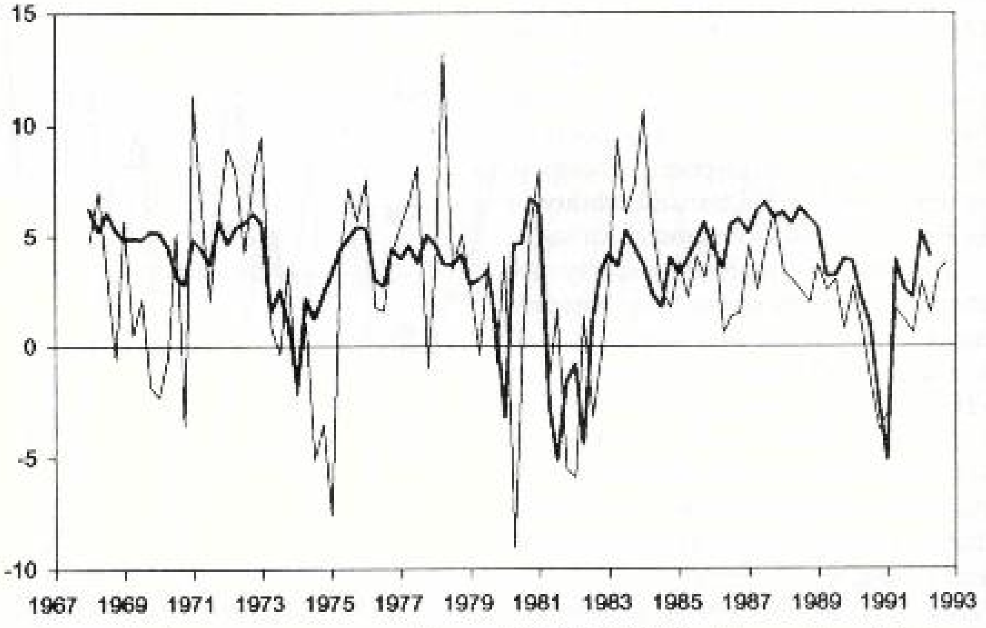

Figure 5. Annualized quarter-to-quarter rate of change in U.S. GNP ((light) and Ap model projections (bold).

addition, the relationships found were statistically significant.

By comparison, the consensus economic forecast of gross national product (GNP) growth between 1972 and 1990 showed a mean forecast error of 28% and a correct prediction for the direction of real GNP change of 69%. The geomagnetic change model for the same period showed a mean forecast error of 50% and a correct projection for the direction of real GNP change of 90% (Figure 4). Quarterly GNP relationships were reviewed using the same procedure (Figure 5). The consumer price index (CPI-U) relationship is shown in Figure 6.

The Ap model lead the GNP changes by six to nine months. The correlation observed ($r = 0.52$) was highly significant ($p < 0.001$). The model correctly projected changes in the GNP 67% of the time, which also was highly significant ($p < 0.001$).

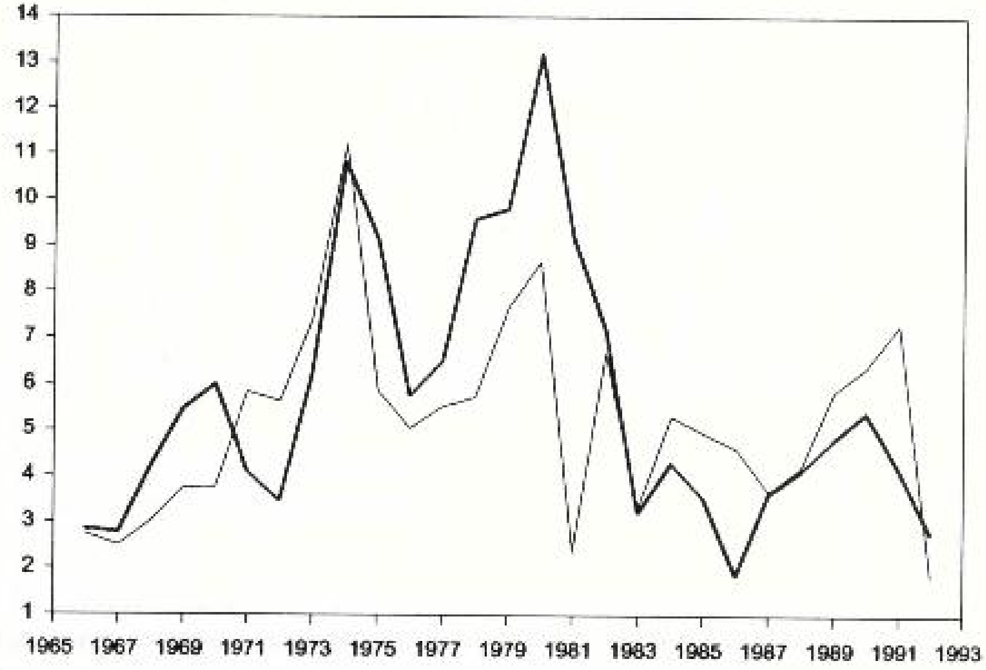

Figure 6. Annual rate of change in the U.S. CPI-U (bold) and Ap geomagnetic field changes (light), 1967-1991.

Table 1. Ap change and economic/financial variables

	Predicted Change in Direction	Statistical Significance	Correlation Coefficient	Statistical Significance
Economic				
U.S. Real GNP	68%	98.0%	0.58	99.9%
U.S. CPI-U	85%	99.9%	0.64	99.9%
Financial				
DJIA	87%	99.9%	0.63	99.0%
Gold	76%	99.0%	0.81	99.9%
Bonds	78%	97.0%	0.82	99.9%

Changes in the geomagnetic field may represent one of the underlying modulators of activity for large macroeconomic measurements, such as GNP or CPI. Obviously, monetary and fiscal policies also bear on economic activity, but this influence may be somewhat less important than presently assumed.

The financial markets seem to be even more directly influenced. The correlations observed were of greater statistical significance and possessed a higher level of directional predictive capability than those observed for the economic variables evaluated.

The spot gold market showed a high degree of correlation in both magnitude and direction (Figure 7). The Dow Jones Industrial Average (DJIA) relationship showed a strong directional capability but was less robust in terms of magnitude of change (Figure 8). A price cycle of approximately 3.4 years also was evident. The relationship determine for the bond market is shown in Figure 9.

The relationship with changes in the geomagnetic field appears statistically stronger in the case of financial markets than for macroeconomic activities. Perhaps the impact and timing of regulatory and political programs have a longer lasting effect on economic developments than on liquid financial mar-

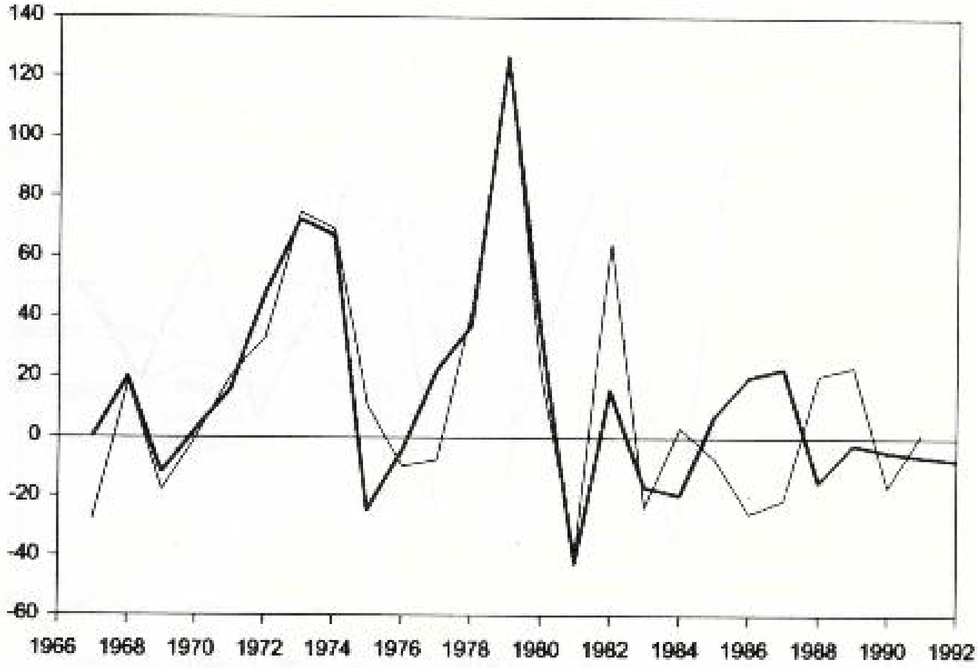

Figure 7. Annual rate of change in spot gold price (bold) and Ap geomagnetic change projection (light), 1967-1991.

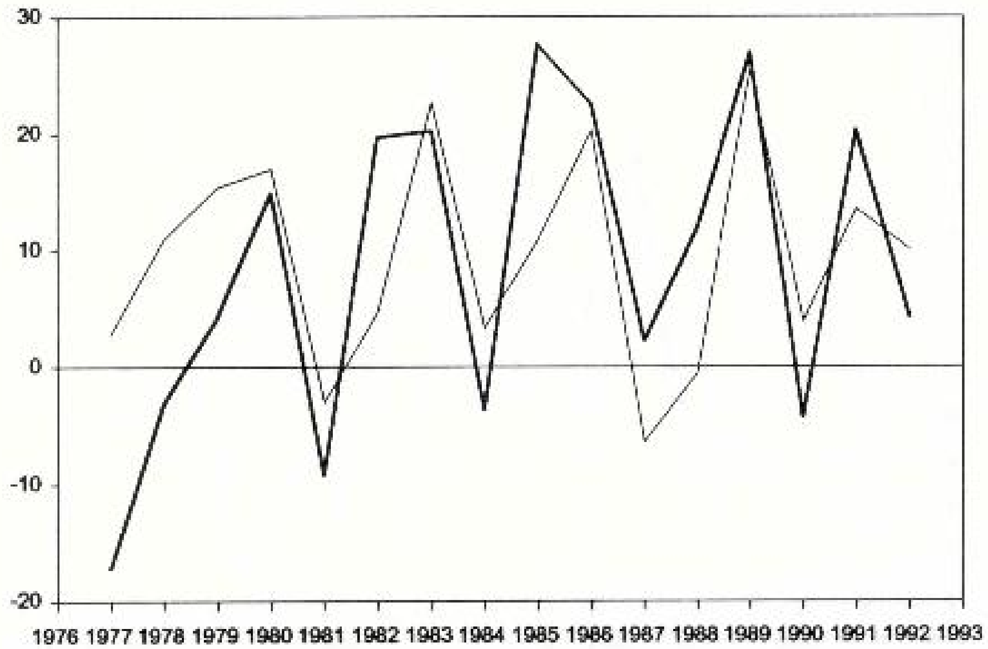

Figure 8. Annual rate of change in the DJIA (bold) and Ap geomagnetic model projections (light), 1977-1992.

kets, which are less handicapped and can more quickly adapt to changing conditions.

Conclusion

The rate of change in the geomagnetic field created by the sun's varying output appears to be a principal factor that modulates a variety of economic and financial activities. Changes in solar output create ELF and VLF waves in the earth's upper atmosphere that are capable of impacting a variety of biological functions, including human behavior.

This analysis represents only the beginning of research into the relationships uncovered. Consistent geomagnetic measurements are available globally every three hours, so shorter term projections of economic and financial market activity may be possible. Longer term projections also may be feasible as the relationship between the geomagnetic field and the solar cycle become better understood.

This approach is based on relationships that appear to be reliable, but it may not stand up under more rigorous examination. Nonetheless, it seems to open up another avenue for anticipating financial market behavior. It also may provide a plausible explanation for the wide variety of biological and economic cycles first identified by Dewey more than fifty years ago. CYCLES

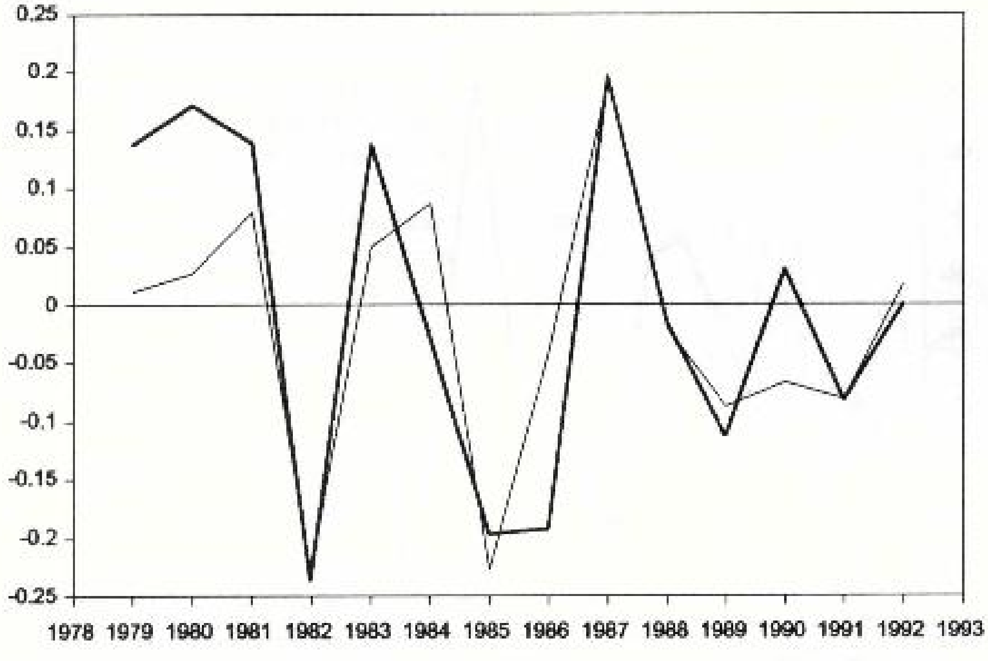

Figure 9. Annual rate of change in 30-year bond yields (bold) and Ap projections (light), 1979-1992.

REFERENCES

Al'pert, Y.F.
1990. *Space Plasma*. Cambridge Univ. Press, Cambridge.

Becker, R.O.
1990. *Cross Currents*. St. Martin's Press, New York.

Blackman, C.F.
1985. *Bioelectromagnetics* 6:1.

Collins, C.J.
1965. Effect of Sunspot Activity on the Stock Market. *Financial Analysts J.* (November-December).

Dewey, E.R.
1968. Economic and Sociological Phenomena Related to Solar Activity and Influences.*Cycles* 19:201-14.

Florig, H.K.
1992. Containing the Costs of the EMF Problem. *Science* 257:468-69.

Foukal, P.V.; Lean, J.
1991. An Empirical Model of Total Solar Irradiance Variation Between 1874 and 1988. *Science* 247:556-58.

Friedman, H.; Becker, R.O.; Bachman, C.H.
1963. *Nature*.200:626.

Garcia-Mata, C.; Shaffner, F.I.
1934. Solar and Economic Relationships: A Preliminary Report. *Quart. J. Econ.* 49:1-51 (November).

Goodman, R.; Henderson, A.S.
1988. *Proc. Natl. Acad. Sci. U.S.A.* 85:3928.

Lednev, V.V.
1991. *Bioelectromagnetics* 12:71.

Le, G.; Russell, C.T.
1993. Effect of Sudden Solar Wind Dynamic Pressure Changes at Subauroral Latitudes: Time Rate of Change of Magnetic Field. *Geophys. Res. Lett.* 20:1-4.

Liboff, A.R.; Williams, Jr., T.; Strong, D.M.; Wistar, Jr., R.
1984. *Science* 223:818.

Lovely, R.H.
1988. *In* Connor, M.E.; Lovely, R.H., eds. *Electromagnetic Fields and Neurobehavioral Function*. Liss, New York.

Luben, R.A.; Cain, C.D.; Chen, M.C.-Y.; Rosen, D.M.; Adey, W.R.
1982. *Proc. Natl. Acad. Sci. U.S.A.* 85:3928.

Lyle, D.B. et al.
1988. *Bioelectromagnetics* 9:303.

Niemira, M.P.
1990. The "New Decade" Recession Effect: Will it Recur in 1990? *Cycles* 41:45.

Rees, R.J.
1989. *Physics and Chemistry of the Upper Atmosphere*. Cambridge Univ. Press, Cambridge.

Robel, R.G. *et al.*
1987. On the Global Mean Structure of the Thermosphere. *J. Geophys. Res.* 92:8745-58.

Thomas, J.R.; Schrot, J.; Liboff, A.
1986. *Bioelectromagnetics* 7:349.

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