Uni-Economic: Sam-Marco Sunspot Financial Indices (SMSFI) Model

Samuel K.M. Ho *
Director, BA-TU Programme, Coventry University & Hang Seng School of Commerce

Marco Lau Chi Keung
Lecturer in Economic & Finance, Hang Seng School of Commerce, HKSAR

* Corresponding Author: samho@hssc.edu.hk

Executive Summary

1. Sunspots (could be as large as 5 times the Earth's diameter) are areas of extremely high electro-magnetic radiations (including X-ray). Thus the Earth experiences variation of solar radiation as the Sunspot sizes and numbers change.

2. Sunspots are cyclical from 0 (Solar Minimum) to as high as 300 (Solar Maximum). The historical annual average varies from 2.4 (2008) to 174 (1949). The periodic time is around 11 years. In other words, we have just experienced the lowest sunspot number in the history of sunspot count by mankind.

3. Dr. George Crile, a distinguished American surgeon, wrote that radiation affects human cells which can be considered as electrical charges.

4. Prof. A.L. Tchijevsky, a Russian scientist, found that from 500 B.C. to 1922 A.D. & 76 countries, 80% of the most significant wars of mankind occurred during the years of maximum sunspot activity.

5. Prof. Suitbert Ertel showed evidence that during the maxima of sunspot activity human behavior (and hence cultural development) is stimulated.

6. Dr. Conyers Morrel (published in BMJ) found increases in pandemics of deadly diseases during the period of minimal sunspot activity.

Authors’ Deduction

S1: When the Earth experiences Solar Minimum, mankind (in particular investors and fund managers) tended to be more conservative and less aggressive.

S2: The recent Solar Minima occurs in 1965, 1975, 1986, 1997 and 2008 (11-year cycle). These are the exact years for Global Stock Crashes.

S3: When the World's 4 major Financial Indices (S&P, FTSE, Neikki & HSI) are correlated using daily data over the last 45 years, there were little correlations found.

S4: However, when S&P, FTSE, Neikki and HSI were correlated with Sunspot Daily Count from the last 45 years, the correlations were amazingly good! Statistical tests deployed were: Unit Root Test, Johansen and Jeuselius Cointegration Test, and Error Correction Model (ECM). The last one was developed by Prof. Clive Granger, the 2003 Nobel Prize Winners on Economics.

S5: Therefore, with the benefit of hind-sight, we should have forecast the 2008 Financial Tsunami - in Oct 08, the Sunspot Number was 0. Actually, the figure ‘0’ spread from 5-10 Oct 2008, with Oct 8 being the date of Financial Tsunami.

S6: Regarding the Gaza dispute at the end of 2008, according to Prof. A.L. Tchijevsky's research, it should NOT be too significant! So we shall see peace pretty quickly.
Fortunately, we do not have to wait for the next half-cycle (5.5 years later) before we shall encounter the Solar Maximum. The next interim Sunspot Height (up to 130 in number) is forecast on **22 Sep 2010**. Therefore, we expect the global economy will pick up by then.

Based on this research finding, it is feasible to develop a new branch of economic theory called “Uni-Economy” standing for Universal Economy (paper accepted by the Oxford Business & Economic Conference in June 09 at Oxford University). The basis of this theory is that the Sunspot Number will affect the economic development of mankind. Therefore, we should make the best use of this natural phenomenon to foretell economic recession and prepare ourselves for speedy recovery. As said in the Chinese saying – whenever there is danger, there will be opportunity!

**ABSTRACT**

Historically, the study of the world's economy was classified into Micro-economic and Macro-economic. Perhaps, contemporary economists should learn from the 'astronomists' about the universe which we are part of it. We shall name this 'Uni-economic'. Many scientists have found that sunspots affect human behaviour. Some research findings even relate the 11 year periodic cycle to war and peace of mankind. It is also widely-known in the medical profession that sunspot radiation actually affects the physiology of our human body. With all these evidence in mind, the aim of this exploratory research paper is to investigate how sunspot activities can affect the investors’ sentiment in the financial world since 1970 when the first post-war financial crisis was built up resulting from the oil crisis in the early '70.

Time series techniques were deployed to track down the changes of Sunspot Counts over the last 38 years on the world’s 3 main financial indices, i.e., S&P, FTSE and Nikkei. It was pretty astonishing to find out that, whilst there are insignificant correlations amongst the 3 financial indices over the period under investigation, the impact of the Sunspot Counts on them are highly significant, even on a day-to-day time series analysis. Furthermore, HSI during the same period is used as a validation instrument. Then, the Model built up is applied to a simulated trading of a HK$1M portfolio of Blue-chips in Hong Kong over a 1-month period. Subject to further verifications, positive findings are recorded.

As a preliminary research finding, a Financial Index named SMSFI is created which is hyperlinked to the daily Sunspot ‘weather forecasting’ from the Space Environment Center, US Government. Calculations indicate that we’re due to see another rise in intense solar activity on 22 September 2010. The SMSFI is also used to predict the outcome by then. Furthermore, it will be both interesting to academics and practitioners on the pattern of the 4 financial indices under investigation from now till the next Solar Minimum in 2019 based on the SMSFI.

**Keywords:** Sunspots numbers, Human Behaviour, Global Financial Indices, Time-series Forecasting

1. **Introduction: What are ‘Uni-economic’ and Sunspot?**

The classical study of the world’s economy can be broadly classified into Micro-economics and Macro-economics. According to Wikipedia, Micro-economics is “a branch of economics that studies how individuals, households and firms and some states make decisions to allocate limited resources.” Macro-economics is “a branch of economics that deals with the performance, structure, and behavior of a national or regional economy as a whole”. Perhaps contemporary economists should learn from the ‘astronomists’ about the universe which we are part of it. The authors shall name this ‘Uni-economics’, and shall define it as “a branch of economics that explore the impact of the universe at large on the economy of mankind, including financial market, industrial, national and global development matters”.

In the first section of the first chapter of the Bible, God started his creation and the first thing He did was “Let there be light”. This creation has put the Sun symbolically into the centre of the Universe affecting mankind. This also gives us the hint that we should study the sun first before human economic activities. Sunspots are dark spots, some as large as 5 times the Earth’s diameter, moving...
across the surface of the sun, contracting and expanding as they go (see Figure 1). These strange and powerful phenomena are known as sunspots. According to George Fischer (1998), a solar astronomer at the University of California, "A sunspot is a dark part of the sun's surface that is cooler than the surrounding area. It turns out it is cooler because of a strong magnetic field there that inhibits the transport of heat via convective motion in the sun. The magnetic field is formed below the sun's surface, and extends out into the sun's corona."

Figure 1: An image of the region around a sunspot

As well as being a darker area on the sun, a sunspot is an area that temporarily has a concentrated magnetic field. This magnetic force inhibits the convective motion, which ordinarily brings hot matter up from the interior of the sun, so the area of the sunspot is cooler than the surrounding plasma and gas. But as Fischer points out, sunspots are actually quite hot. "Instead of being about 5,400°C like the rest of the photosphere, the temperature of a sunspot is more like 3,700°C. But that is still very hot, compared to anything here on the Earth."

2. The Sunspot Cycle

In the last few decades, the forces behind sunspots are becoming better understood, but we have known for over 160 years that sunspots appear in cycles (Figure 2). The average number of visible sunspots varies over time, increasing and decreasing on a regular cycle of an average about 11 years. An amateur astronomer, Heinrich Schwabe, was the first to note this cycle, in 1843. The part of the cycle with low sunspot activity is referred to as "solar minimum" while the portion of the cycle with high activity is known as "solar maximum."
3. Sunspot Light Image and X-ray Image

George Fischer discusses what can be seen in white light and x-ray images of the sun.

Will the dark areas of high sunspot activity visible in white light images correspond to the bright areas of active regions visible in the x-ray images? According to Fischer, "It is known that the area of sunspots group is roughly proportional to the amount of x-rays coming out of an active region."

4. The Sun-Earth Connection

The sun's energy has a great effect on Earth. Its light provides energy for photosynthesis in plants and algae, the basis for the food chain, which ultimately feeds almost all life on Earth. Scientists today have discovered a lot about the way the sunspots affect the Earth. According to Dearborn (1998), "The sunspot itself, the dark region on the sun, doesn't by itself affect the Earth. However, it is produced by a magnetic field, and that magnetic field doesn't just stop, it comes to the surface and expands out above the surface...." Hot material called plasma near a sunspot interacts with magnetic fields, and the plasma can burst up and out from the sun, in what is called a solar flare. Energetic particles, x-rays and magnetic fields from these solar flares bombard the Earth in what are called...
geomagnetic storms. When these storms reach Earth, they affect us in many ways.

Figure 4: A NSAS illustration showing the earth’s magnetosphere and its interaction with the sun

Ordinarily, the Earth's own magnetic field protects the Earth from most of the sun's emissions. However during periods of intense sunspot activity, which coincide with solar flares and coronal mass ejections, the geomagnetic flow from the sun is much stronger. These magnetic storms produce heightened, spectacular displays of the Northern and Southern Polar Lights (Figure 4).

As Fisher describes it, "The Earth has a protective cocoon of magnetic field called the magnetosphere, and it normally protects us from the magnetic particles of the solar wind, and the other energetic particles in the solar wind. But during a coronal mass ejection we actually have a chunk of the sun that breaks away and hits the Earth's magnetosphere, and disturbs it, and this disturbance shows up as Polar Lights."

5. The Effect of Sunspots on the Earth's Climate

Even though sunspots are darker, cooler regions on the face of the sun, periods of high sunspot activity are associated with a very slight increase in the total energy output of the sun. Dark sunspot areas are surrounded by areas of increased brightness. Some parts of the solar spectrum, especially ultraviolet, increase a great deal during sunspot activity. Even though ultraviolet radiation makes very little contribution to the total energy that comes from the sun, changes in this type of radiation can have a large effect on the Earth's atmosphere, especially the energy balance and chemistry of the outer atmosphere. Though the connection between sunspot activity and the Earth's climate is still being debated, it is known that a period of unusually low sunspot activity from 1645-1715, called the Maunder Minimum, coincided with a period of long cold winters and severe cold temperatures in Western Europe, often called the "Little Ice Age." However, as far as we can currently tell, variations in the sunspot cycle seem to have less impact on the Earth's climate than human actions, such as burning fossil fuels or clear-cutting forests, do.

6. Sunspots and Human Behavior

Borderland Sciences has been investigating the relationship of the Sun and human behaviour for many years, and we are quite confident that we can predict behaviours based on sunspot fluctuations over very short and long durations within the Solar Cycle of 11 years (James Borges, 1998?). Historically, research has been conducted to link the 11 year cycle of the sun to changes in human behavior and society. The most famous research had been done by professor A.L. Tchijevsky, a Russian scientist, who presented a paper to the American Meteorological Society at Philadelphia in the late 19th century. He prepared a study of the history of mass human movement compared to the solar cycle, beginning with the division of the Solar cycle into four parts: 1) Minimum sunspot activity; 2) increasing sunspot activity; 3) maximum sunspot activity; 4) Decreasing sunspot activity. He then divided up the agitation of mass human movements into five phases:
(a) provoking influence of leaders upon masses
(b) the "exciting" effect of emphasized ideas upon the masses
(c) the velocity of incitability due to the presence of a single psychic center
(d) the extensive areas covered by mass movements

By these comparisons he constructed an "Index of Mass Human Excitability" covering each year from 500 B.C. to 1922 A.D. He investigated the histories of 72 countries in that period, noting signs of human unrest such as wars, revolutions, riots, expeditions and migrations, plus the number of humans involved. Tchijevsky found that fully 80% of the most significant events occurred during the years of maximum sunspot activity. He maintained that the "exciting" period may be explained by an acute change in the nervous and psychic character of humanity, which takes place at sunspot maxima.

Tchijevsky discovered that the solar minimum is the lag period when repression is tolerated by the masses, as if they lacked the vital energy to make the needed changes. He found that during the sunspot maximum, the movement of humans is also at its peak. Tchijevsky's study is the foundation of sunspot theory on human behavior, and as Harlan True Stetson, in his book Sunspots and Their Effects (available from BSRF), stated, “Until, however, someone can arrive at a more convincing excitability quotient for mass movements than professor Tchijevsky appears yet to have done, scientists will be reluctant to subscribe to all the conclusions which he sets forth.” Stetson did acknowledge that the mechanism by which ultraviolet radiation is absorbed was still a puzzle biologists had to solve.

The mechanism behind the stimulation of human behavior is still a mystery, but the theories of Georges Lakhovsky may shed some light. He considered his book, “The Secret of Life”, the extension of a scientific hypothesis of a new theory of life. The Sun is one of Earth's primary sources of cosmic radiation. While the Sun does produce its own radiations, solar winds actually capture passing cosmic dust and radiation and blow it into the Earth’s atmosphere. While it may seem frightening to some, this can actually be considered the Primal Vibration that sets the cells vibrating with Vital Force. This is the Prana, that Cosmic Breath, which is meant to vitalize man, and is the source for our evolution.

7. Sun’s Radiation and Human Biological Reaction

Dr. George Crile, a distinguished American surgeon, studied the sun in light of its radiant energy. In the ‘Preliminary Remarks’ to Lakhovsky’s The Secret of Life, Professor d’Arsonval quotes Crile: “It is clear that radiation produces the electrical current which operates adaptively the organism as a whole, producing memory, reason, imagination, emotion, the special senses, secretions, muscular action, the response to infection, normal growth, and the growth of benign tumours and cancers, all of which are governed adaptively by the electric charges that are generated by the short wave or ionizing radiation in protoplasm.”

He felt that the entire energy system of living beings is controlled by radiant energy and electrical forces. D’Arsonval points out that Lakhovsky and Crile found that living cells are electrical cells functioning as system of generators, inductance lines, and insulators. The underlying mechanism is the oscillating circuit. D’Arsonval explains further that a conductor is said to possess inductance if a current flowing through it causes a magnetic field to be set up round it. From such a circuit, energy is readily given off in the form of waves. According to Lakhovsky, the nucleus of a living cell may be compared to an electrical oscillating circuit. The nucleus consists of tubular filaments, chromosomes, mitochondria, made up of insulating material and filled with a conducting fluid containing all the mineral salts found in sea water. These filaments are thus comparable to oscillating circuits endowed with capacity according to a specific frequency.

The cosmic radiation from the Sun is a blessing of Vital Force. As Lakhovsky has postulated, it is the cosmic radiations that give the cells their vibrant oscillations. While the sunspot maxima is occurring, the solar flares and the subsequent geo-magnetic reactions effect the many subtle reactions...
that take place within our bodies at the atomic level. It has been theorized that this has a direct relationship to the metabolism of the body. The increase of penetrating waves during a solar storm causes an excitation in these electro-chemical reactions within the body. Tchijevsky also identified correlations between changes in solar magnetic activity with biological processes. In light of Lakhovsky’s theory in his own words, “…with the aid of elementary analogies, that the cell, essential organic unit in all living beings, is nothing but an electromagnetic resonator, capable of emitting and absorbing radiations of very high frequency.” A plausible mechanism is provided to understanding the stimulating effects the radiation from the Sun has on human behavior.

8. Historical Evidence of the Link between Sunspot Cycle with Human Creativity and Cultural Development

In another historical study Suitbert Ertel writes in his article “Synchronous Bursts of Activity in Independent Cultures; Evidence for Extraterrestrial Connections” that evidence has been reported suggesting a link between historical oscillations of scientific creativity and solar cyclic variation. Eddy’s discovery of abnormal secular periods of solar inactivity (Maunders minimum type) offered the opportunity to put the present hypothesis to a crucial test. Using time series of flourish years of creators in science, literature and painting (A.D. 600-1800), it was found as expected:

1) Cultural flourish curves show marked discontinuities (bursts) after the onset of secular solar excursions synchronously in Europe and China;
2) During periods of extended solar excursions, bursts of creativity in painting, literature, and science succeeded one another with lags of about 10-15 years;
3) The reported regularities of cultural output are prominent throughout with eminent creators. They decrease with ordinary professionals. The hypothesized extraterrestrial connection of human culture has thus been strengthened.

The above evidence shows that during the maxima of sunspot activity human behavior is stimulated.

There are some Russian researches that show an increase in cardiac problems during sunspot maxima. We could see the stress of solar activity on the biology of living things as an evolutionary agent weeding out the old and sick and strengthening those who can resonate with its radiations. In his ‘Preliminary remarks to Lakhovsky’s The Secret of Life the Professor d’Arsonval gives several examples of research done in the last hundred years that shows the most malefic effects from solar activity come at the sunspot minima. He notes from the British Medical Journal, March 7th & 14th of 1936 that both Colonel C.A. Gill and Dr. Conyers Morrel found increases in pandemics of deadly diseases during the period of minimal sunspot activity. In Gill’s study he showed that every pandemic of malaria since sunspot records were taken had occurred when sunspot numbers were lowest. Similar trends were observed in East Africa and elsewhere with Yellow fever epidemics since 1800 occur during the sunspot minima. Dr. Conyers Morrel also finds that, “…waves of epidemic diseases covering considerable periods exhibit a very close correspondence with the phases of sunspot periods. Diphtheria, Typhus, and Dysentery seemed to prosper when there was an absence of solar activity.

9. Sunspot and Financial Indices Cycles – Econometrics methodology

9.1 Past Literature

There have been several claims and counterclaims for the existence of a correlation between sunspot activity (as measured by the number of sunspots) and the economy or stock-market movements (Modis, 2007). Interestingly, opponents of this notion, like astronomers Wall and Jenkins (2003), claim that this correlation is well-known but mainly as folklore because trying to substantiate it is very difficult — and trying to find an underlying physical cause even more so. But they admit that this correlation may after all exist because global temperature is now known to correlate with sunspot number and long-term weather trends may have physical, social and economic effects.
At the same time, proponents of this notion, like “guru” Mandeville (2003), claim, “it is easy to see that both political and economic affairs are profoundly caught up and influenced by the ‘waves’ of sunspot energy.” But he also admits that there is zero correlation between daily price movements and average daily sunspot numbers and there is only a weak connection between long-term historical trends in the prices and average monthly or annual trends in the numbers of the sunspots.

Unfortunately, the above claims fail to provide a scientific explanation on the link between sunspot and human activities, hence the stock movement. Moreover, they have not provided a rigorous proof based on sound statistical theory on the correlation between sunspot number and the major financial indices of the world.

9.2 Analytical Techniques Deployed

The econometrics methodology deployed is in three steps. Firstly, time series techniques were deployed to track down the changes of Sunspot Counts over the last 38 years on the world’s 3 main financial indices, i.e., S&P, FTSE and Nikkei. Secondly, the long run function of a particular stock price index could be specified as a natural logarithm transformation function. Finally, Granger’s (2003 Nobel Prize Winner in Economics) Cointegration Methodology is deployed to test the equilibrium relationships.

9.3 Preliminary Results

Time series techniques were deployed to track down the changes of Sunspot Counts over the last 38 years on the world’s 3 main financial indices, i.e., S&P, FTSE and Nikkei. The historical data of Heng Seng Index (HSI), FTSE_ALL (FTSE), S&P (SP), Japan Nikkei Index (Nik) and the number of sunspot (SUN) are plotted in Figure 5 and readers may have more information regarding the behavior of those daily time series span from 4/4/1962 to 26/12/2008). Two preliminary observations were found. First, the time series of “number of sunspots” exhibits strong cyclical behaviour. Second, all three stock markets seem to commove together, in particular for “FTSE” “Nik” and “S&P”.

June 24-26, 2009
St. Hugh's College, Oxford University, Oxford, UK
Figure 5: Historical Data of Stock Indexes and Numbers of Sunspot (4/4/1962-26/12/2008)
In order to have a clearer picture regarding all series under investigation, series in natural logarithm are plotted in Figure 6.

**Figure 6: Natural logarithm of variables**

### 9.4 Long Run Equation

The long run function of a particular stock price index could be specified as below, for example, the HSI function may be written as:

\[
\text{INHSI}_t = \alpha_0 + \alpha_1 \text{LNFTSE}_t + \alpha_2 \text{LNSP}_t + \alpha_3 \text{LNNIK}_t + \alpha_4 \text{LNSUN}_t + \epsilon_t
\]  

(1)

Where \( \alpha_0 \) was the constant intercept term. \( \alpha_1, \alpha_2, \alpha_3 \) and \( \alpha_4 \) are sensitivity for LNFTSE, LNSP and LNNIK and LNSUN respectively; \( \epsilon_{i,t} \) was a random disturbance term with its usual classical assumptions; and \( L \) was natural logarithm transformation operator.

We expected \( \alpha_1 > 0, \alpha_2 > 0, \alpha_3 > 0 \) and \( \alpha_4 \) was uncertain. However, it was well known that spurious regression was problematic if using Ordinary Least Squares (OLS) when time series are not with the same order of integration. Moreover, if time series have a unit root we need to take the first difference of variables in eq (1) in order to obtain a stationary series:

\[
\Delta \text{INHSI}_t = \alpha_0 + \alpha_1 \Delta \text{LNFTSE}_t + \alpha_2 \Delta \text{LNSP}_t + \alpha_3 \Delta \text{LNNIK}_t + \alpha_4 \Delta \text{LNSUN}_t + \epsilon_t
\]  

(2)

For the eq (2) \( \Delta \) is the difference transformation operator. However, Maddala (1992) argues that “long-run information” in the data was ignored in eq (2) once the data was manipulated by taking its first difference. Hence, the error correction (EC) term should be introduced and it was the central idea of co-integration theory. The one period lagged EC term, which integrated the short-run dynamics, in the long run demand function was introduced and eq (2) becomes:

\[
\Delta \text{INHSI}_t = \alpha_0 + \alpha_1 \Delta \text{LNFTSE}_t + \alpha_2 \Delta \text{LNSP}_t + \alpha_3 \Delta \text{LNNIK}_t + \alpha_4 \Delta \text{LNSUN}_t + \beta EC_{t-1} \epsilon_t
\]  

(3)

where \( EC_{t-1} \) was the one period lagged error-correction term and eq(3) was called the Error Correction Model (ECM). The ECM model was estimated to determine the short-run dynamic
behavior of index function. Two features of ECM we should mention. Firstly, all variables included in the ECM were stationary and first differenced to avoid superior outcomes. Secondly, the sign of the $EC_{t-1}$ must be negative because the change of index can diverge from its long run equilibrium in the short run. However, the error term, $EC_{t-1}$ will correct such divergence behavior in the next period once such disequilibrium occurred. This implied that the larger the coefficient ($\beta$) of $EC_{t-1}$ the higher the speed of convergence toward the equilibrium.¹

### 9.5 Unit Root Test

Unit root tests can be used to determine if trending data should be first differenced to render the data stationary. Pre-testing for unit roots was often a first step in the cointegration modeling which aimed to detect long-run equilibrium relationships among nonstationary time series variables. If the variables in question were I (1), then cointegration techniques can be used to model these long-run relations. Useful surveys on issues associated with unit root testing are given in Stock (1994), Maddala and Kim (1998), and Phillips and Xiao (1998).

Stationarity of a time series can be tested by Augmented Dicky Fuller (ADF) unit root test pioneered by Dickey and Fuller (1979). They showed that under the null hypothesis of a unit root, ADF statistic did not follow the conventional Student's t-distribution; they further derived the asymptotic results and simulated critical values for various test and sample sizes. The order of integration of the variables in eq (2) may be determined by applying ADF test. Consider a series at time $t$,

$$\Delta q_t = \alpha_0 + b \Delta q_{t-1} + \sum_{i=2}^{k} \sigma_i \Delta q_{t-i} + \varepsilon_t$$  \hspace{1cm} (4)$$

Where $q_t$ can be replaced by time series $LM_{it}$, $LP_{it}$, and $LGDP_{it}$, $\Delta q_t$ was the series of interest in first difference. $\sum_{i=1}^{k} \sigma_i \Delta q_{t-i}$ is the augmenting term and $\varepsilon_t$ was the Independently and Identically (IID) distributed error, i.e. $\varepsilon_t \sim iid(0, \sigma^2)$. Equation (4) were estimated by Ordinary Least Square (OLS) technique, and the unit root null hypothesis was rejected when the ADF-statistic was found to be significant for the null: $b = 0$ against the alternative $b < 0$. Findings were presented in table 1, which indicated that all variables in our study were non-stationary, therefore cointegration and error correction approaches was proposed in the next sections. Phillips and Perron (1988) (hereafter PP test) proposed an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root.

### 9.6 Johansen and Jeuselius Cointegration test and ECM

The empirical model that was used in the 1980s was based on the assumption that the variables in these models were stationary. However, the problem was that statistical inference associated with stationary processes is no longer valid if the time series were indeed following nonstationary processes.

Granger (2003) demonstrated that the statistical methods used for stationary time series could yield wholly misleading results when applied to the analysis of nonstationary data. His significant discovery was that specific combinations of nonstationary time series may exhibit stationarity, thereby allowing for correct statistical inference. Granger called this phenomenon cointegration. He developed methods that have become invaluable in systems where short-run dynamics are affected by large random disturbances and long-run dynamics are restricted by economic equilibrium relationships. Examples include the relations between wealth and consumption, exchange rates and price levels, and short and long-term interest rates.

Granger and Newbold pointed out that traditional OLS test may often suggest a statistically significant

¹ Results are available upon request.

June 24-26, 2009
St. Hugh’s College, Oxford University, Oxford, UK

OBEC/SMSFIM/v.2/090508/ P-11
relationship between variables where none in fact existed. They reached their conclusion by generating two independent nonstationary series and regressed these series on each other using traditional OLS. Surprisingly, the coefficient estimated was highly statistically significant despite the fact that the variables in the regression were independent. Later on, Engle and Granger considered the problem of testing the null hypothesis of no cointegration between a set of non-stationary variables and provided a rigorous proof of the Granger representation theorem. They won the Nobel Prize in Economics in 2003 due to their innovation on the framework of cointegration and error correction.

The term “cointegration” can be viewed as the statistical expression of the nature of equilibrium relationships. Variables may drift apart in the short run but if they diverge without bound, no equilibrium relationship could be said to be existed. Therefore, economic significance can be defined in terms of testing for equilibrium.

If all series were I(1) we may apply Johansen and Juseilus cointegration test in order to see whether any combinations of the variables in eq(1) are cointegrated. Given a group of non-stationary series, we may be interested in determining whether the series are cointegrated, and if they were, in identifying the cointegrating (long-run equilibrium) relationships. We implemented Vector Auto-Regressive (VAR)-based cointegration tests as developed by Johansen (1990,1991,1995) to the eq (1).

Consider a VAR of order p:

\[ y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + \beta x_t + dD + \epsilon_t \]  

(5)

Where \( y_t \) was a k-vector of non-stationary I(1) variables and in our case it consisted LNHSI, LFTSE, LNSP, and LNSUN; \( \epsilon \) was a vector of innovations.

We can rewrite the VAR as:

\[ \Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \beta x_t + \epsilon_t \]  

(6)

where \( \Pi = \sum_{i=1}^{p} A_i - I \), \( \Gamma_i = - \sum_{j=i+1}^{p} A_j \)

Granger’s representation theorem asserted that if the coefficient matrix \( \Pi \) has reduced rank \( r < k \), then there existed \( k \times r \) matrices \( \alpha \) and \( \beta \) each with rank \( r \) such that \( \Pi = \alpha \beta' \) and \( \beta' y_t \) was I(0). \( r \) was the number of cointegrating relations (the cointegrating rank) and each column of \( \beta \) is the cointegrating vector. As explained beforehand, the elements of \( \alpha \) were known as the adjustment parameters in the VEC model. Johansen’s method was to estimate the \( \Pi \) matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of \( \Pi \). It was pretty astonishing to find out that, whilst there are insignificant correlations amongst the 3 financial indices over the period under investigation, the impact of the Sunspot Counts on them are highly significant, even on a day-to-day time series analysis. Empirical findings were presented in table 2.

10. Empirical Results

10.1 Unit Root Test

Table 1 presented the result for ADF unit root test on variables of our interest. The number of augmenting terms, \( k \) was chosen by using Modified Akaike Information Criterion (MAIC) as suggested by Elliot, Rothenberg and Stock. ADF test show evidence that all series are I (1) variables. ADF and PP unit root tests with time trend drew to the same conclusion, the results will not be reported here to save space but made available upon request. The results were expected since the time series dynamics in Figure 5 do not exhibit mean-reverting properties. Since we confirmed that all variables are non-stationary cointegration techniques can be used to model these long-run relations in the next section.
Table 1: Unit root test

Group unit root test: Summary
Series: LNFTSE, LNHSI, LNNIK, LNSP
Date: 01/07/09    Time: 17:43
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic selection of lags based on AIC: 14 to 37
Newey-West bandwidth selection using Bartlett kernel

<table>
<thead>
<tr>
<th>Method</th>
<th>Statistic</th>
<th>Prob.**</th>
<th>Cross-sections</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null: Unit root (assumes common unit root process)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Levin, Lin &amp; Chu t*</td>
<td>2.15153</td>
<td>0.9843</td>
<td>4</td>
<td>47588</td>
</tr>
<tr>
<td>Breitung t-stat</td>
<td>2.71512</td>
<td>0.9967</td>
<td>4</td>
<td>47584</td>
</tr>
<tr>
<td>Null: Unit root (assumes individual unit root process)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Im, Pesaran and Shin W-stat</td>
<td>1.28445</td>
<td>0.9005</td>
<td>4</td>
<td>47588</td>
</tr>
<tr>
<td>ADF - Fisher Chi-square</td>
<td>3.87690</td>
<td>0.8681</td>
<td>4</td>
<td>47588</td>
</tr>
<tr>
<td>PP - Fisher Chi-square</td>
<td>2.93938</td>
<td>0.9381</td>
<td>4</td>
<td>47707</td>
</tr>
</tbody>
</table>

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Null Hypothesis: LNSUN has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 29 (Automatic based on AIC, MAXLAG=39)

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller test statistic</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1.825463</td>
<td>0.6925</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -3.959079
- 5% level: -3.410314
- 10% level: -3.126907


10.2 Johansen and Jeuselius Cointegration test

Lag of four in level for the Vector Auto-Regressive (VAR) model specification was selected as suggested by Pesaran and Pesaran. Table 2 presents the findings. Take the determinants of Hong Kong Stock market as an example, we first look at null hypothesis of no cointegration (r=0) among variables. The p-value of the maximal eigenvalue test for apparel and non-apparel fibers are 0.0000 & 0.0001 respectively, therefore we conclude that the null hypothesis of no cointegration (r=0) was rejected and the conclusions are in favor of the alternative of r=1 at the 1% significant level. Since the null hypothesis of $r \leq 1$ & $r \leq 2$ cannot be rejected for both apparel and non-apparel fibers at the 1% significant level we hence conclude that there was a unique cointegrating relationship among variables under examination. Trace test also found the same conclusion that there was strong evidence in support of a unique cointegrating relationship among variables and we came to the same conclusion that all variables maintained a unique cointegrating relationship. It was pretty astonishing to find out that, whilst there are insignificant correlations amongst the 4 financial indices over the period under investigation, the impact of the Sunspot Counts on them are highly significant, even on a day-to-day time series analysis (see Table 3)
## Table 2a: Johansen and Jeuselius Cointegration Test #1

Date: 01/07/09   Time: 17:49  
Sample (adjusted): 8/07/1964 12/26/2008  
Included observations: 10002 after adjustments  
Trend assumption: Linear deterministic trend  
Series: LNFTSE LNHSI LNNIK LNSP LNSUN  
Lags interval (in first differences): 1 to 4  

**Unrestricted Cointegration Rank Test (Trace)**

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Trace Eigenvale</th>
<th>Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.018384</td>
<td>218.7169</td>
<td>69.81889</td>
<td>0.0000</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.001763</td>
<td>33.13379</td>
<td>47.85613</td>
<td>0.5494</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.000961</td>
<td>15.48504</td>
<td>29.79707</td>
<td>0.7478</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.000439</td>
<td>5.866159</td>
<td>15.49471</td>
<td>0.7113</td>
</tr>
<tr>
<td>At most 4</td>
<td>0.000147</td>
<td>1.470484</td>
<td>3.841466</td>
<td>0.2253</td>
</tr>
</tbody>
</table>

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level  
* denotes rejection of the hypothesis at the 0.05 level  
**MacKinnon-Haug-Michelis (1999) p-values

**Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Max-Eigen Eigenvale</th>
<th>Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.018384</td>
<td>185.5831</td>
<td>33.87687</td>
<td>0.0001</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.001763</td>
<td>17.64875</td>
<td>27.58434</td>
<td>0.5246</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.000961</td>
<td>9.61880</td>
<td>21.13162</td>
<td>0.7796</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.000439</td>
<td>4.395676</td>
<td>14.26460</td>
<td>0.8154</td>
</tr>
<tr>
<td>At most 4</td>
<td>0.000147</td>
<td>1.470484</td>
<td>3.841466</td>
<td>0.2253</td>
</tr>
</tbody>
</table>

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level  
* denotes rejection of the hypothesis at the 0.05 level  
**MacKinnon-Haug-Michelis (1999) p-values

## Table 2b: Johansen and Jeuselius Cointegration Test #2

Date: 01/07/09   Time: 17:50  
Sample (adjusted): 8/07/1964 12/26/2008  
Included observations: 11581 after adjustments  
Trend assumption: Linear deterministic trend  
Series: LNFTSE LNHSI LNNIK LNSP  
Lags interval (in first differences): 1 to 4  

**Unrestricted Cointegration Rank Test (Trace)**

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Trace Eigenvale</th>
<th>Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.001984</td>
<td>41.01946</td>
<td>47.85613</td>
<td>0.1881</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.000802</td>
<td>18.01634</td>
<td>29.79707</td>
<td>0.5648</td>
</tr>
</tbody>
</table>
Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvale)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Max-Eigenvalue</th>
<th>Statistic</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.001984</td>
<td>23.00313</td>
<td>27.58434</td>
<td>0.1733</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.000802</td>
<td>9.291077</td>
<td>21.13162</td>
<td>0.8083</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.000593</td>
<td>6.868198</td>
<td>14.26460</td>
<td>0.5048</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.000160</td>
<td>1.857061</td>
<td>3.841466</td>
<td>0.1730</td>
</tr>
</tbody>
</table>

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

10.3 Impulse Response Function

Figure 7 presented the impulse response functions to highlight the persistence and impact of one standard deviation shock, for example of INFTSE, LN SP, LNNIK, and LNSUN on LNHSI over a given horizons of 1 year (365 days). The initial impact effect of a unit shock in number of sunspots (measured as one standard deviation) on LNHSI was positive and remains persistent after 50 days (top left panel).
Figure 7: The impulse response functions to highlight the persistence and impact of one standard deviation shock.
10.4 Long Run Price and Income elasticity

Lastly, we use HSI during the same period is used as a validation instrument. Table 3 presents the long run estimates such that:

\[ LNHSI_t + \alpha_1 LNFTSE_t + \alpha_2 LNSP_t + \alpha_3 LNSUN = I(0) \]  

(7)

which means the linear combination of the above variables is stationary.

Rewrite Eq. (7) we have:

\[ LNHSI_t = \alpha_1 LNFTSE_t + \alpha_2 LNSP + \alpha_3 LNIK + \alpha_4 LNSUN, \]  

(8)

Table 3: Long run estimates

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-4.117457</td>
<td>-60.44678</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNFTSE</td>
<td>0.650344</td>
<td>24.53959</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNSP</td>
<td>0.583104</td>
<td>24.41540</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNIK</td>
<td>0.423528</td>
<td>33.83045</td>
<td>0.0000</td>
</tr>
<tr>
<td>LNSUN</td>
<td>0.086945</td>
<td>20.32989</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

R-squared 0.955425  Mean dependent var 7.528608
Adjusted R-squared 0.955409  S.D. dependent var 1.767371
S.E. of regression 0.373210  Akaike info criterion 0.867111
Sum squared resid 1505.957  Schwarz criterion 0.870480
Log likelihood -4684.770  Hannan-Quinn criter. 0.868247
F-statistic 57936.48  Durbin-Watson stat 0.005611
Prob(F-statistic) 0.000000

Our estimates suggest the following long run relationship which we shall call Sam-Marco Sunspot Financial Indices (SMSFI) Model:

\[ LNHSI_t = -4.12 + 0.65 * LNFTSE_t + 0.58 * LNSP + 0.24 LNIK + 0.087 * LNSUN_t, \]  

(9)

Equation (9) suggested that 1% increase in LNFTSE leads to 0.65% increase in LNHSI, while LNSP has less impact on LNHSI. Finally, 1% increase in the number of sunspot will lead to 0.087% increase in LNHSI.
10.5 Time-series Forecasting using the SMSFI Model developed

A linear regression model based on the sample dataset from 4/04/1962 to 12/26/2008 arrived at the following formula:

\[
\text{HSI (Forecast)} = -5.07 + 0.073 \times \text{SP} - 0.0116 \times \text{FTSE} + 0.000489 \times \text{NEIK} - 0.00459 \times \text{SSN} + 0.996 \times \text{HSI}(-1 \text{ for all indices})
\]

with the Dubin-Watson Test Statistic = 2.03 (measured against the best possible value of 2)

The above formula was used to forecast the HSI 3 months after the financial tsunami when the index was in a more steady state. The results of a 50-day period review a mean shift of +25 points against the actual HSI data. In the long run, this shift is acceptable for forecasting purposes.

![HSI Forecast by SMSFI Model](image)

**Figure 8:** Time-series forecasting on the HSI after the financial tsunami from 1/10/08 to 30/4/09

**BLUE** – Actual HSI  
**RED** – Forecast HSI, with an average upward shift of +25 points (around +0.3%)

11. Conclusion

Sunspots (could be as large as 5 times the Earth's diameter) are areas of extremely high electro-magnetic radiations (including X-ray). Thus the Earth experiences variation of solar radiation as the Sunspot sizes and numbers change. Sunspots are cyclical from 0 (Solar Minimum) to as high as 300 (Solar Maximum). The historical annual average varies from 2.4 (2008) to 174 (1949). The periodic time is around 11 years. When the Earth experiences Solar Minimum, mankind tended to be more conservative and less aggressive.

The recent Solar Minima occurs in 1975, 1986, 1997 and 2008. These are the exact years for Global Stock Crashes. When the World's 4 major Financial Indices (S&P, FTSE, Neikki and HSI) are correlated using daily data over the last 40 years, there were little correlations found. However, when S&P, FTSE, Neikki and HSI were correlated with Sunspot Daily Count from the last 40 years, the correlations were amazingly good! Statistical tests deployed were: Unit Root Test, Johansen and Jeuselius Cointegration Test, and Error Correction Model (ECM). The last one was developed by Prof. Robert Eagle and Prof. Clive Granger, the 2003 Nobel Prize Winners on Economics.
Our estimates suggest the following long run relationship which we shall call Sam-Marco Sunspot Financial Indices (SMSFI) Model for HSI:

\[
\text{HSI (Forecast)} = -5.07 + 0.073 \ast \text{SP} - 0.0116 \ast \text{FTSE} + 0.000489 \ast \text{NEIK} - 0.00459 \ast \text{SSN} + 0.996 \ast \text{HSI(-1 for all indices)} \quad (9)
\]

On the 2008 Financial Tsunami date – 8 October 08, the Sunspot Number was 0. Actually, the figure ‘0’ spread from 5-10 October 2008. So, the evidence on the SMSFI was pretty obvious. Regarding the Gaza dispute at the end of 2008, according to Prof. A.L. Tchijevsky’s research, it should not be too significant! So we shall see peace pretty quickly. The next interim Sunspot Height (up to 130 in number) is forecast on 22 Sep 2010. Therefore, we expect the global economy will pick up by then.

For those who are interested in investing in the stock market, it would be useful to review the Sunspot Count website (www.spaceweather.com) first. However, from the experience of the market fluctuation since the financial tsunami in October 2008, it is recommended that the forecasting should be based on weekly data of the SMSFI, rather than daily fluctuating dataset, as the latter is also influenced by financial and political news.

The classical study of the world’s economy can be broadly classified into Micro-economics and Macro-economics. Perhaps contemporary economists should learn from the ‘astronomists’ about the universe which we are part of it. The authors have named this ‘Uni-economics’, and defined it as “a branch of economics that explore the impact of the universe at large on the economy of mankind, including financial market, industrial, national and global development matters”. There is a Chinese saying that “When there is Danger, there is Opportunity”. It is hoped that with the finding from the “SMSFI Model”, the readers are confident to prepare themselves for the up-coming economic bloom in September 2010. Actions could include investing at low premium costs; strengthen organisational strategies and management; encouraging friends, relatives and business partners to look forward positively; and finally helping own company, country and the global economy to recover.

12. Further Research Questions

12.1 When the SMSFI Model is applied to a simulated trading of a HK$1M portfolio of Blue-chips in Hong Kong over a 3-month period using (9), what is the forecasting accuracy?

12.2 Calculations indicate that we are due to see another rise in intense solar activity on 22 September 2010. What will be the forecasting of the financial indices by then based on the SMSFI?

12.3 Based on the findings of 3. above, can we conclude with 95% confidence that the global economy is going to recover at an interim period by 22 September 2010?

12.4 What will be the pattern of the 4 financial indices under investigation from now till the next Solar Minimum in 2019 based on the SMSFI?
References
Lakhovsky, Georges (1985), The Secret of Life, BSRF.

Useful Sunspot Data Websites:

The Solar Data Analysis Center at:  http://umbra.nascom.nasa.gov/
The Solar Data Analysis Center at NASA’s Goddard Space Flight Center has information on many solar research projects, and a fantastic archive of solar images, both past and current, including the SOHO eruptive prominence of the week.

Today's Space Weather at:  http://www.sel.bldrdoc.gov/today.html
Presented by the Space Environment Center, one of NOAA's research laboratories, this site provides a daily update on levels of solar activity, and the intensities of solar emissions reaching Earth.

European Space Agency Sunspot Data at: http://space-env.esa.int/Data_Plots/noaa/ssn_plot.html

The YOHKOH Data Archive at:  http://ydac.mssl.ucl.ac.uk/ydac/

Authors’ Background

Samuel K. M. Ho is the Director of the BA-TU Programme from the Coventry University (UK) operated by the Hang Seng School of Commerce, funded by the HSBC Group. He is also the Professor of Strategic and Quality Management of the International Management Centres, UK. Before then, he was the Professor of Strategy and Quality at the Luton Business School, the first professor in that discipline in the UK. In 1987-88, he was awarded the Oshikawa Fellowship by the Asian Productivity Organization to do research in South East Asia and Japan. In 1993 he was invited as the first Quality Expert to the Malaysian Government by the Asian Development Bank for 6 months. As the Editor of the Managing Service Quality Journal and a guest editor for four international journals on quality management, he has over 120 publications. As an ex-Research Fellow at Cambridge, and Guest Speaker at Oxford, he is also Visiting Professor in Business Excellence of Coventry & Paisley (UK), RMIT (Australia) and Vaxjo (Sweden) University Business Schools.

Marco C.K. Lau is the Lecturer in Economic & Finance at the Hang Seng School of Commerce. Before then, he was a Research Fellow at the HK Polytechnic University, specialising in conducting quantitative research on macro-economic modeling, with particular application in the textile and clothing global trade. He published in such reputable journals as Journal of Applied Economics Letters, China Economic Review, Journal of the Textile Institute, Empirical Economics Letters, China and the World Economy, and International Research Journal of Economics and Finance etc. His specialty is in the application of econometric models and time series forecasting techniques in business and management.