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Article

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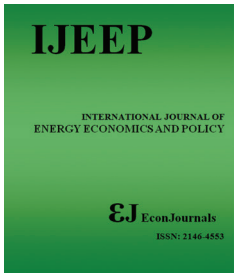

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Modelling the Impact of the Solar Activity on Demographic and Economic Indicators

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ABSTRACT

Researchers devoted a great attention to the studying of the solar activity for a long time. The reason is that the Sun has a strong impact on the world and people's lives. An increase in solar activity triggers world magnetic field that causes to increase the physical and mental health of the people. Human capital has a very important role in economic, social and demographic development. Therefore, solar activity can be considered as an important factor for the above detailed areas. The solar activity is defined with different indicators. The results of the econometric models indicate that an increase in solar activity (Wolf number) has a positive effect on rate, natural population growth, marriage and a negative effect on mortality and divorces. The solar activity has a positive impact on world gross domestic product, investment and world oil prices.

Keywords: Solar Activity, Human Factor, Demographic Indicators, Natural Growth, Gross Domestic Product, World Oil Price
JEL Classifications: C51, C59, J11, J19

1. INTRODUCTION

During the recent years, researchers pay more attention to the study of activity of the Sun. The reason is that the Sun has a strong influence on the lives of people and the Earth. Solar activity triggers the magnetic surface of the Earth, and thus affects the physical and mental health of people. The great encyclopedic scientist Nasreddin Tusi, who created the observatory in Maragha in XIII century, proved to Hulaku khan through his experiement that the reasons for the processes on the Earth should be searched on the sky.

Solar activity is characterized with different parameters. The most commonly used one is Wolf's number. Note that solar activity is a periodic with 10–12 years frequency (Chizhevskij, 1924; Obridko and Oraevskij, 1993; Chertkov, 1985; Sytinski, 1998; Lupachev, 1996). This figure is estimated mostly in an empirical way.

There could be significant changes in the development of indicators affecting the demographic indicators (mortality, rate, natural population growth, life expectancy, immigration, and marriage and divorce rates). There are a number of scientific studies which investigate the impact of the Sun's activity on demographic and economic and other processes (The Sun is Under Accusation: The Financial Crisis is Caused by Low Solar Activity Hasanli and Ismaylov, 2012; Pakhalov, URL,2 2011; Chizhevskij, 1995; Maddison, 1964; Yandiev, 2010; Tesis, URL).

Still, in XIX century French physician Clement Juqlar during the years of his study investigated the mortality and marriage rate and came to the conclusion that there is a pattern, or rather periodicity in their occurence. The periodicity of the demographic processes brings about the other increase and decreasing socio-economic processes.

Maddison showed the correlation between the world economy and Sun activity using the statistic data (Maddison, 1964).

2. THE THEORETICAL ASPECTS OF STUDYING OF THE PROBLEM BY THE MEANS OF ECONOMETRIC MODELS

The Wolf number, which reflects the Solar activity, provides the basis for the econometric assessment of various demographic indicators, like the natural population growth, mortality, rate statistics, the number of population, GDP, world oil prices and etc. (Christopher, 1992).

As stated above, the periodic activity of the sun (increase and decrease) can be reflected as the following approximated equation based on time regression.

$$SA = a_0 + a_1 f(t) + a_2 \sin\left(\frac{2\pi}{T} t\right) + a_3 \sin\left(\frac{2\pi}{2T} t\right) + a_4 \sin\left(\frac{2\pi}{3T} t\right) + u \quad (1)$$

Here, *SA* - Sun activity, *f*(t) the function of time trend, a_0, a_1, a_3, a_4 - parameters. *t* (*TREND*) - is a period of solar activity.

The main result of the realization of the computer regression model (1) is identification of the length of period (T-parameter) of the Wolf number, characterizing the sun's activity.

The effect of the solar activity on the natural growth (NG) of the world population can be seen by the following regression equation.

W_NG=c(1)+c(2)*SA+e (2)

Here, W_NG–the natural population growth per capita, c(1) and c(2) are parameters, e–is i.i.d random number. It should be noted that, the natural population growth per capita is calculated as difference between number of new borns and number of deaths per one thousand people.

It would be more correct to think that the solar activity affects indirectly, rather than directly, life expectancy of people. Solar activity positively impact the human activity, increasing the volume of production, increases its products per capita, per capita increase welfare and living conditions of people (The Impact of the Solar Activity on People and the Economy) and as a result increases the length of life expectancy (for example, natural population growth, labor) (Figure 1).

The effect of the per capita GDP (GDP_PC) on the length of life expectancy was estimated by the following logarithmic-linear regression equation (L_LE).

LOG(L_LE)=C(1)+C(2)*LOG(GDP_PC)+C(3)*@TREND (3)

Here, @TREND - shows the time passed.

Without the doubts oil prices affect the development trends of the countries around the world. However, we do not know the scientific method exactly for an accurate forecast of oil prices. There is extensive experience when the forecasts of the influential international organizations in connection with oil prices differ from the actual prices. Yet research in this area continues. Along with economic factors that influence the political factor is associated with the complexity of projected oil prices are up. In this case, another factor in the impact of solar activity of world oil prices and the study was estimated (the most prevalent indicator is Wolf number that characterizes the activity of the sun. Wolf number is the number of spots and spot groups of the sun. Rudolf Wolf was the first author of the calculation on sunspots and spot groups who lived in Zurich, Switzerland in 1848 and it was called Wolf number in his honor. It is important to mention that there are other indicators which characterize the solar activity. For instance: Radioactive emanation flow or intensity which has 10.7 sm. longitude; Magnetic field of the sun (black spots). Intensity of magnetic field is usually positively related to black spots. www.speceweather.com, www.eflu.ru). The question may arise in the first place: What could be the theoretical basis for influence of the activity of the sun on oil prices? So, do not have solar activity, but there is the ancient history of oil extraction. To eliminate this misunderstanding we should pay attention to the following transmission mechanism of solar activity: Law of demand and world oil prices to affect volume of GDP change allows interpretation of statistical data. Thus, the volume of energy consumption growth of products includes the increase in oil demand. According to the law requirements and this in turn leads to an increase in oil prices. Numerous other causes can also lead to change of oil prices is true. However, volume remains one of the main factors that affect the change of oil prices, changing of products. Thus, the effect of the changes of sun activity on changes in oil prices can be reflected in the following transmission mechanism (Figure 2).

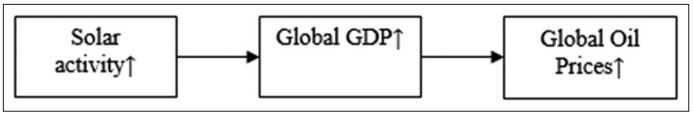
In order to solve the problem we will apply the Eviews Software Package which will assess the impact of sun's activity on the oil prices in two steps using the least squares method. Thus, initially it would be assessed using the following regression model:

WOP=C(1)+C(2)*LOG(W_CDP), (4)

Here, WOP – world oil prices, W_CDP - the volume of global gross domestic product. C(1) and C(2) are parameters, which show the impact of global GDP on world oil prices. It should be noted that considering that W_CDP is the volume of global GDP its effect on global oil prices are studied through application of

Figure 1: The indirect effect of solar activity on the length of life expectancy of people

Figure 2: The transmission mechanism of the effect of sun activity on global oil prices



natural logarithm LOG (W_CDP) of global GDP (based on e – Eylerfigure, e≈272).

Further, we assess the parameters using the following regression equation:

$$LOG(W\_CDP)=a(0)+a(1)*SA+a(2)*t \quad (5)$$

Here, SA - the ratio indicating the solar activity, t shows the time. a(1) and a(2) are parameters, which show the impact of global GDP on world oil prices.

If we please (5) into (4), we will get the econometric model of the effect of sun activity on global oil prices.

$$WOP = c(0)+c(1)*a(0)+ c(1)*a(1)*SA + c(1)*a(2)*t \quad (6)$$

Considering the picture 2, the effect of the sun activity on world oil prices can be seen by the following regression equation.

$$WOP=b(0)+b(1)*SA+b(2)*t \quad (7)$$

or

$$WOP=b(0)+b(1)*SA \quad (8)$$

As a result, the values of parameters b(0), b(1) and b(2) taken from regression (7) should be close to these derived from equation (6):

$$b(0)\approx c(0)+c(1)*a(0) \quad (9)$$

$$b(1)\approx c(1)*a(1) \quad (10)$$

$$b(2)\approx c(1)*a(2) \quad (11)$$

If the (8) regression equation received adequate assessment of the condition of the various specifications and performance of a single model is broken and b(0) and b(2) coefficients of interpretation it is important that even if true, then (7) the other (9), and the (10) relations of payment due (not homogenious).

3. THE INFORMATION DATABASE AND TIME SEQUENCE OF THE ECONOMETRIC MODELS

Statistic data which is available at the following internet resources provides information database of econometric models. Information on the dynamics of Wolf number from characterizes of solar activity is available at https://www.quandl.com/SIDC/SUNSPOTS_A-Sunspot-Numbers-Annual. Information on dynamics of human birth, death, natural population growth and life expectancy is available at http://data.worldbank.org/data-catalog/world-development-indicators. Information on dynamics of global oil prices is available at http://chartsbin.com/view/oau. Information on dynamics of global GDP is available at http://kushnirs.org/macroeconomics/gdp/gdp_world.htm.

4. THE REALIZATION OF THE ECONOMETRIC MODEL THROUGH COMPUTER

(1) Regression equations have been realized through Eviews Applied Program Package 8 based on information provided.

The following model was obtained from the application of regression equation:

$$GA=34.5126862614+0.0916014925627*@TREND-10.1031036557*SIN(2*180/2*11.1*@TREND) \quad (12)$$

(10) The statistic characteristics of the model were given in Table 1.

The statistical characteristics and related tests showed that the model is adequate. In Figure 3 and they were given the dynamics of the difference between the actual numbers and these in the model.

Table 1: The statistical characteristics of the model (12)

Dependent variable: GA				
Method: Least squares				
Sample (adjusted): 1702 2013				
Included observations: 312 after adjustments				
Convergence not achieved after 500 iterations				
MA Backcast: 1700 1701				
Variable	**Coefficient**	**SE**	**t-statistic**	**Prob.**
C	34.51269	6.927018	4.982330	0.0000
@TREND	0.091601	0.037706	2.429336	0.0157
SIN (2*180/2*11.1*@TREND)	−10.10310	4.873836	−2.072927	0.0390
R-squared	0.417016	Mean dependent var		49.79487
Adjusted R-squared	0.409421	SD dependent var		40.26799
SE of regression	30.94562	Akaike info criterion		9.718236
Sum squared resid	293992.8	Schwarz criterion		9.778220
Log likelihood	−1511.045	Hannan-Quinn criter.		9.742209
F-statistic	54.90038	Durbin-Watson stat		0.717705
Prob (F-statistic)	0.000000			

Model (12) than the solar activity appears that the average period 11, 1 years. This results in some literature data from the same period although wolf.

Reflecting the (2) effect of solar activity (Wolf number) on the natural growth of the equation econometric models was about regression parameters as the following.

W_NG=13.1078669345+0.0181039336177*SA (14)

t-test (19.69927) (2.112919)

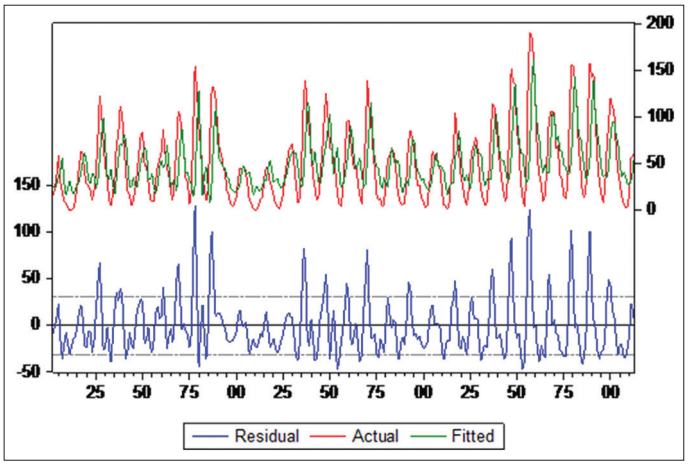
R-squared=0.125885

In here, W_NG is a global natural population growth per capita. SA is a Wolf number which characterize the solar activity. It is important to note that the natural population growth is calculated as difference between number of new borns and number of deaths per one thousand people.

The statistical characteristics and relevant tests show that the model (14) is adequate.

You can see that for every thousand people is about 13 people and 100 units of every thousand natural growth of solar activity on the natural growth of the average growth of about 2 people, increases the Wolf number (14) from the world. It should be noted that the Azerbaijani relevant numbers about 2, 7 people (Hasanli and Ismaylov, 2012). As (14) for natural growth dynamics of the solar activity (determination ratio (R-squared) 0.125885) may be due to a change in that year only about 12.6% of the change in the world can see that from every 1000 years of study.

Figure 3: The wolf numbers received from the model, dynamics between statistical data and results of the model



Influence of quantity of GDP per capita (GDP_PC) and time factors on global life expectancy of (@TREND) people is presented at the following logarithmic-linear equation.

The results of evaluation of equation (3) as following:

LOG(L_LE)=3.64226658119+0.0304506504824*

LOG(GDP_PC)+0.00223361636753*@TREND (15)

Model (15) the statistic characteristics of the model were given in Table 2.

Statistic characteristics and relevant tests indicated that, (12) model is adequate. The received results show that time factors and GDP per capita positively influences global life expectancy of the people.

The results show that the (L_LE) volume of (GDP_PC) GDP per capita life expectancy of people in the world has a positive effect on the length of period. So, the per capita GDP compared to 0.0304506504824 units, the elasticity coefficient is equal to the length of human life expectancy in the world. Thus, per capita GDP growth of about 0.03% to 1% length increases life expectancy. In other words, the volume of GDP per capita increased by 1% and 0.2% (about 1 months) by increasing annually during 1,162553 years to human life.

The following results were assessed in the system of equations (4) Eviews econometric model.

WOP=−3943.06381389+378.620615412*LOG(W_CDP) (16)

Econometric models (16) and statistical characteristics of the relevant tests showed that the model is adequate.

Table 2: The statistical characteristics of the model (15)

Dependent variable: LOG(L_LE)				
Method: Least squares				
Sample (adjusted): 1970–2012				
Included observations: 43 after adjustments				
Variable	**Coefficient**	**SE**	**t-statistic**	**Prob.**
C	3.642267	0.007592	479.7507	0.0000
LOG(GDP_PC)	0.030451	0.003490	8.724608	0.0000
@TREND	0.002234	0.000181	12.30842	0.0000
R-squared	0.995889	Mean dependent var		4.183331
Adjusted R-squared	0.995683	SD dependent var		0.047759
SE of regression	0.003138	Akaike info criterion		−8.623349
Sum squared resid	0.000394	Schwarz criterion		−8.500474
Log likelihood	188.4020	Hannan-Quinn criter.		−8.578036
F-statistic	4844.752	Durbin-Watson stat		0.298836
Prob (F-statistic)	0.000000			

Model (16) shows that global GDP is expected to (WCDP) have a positive effect on the level of (WOP) world oil prices.

The following results were assessed in the system of equations – the regression equation (5) of Eviews econometric model.

LOG(W_CDP)=0.274798400382+0.000208091688191* SA+0.0292591194144*@TREND (17)

Econometric models (17) and statistical characteristics of the relevant tests showed that the model is adequate. Model (17) appears that the Sun is positively affecting the activity of world (SA) GDP. Thus, the growth of world GDP increases by 0, 2% the amount of solar activity of every single Wolf number. Also the time when technological progress, technological innovation, innovation, every year the volume of gross domestic product growth is natural as a constantly developing trend, rather than the model shows that in connection with 2.93%.

The following results were assessed in the system of regression equations (8) of Eviews econometric model. Regression equation of econometric regression equation model for non-payment of the conditions imposed as a result of the evaluation that (7) acquired over the remains of Gaussian-Markov was not adequate.

WOP=46.6929999007+0.0812030988143*SA (18)

Econometric models (18) and statistical characteristics of the relevant tests showed that the model is adequate.

Model (18) shows that Solar Activity (SA) has a positive effect on the level (WOP) of world oil prices. Thus, every single Wolf, per capita growth of world oil prices level, or rather the price of oil increases in price of 0,081 USD in 1970, in other words 8,1 cents each barrel in line with the solar activity. Model (17) implies that many other factors that influence world oil prices remained stable at minimum level of world oil prices by an average of 46,7 USD, which may be the lowest price for any barell with the condition of the solar activity of another.

The above two steps are under (17) way to determine the impact on oil prices of provisions of the celebrations following the model of the spring if we got out of our Solar activity mechanism in the transmission view of the solar activity of (16) the small square.

WOP=−3839.02+0.078788*SA+11.07811*@trend (19)

As we can see from the model (19) the conditions mentioned above are met in accordance with correlation (11). This once again shows the existence of the impact on oil prices of the intense sun.

5. CONCLUSION

Following conclusions are derived from the study:

1. Using the econometric models we have proved the period of the sun activity is around 11, 1 years. Although this number differs from the calculations provided in certain literatures, however it is the same as Wolf number.
2. For every thousand people is about 13 people and 100 units of growth of solar activity on the natural population growth of the average growth of about 2 people is increasing every thousand Wolf number in the world. It should be noted that the Azerbaijani relevant numbers about 2, 7 people. Econometric model also showed that for every thousand people in the study of the dynamics of the solar activity may be due to a change in that year only about 12, 6% of the natural growth rate of the world.
3. The volume of GDP per capita life expectancy of people in the world has a positive effect on the length and time tradition. So, the per capita GDP compared to 0.0304506504824 units, the elasticity coefficient is equal to the length of human life expectancy in the world. Thus, per capita GDP growth of about 0.03% to 1% length increases life expectancy. In other words, the volume of GDP per capita increased by 1% and 0.2% (about 1 months) by increasing every year due to increase in length of human life by average of 1,162553 years.
4. Sun activity has positive effect on world oil prices. Thus, every single Wolf, per capita growth of world oil prices level, or rather the price of oil increases in price of 0.081 USD in 1970, in other words 8.1 cents each barrel solar activity. Model (17) implies that many other factors that influence world oil prices remained stable in world oil prices by an average of 46, 7 USD, the lowest price for all with the condition of solar activity at minimum level.

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