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DECLINE IN GLOBAL GDP GROWTH AFTER SOLAR MAXIMUMS (1961–2024)

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Abstract: The article uses the methodological approach developed by W.S. Jevons and A.L. Chizhevsky. The author found that for the years 1961–2024, immediately after each solar maximum, there was a general decrease in global GDP by an average of -1.903% over two years. The correlation coefficient of Wolf numbers in the years of maximum solar activity and the subsequent decrease in worldwide GDP percentage is -0.806. This made it possible to develop a forecast for a decrease in global GDP for 2025 and 2026 as a whole by -2.2%. The forecast value of annual GDP growth in 2025 around the world is 2.32%. The next years of high economic growth are expected to be 2027, 2028, and 2029, with projected annual global GDP growth of 4.38, 4.29, and 3.85 (%), respectively.

Keywords: global GDP, economic cycles, solar activity cycles, Wolf number, economic crisis

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Introduction

The relevance of the research question owes to the constant need to forecast economic dynamics. The purpose of the study was to identify the links between solar and global economic activity for the period 1961–2024. A Google search yielded only the author's preprint on the topic "Economic crises and solar activity extremes: Calculating the decline in global GDP growth in 2025". Thus, the focus of this article has unconditional scientific novelty.

Methods

In his article "Solar–Commercial Cycles", William Stanley Jevons placed graphs of solar activity cycles (Wolf number cycles) and grain price cycles in Delhi for the period 1760–1810 one under the other (Jevons, 1882); that is, he compared solar and economic activity.

Alexander Leonidovich Chizhevsky, in his monograph "The Cosmic Pulse of Life: Earth in the Embrace of the Sun" (Chapter 4, "The Sun and Epidemics", Fig. 33) constructed a diagram showing the average solar activity cycle over a hundred years (Wolf number cycle) and the average incidence of cholera in Russia for the period 1823–1923 according to the solar cycle (Chizhevsky, 1976).

This study compares solar and economic activity for the years 1961–2024 and plots the average solar and average economic cycles on a single chart.

Study

The annual mean Wolf numbers, which are the main indicator of solar activity (SA), were taken from a well-known astrophysical website intended for the definition, conservation, and distribution of the international sunspot number (SILSO, 2025). They are presented in column 2 of Table 1.

The ordinal numbers of years in column 3 of Table 1 are defined as follows. The first year in the SA cycle is considered to be the first year of its growth, i.e., the growth of the Wolf number, which is presented in column 2. Then the years are numbered in order, and the last year in the cycle is considered to be the year of the least SA. The minimum yearly Wolf numbers in Table 1 are highlighted in blue. The years with maximum activity are highlighted in red.

The World Bank provides data on global GDP growth (as a yearly percentage). They are presented in column 4 of Table 1 (World Bank Group, 2025).

Column 5 of Table 1 presents the estimated annual change in GDP growth worldwide, as a year-on-year percentage for 1961–2024.

Column 6 of Table 1 presents the estimated percent change in global GDP growth annually during the two years immediately following a solar maximum from 1961 to 2024.

The last row of column 6 presents the projected cumulative annual decline in global GDP growth through 2025 and 2026.

Table 1. Average annual Wolf numbers, ordinal numbers of years in solar activity cycles and worldwide GDP growth (annual %), 1961–2024

1. Year	2. Wolf number	3. Ordinal number of the year in the cycle of solar activity	4. Annual global GDP growth, %, 1961–2024	5. Change in global GDP growth, year-on-year, %, 1961–2024	6. Change in annual global GDP growth, two years after solar maximum, %, 1961–2024
1961	76.4	7	4.051201445	-	
1962	53.4	8	5.329240809	1.278039364	
1963	39.9	9	5.002177559	-0.327063251	
1964	**15**	**10**	**6.558702169**	**1.556524611**	
1965	22	1	5.630119414	-0.928582755	
1966	66.8	2	5.465856672	-0.164262742	
1967	132.9	3	3.815103335	-1.650753337	
1968	**150**	**4**	**5.965139767**	**2.150036432**	
1969	149.4	5	5.991213492	0.026073725	
1970	148	6	3.747988413	-2.243225079	-2.217151354
1971	94.4	7	4.271895884	0.523907471	
1972	97.6	8	5.604074172	1.332178289	
1973	54.1	9	6.405681584	0.801607412	
1974	49.2	10	1.927402868	-4.478278716	
1975	22.5	11	0.567446277	-1.359956591	
1976	**18.4**	**12**	**5.184755091**	**4.617308814**	
1977	39.3	1	4.010437425	-1.17431 7666	
1978	131	2	4.162449986	0.152012561	
1979	**220.1**	**3**	**4.185312074**	**0.022862088**	
1980	218.9	4	1.884448933	-2.30086314	
1981	198.9	5	1.941185303	0.05673637	-2.244126771
1982	162.4	6	0.353390703	-1.5877946	
1983	91	7	2.631337076	2.277946373	
1984	60.5	8	4.677376036	2.04603896	
1985	20.6	9	3.709364231	-0.968011805	
1986	**14.8**	**10**	**3.234538007**	**-0.474826223**	
1987	33.9	1	3.754643173	0.520105165	
1988	123	2	4.551719386	0.797076213	
1989	**211.1**	**3**	**3.724553822**	**-0.827165564**	
1990	191.8	4	2.723395357	-1.001158466	
1991	203.3	5	1.217527776	-1.505867581	-2.507026047
1992	133	6	2.03058559 9	0.813057824	
1993	76.1	7	1.847531751	-0.183053 849	

1. Year	2. Wolf number	3. Ordinal number of the year in the cycle of solar activity	4. Annual global GDP growth, %, 1961–2024	5. Change in global GDP growth, year-on-year, %, 1961–2024	6. Change in annual global GDP growth, two years after solar maximum, %, 1961–2024
1994	44.9	8	3.3494459	1.501914149	
1995	25.1	9	3.106383252	-0.243062648	
1996	**11.6**	**10**	**3.590032146**	**0.483648894**	
1997	28.9	1	3.959018253	0.368986107	
1998	88.3	2	2.851657777	-1.107360476	
1999	136.3	3	3.596285046	0.744627269	
2000	**173.9**	**4**	**4.542101988**	**0.945816941**	
2001	170.4	5	2.040121835	-2.501980152	
2002	163.6	6	2.331328373	0.291206538	-2.210773614
2003	99.3	7	3.109183391	0.777855018	
2004	65.3	8	4.4849971	1.375813709	
2005	45.8	9	4.038615261	-0.446381839	
2006	24.7	10	4.471221167	0.432605906	
2007	12.6	11	4.385583222	-0.085637946	
2008	**4.2**	**12**	**2.073952726**	**-2.311630495**	
2009	4.8	1	- 1.319598224	-3.39 3550951	
2010	24.9	2	4.527147072	5.846745296	
2011	80.8	3	3.347310983	-1.179836089	
2012	84.5	4	2.707281148	-0.640029835	
2013	94	5	2.889022013	0.181740865	
2014	**113.3**	**6**	**3.148623748**	**0.259601736**	
2015	69.8	7	3.134515325	-0.014108423	
2016	39.8	8	2.814360897	-0.320154429	-0.334262851
2017	21.7	9	3.456341601	0.641980705	
2018	7	10	3.296091281	-0.16025032	
2019	**3.6**	**11**	**2.71004016**	**-0.586051121**	
2020	8.8	1	-2.849082347	-5.559122507	
2021	29.6	2	6.419541277	9.268623624	
2022	83, 2	3	3.359911383	-3.059629895	
2023	125, 5	4	2.943332731	-0.416578652	
2024	**154.6**	**5**	**2.863263026**	**-0.080069704**	
2025		6			
2026		7			-2.2 (forecast)

Source: 1. DC-SILSO, Royal Observatory of Belgium, Brussels; 2. World Bank Group. GDP growth (annual %), https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

Table 2 was constructed based on the statistical data in Table 1.

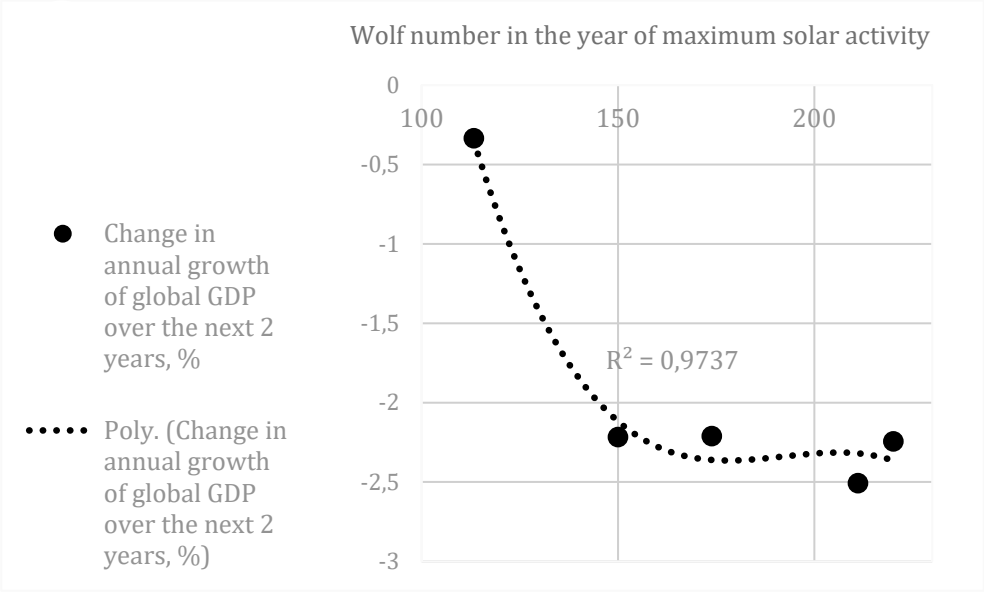
Table 2. Years of solar maximums, Wolf numbers, and the decline in global GDP growth in the two years immediately following solar maximums

1. Item No.	2. Year of maximum solar activity	3. Wolf number	4. Decrease in global GDP growth over the next 2 years, %
1	1968	150	-2,217151354
2	1979	220.1	-2,244126771
3	1989	211.1	-2,507026047
4	2000	173.9	-2,210773614
5	2014	113.3	-0,334262851
6	Correlation coefficient of columns 3 and 4 -0,806307923		
	Average decline in global GDP, % -1,902668127		
7	2024	154.6	-2,2 (forecast)

Source: 1. DC-SILSO, Royal Observatory of Belgium, Brussels; 2.World Bank Group. GDP growth (annual %), https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

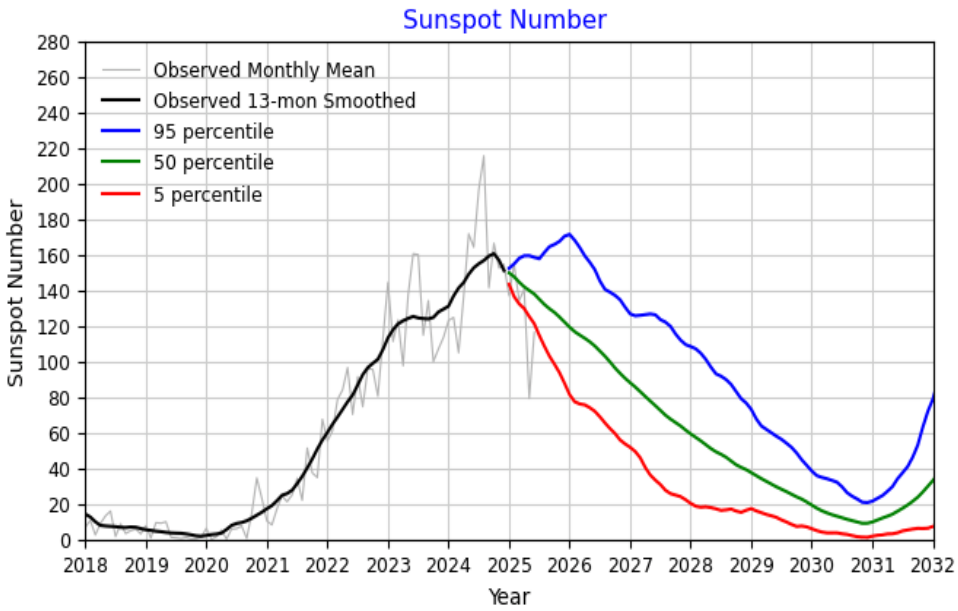
Based on the data in rows 1–5 and columns 3 and 4 of Table 2, Figure 1 presents a diagram demonstrating a strong relationship between the annual average Wolf numbers in the years of maximum solar activity and the immediate subsequent decline in world economic activity over a two-year period. The correlation coefficient value of -0.806 indicates a strong inverse relationship between solar activity in the years of its maximum and the decline in world economic activity that follows over a two-year period. It is important to note that throughout the entire history of observations (1961–2024), a decrease in the annual growth rate of worldwide GDP has occurred every time within two years after the SA maximums, without exception.

NASA forecasted that 2024 was highly likely to be the year of maximum solar activity in the current 25th cycle (NASA, 2025). This forecast has been copied in Figure 2. The Wolf number for 2024 is 154.6 (see Table 1). In the diagram in Figure 1, it corresponds to a decline in global GDP over the next two years (2025 and 2026) of -2.2%.



Source: Data in lines 1–5 and columns 3 and 4 of Table 1.

Figure 1. Strong inverse relationship between Wolf numbers in years of maximum solar activity and subsequent two-year decline in global economic activity



Source: NASA, https://www.nasa.gov/solar-cycle-progression-and-forecast/.

Figure 2. Forecast of the development of the current 25th cycle of solar activity

The statistical data in Table 1 were then grouped by the ordinal numbers of years within SA cycles. These grouping results are presented in Table 3. Column 2 of Table 3 shows the number of such years for the period 1955–2024.

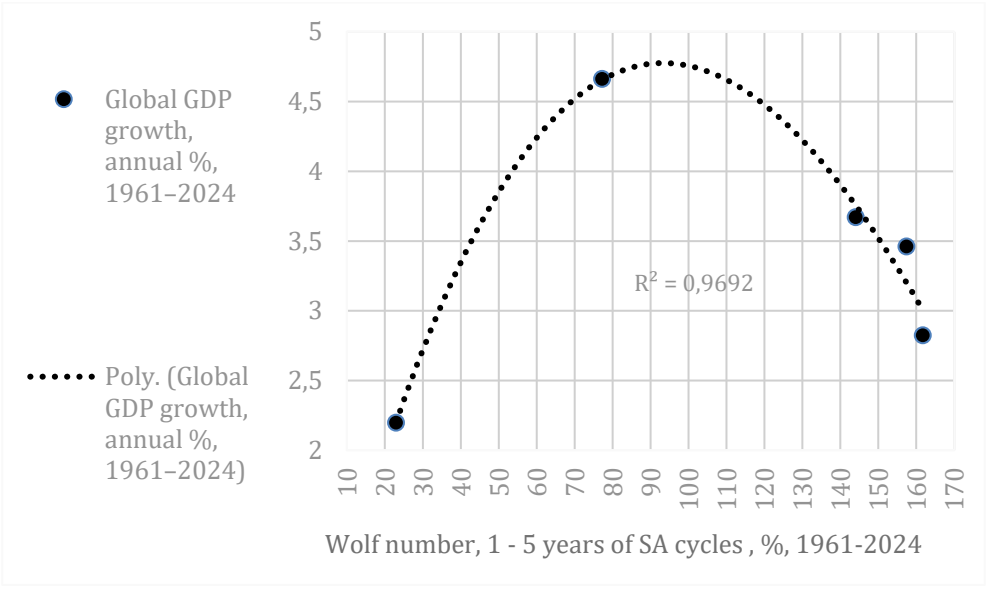
Based on rows 1–5 (years of increasing solar activity) and columns 3 and 4 of Table 3, the following diagram is constructed in Figure 3. The diagram shows that the average annual growth rate of GDP around the world is significantly higher during years with average values of solar activity (Wolf numbers) and significantly lower during years with extremes, that is, maximum or minimum solar activity. The approximation coefficient in this diagram is 0.9692.

Table 3. Grouping of data from Table 1
by ordinal numbers of years in solar activity cycles

1. Ordinal number of year in the SA cycle	2. Number of such years from 1961 to 2024	Arithmetic mean:		5. Change from the previous year
		3. Wolf numbers	4. Global GDP growth, annual %	
1	7	22.93333333	2.197589616	-1.431764293
2	7	77.26666667	4.663062028	2.465472413
3	7	144.0666667	3.671412774	-0.991649255
4	7	157.4333333	3.460949987	-0.210462787
5	**7**	**161.7666667**	**2.823722241**	**-0.637227746**
6	6	144.06	2.322383367	-0.501338873
7	6	84.5	3.174277479	0.851894111
8	6	60.25	4.376582486	1.202305007
9	6	34.53333333	4.286427248	-0.090155238
10	**6**	**20.38333333**	**3.846331273**	**-0.440095975**
11	**3**	**12.I**	**2.554356553**	**-1.29197472**
12	**2**	**11.3**	**3.629353909**	**1.074997355**
Total:	64			
Arithmetic mean		83.75625	3.461497267	

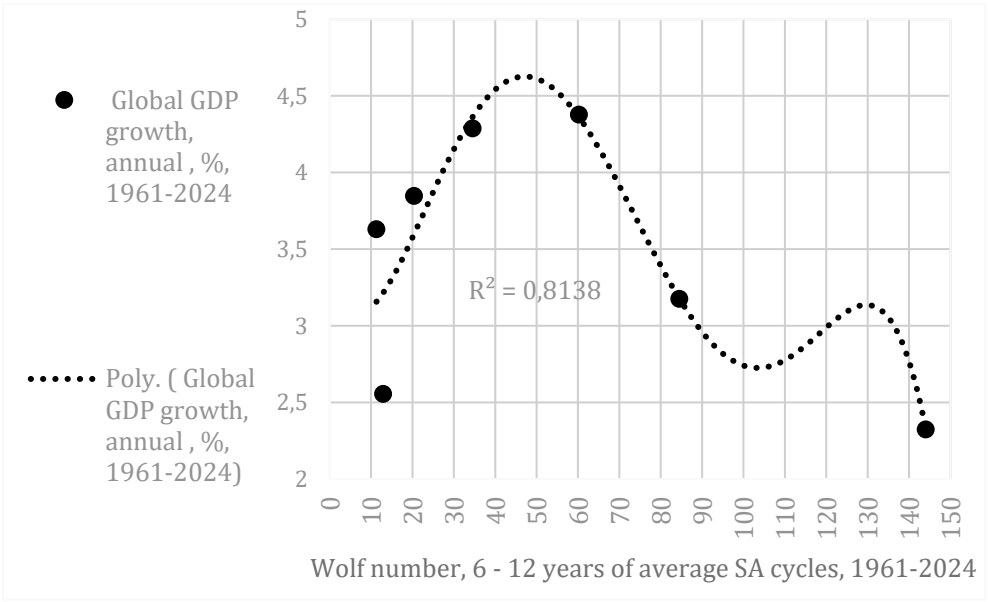
Source: Statistical data in Table 1.

Based on rows 6–12 (years of decreasing solar activity) and columns 3 and 4 of Table 3, the following diagram was constructed in Figure 4. This diagram also shows that the annual growth rate of global GDP is lower during years of extremes (maximums and minimums) of solar activity.



Source: Rows 1–5 and columns 3 and 4 of Table 3.

Figure 3. Wolf numbers and annual percent growth of world GDP, years 1–5 of the average SA cycle (years of SA growth) over 30 years of observations (1961–2024)



Source: Rows 6–12 and columns 3 and 4 of Table 3.

Figure 4. Wolf numbers and global GDP growth, percentage per year, years 6–12 of average SA cycle (years of SA decline) over 34 years of observations (1961–2024)

Dr. Igor Nikulin, senior researcher at the Sternberg Astronomical Institute, notes in an interview with *Rossiyskaya Gazeta* that "over millions of years of evolution, all living beings have adapted to the average values of these factors (temperature, pressure, atmospheric composition, magnetic field – V.B.), and even small deviations in one direction or another have a negative impact on their vital functions" (Valentinov, 2005).

The diagrams in Figures 3 and 4 show that the human body has adapted to average solar activity. Deviations towards solar activity extremes lead to a significant decrease in the annual growth of global GDP.

The conducted research also allows us to forecast the annual growth of global GDP. For example, the ordinal number of 2025 in the current 25th cycle of the SA cycle is 6. In Table 3, it corresponds to the average long-term value of global GDP growth equal to 2.32%, which we take as the forecast value for 2025.

Events such as military actions, significant changes in tariffs in foreign trade and other abrupt shifts in economic policy can significantly distort the natural economic cycle. The impact of the above factors should be assessed separately.

As shown by the data in Table 3, higher than average annual global GDP growth (3.46%) occurs in the 2nd, 3rd, 8th, 9th, and 10th years of the average SA cycle. The nearest such years should be 2027, 2028, and 2029 with the projected annual growth of global GDP equal to 4.38, 4.29, and 3.85 (%), respectively.

Results

The work, using statistical data for 1961–2024, has proven a strong connection between solar activity in the years of its maximums and a subsequent decrease in annual global GDP growth. It has also been clearly shown that annual GDP growth worldwide decreases during years of extremes (maximums and minimums) in solar activity. Economic crises are most likely in these years.

Discussion

It seems appropriate to conduct further research to determine the influence of extremes (maximums and minimums) in solar activity on the growth of pessimism, uncertainty, panic, fear, etc., all of which lead to an increase in the propensity to save and a decrease in the annual growth of global GDP.

Conclusion

The developed model (see Fig. 1) allows us to determine the decline in world economic activity within two years immediately after the maximum solar activity based on the Wolf number in the year of the maximum solar activity. In particular, it implies a total decline in global economic activity for 2025 and 2026 in the amount of 2.2%.

Conflicts of Interest

The author has no conflicts of interest to declare.

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NASA, https://www.nasa.gov/solar-cycle-progression-and-forecast/.

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