Sunspots, Unemployment, and Recessions, or Can the Solar Activity Cycle Cause the Business Cycle?

Mikhail Gorbanev

June 2012

Outline

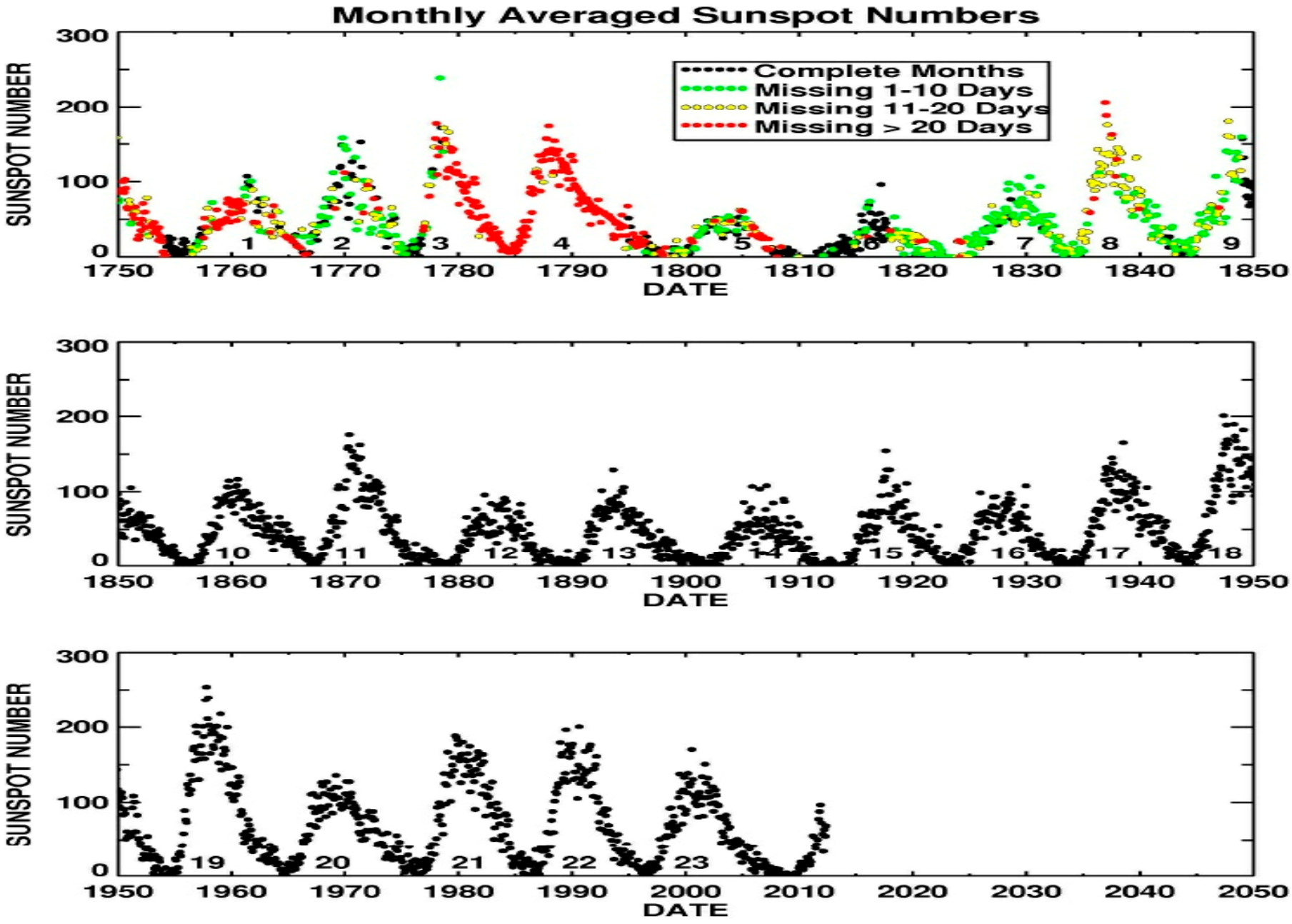
- **What are the sunspots, solar cycles, and solar maximums?**
- **A few fascinating charts suggest that solar maximums somehow trigger recessions, unemployment hikes, and business conditions worsening in the US and other countries.**
- **Correlations and Granger causality tests confirm statistical significance of the links.**
- **What is in the literature about it? Not much, and not in the most respected sources. Possible explanations: Psychological theory of the cycle? Geomagnetic disturbances? Ultraviolet rays?**
- **Policy implications: The next maximum of solar activity is projected in 2013. Turning point in the US unemployment rate trend is likely in 2012. US recession is most likely in the second half of 2013.**

What Are the Sunspots, Solar Cycles, and Solar Maximums?

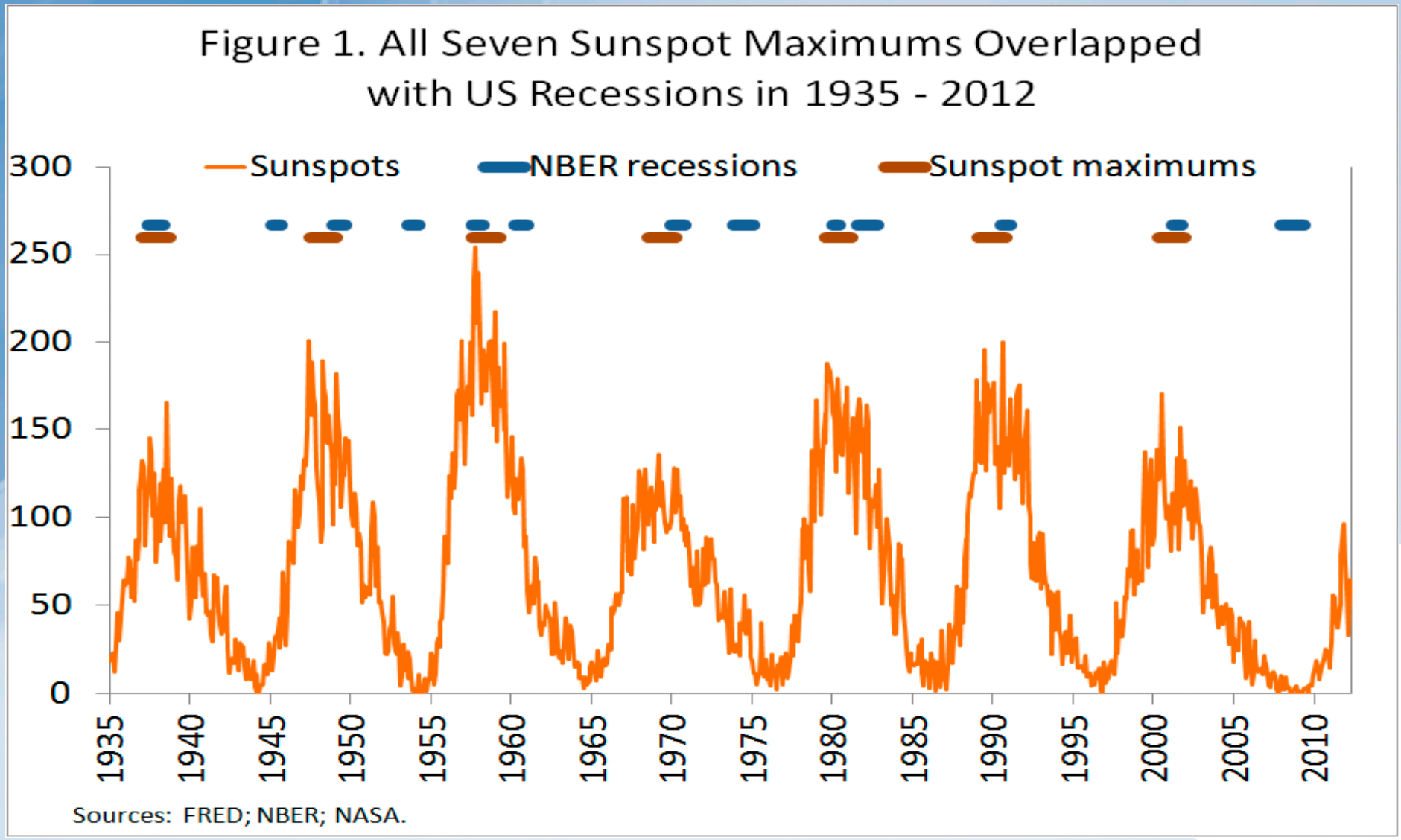
Sunspots are temporary phenomena on the photosphere of the Sun that appear visibly as dark spots compared to surrounding regions. The “sunspot number” is calculated by first counting the number of sunspot groups and then the number of individual sunspots. The "sunspot number" is the sum of the number of individual sunspots and ten times the number of groups.

The number of sunspots fluctuates with an approximate 11-year cycle known as the “solar cycle”. Sunspot numbers rise faster on the “upward” slope and fall more slowly on the “downward”. The cycle is not exactly regular. Significant variations in the number of sunspots are known over longer spans of time.

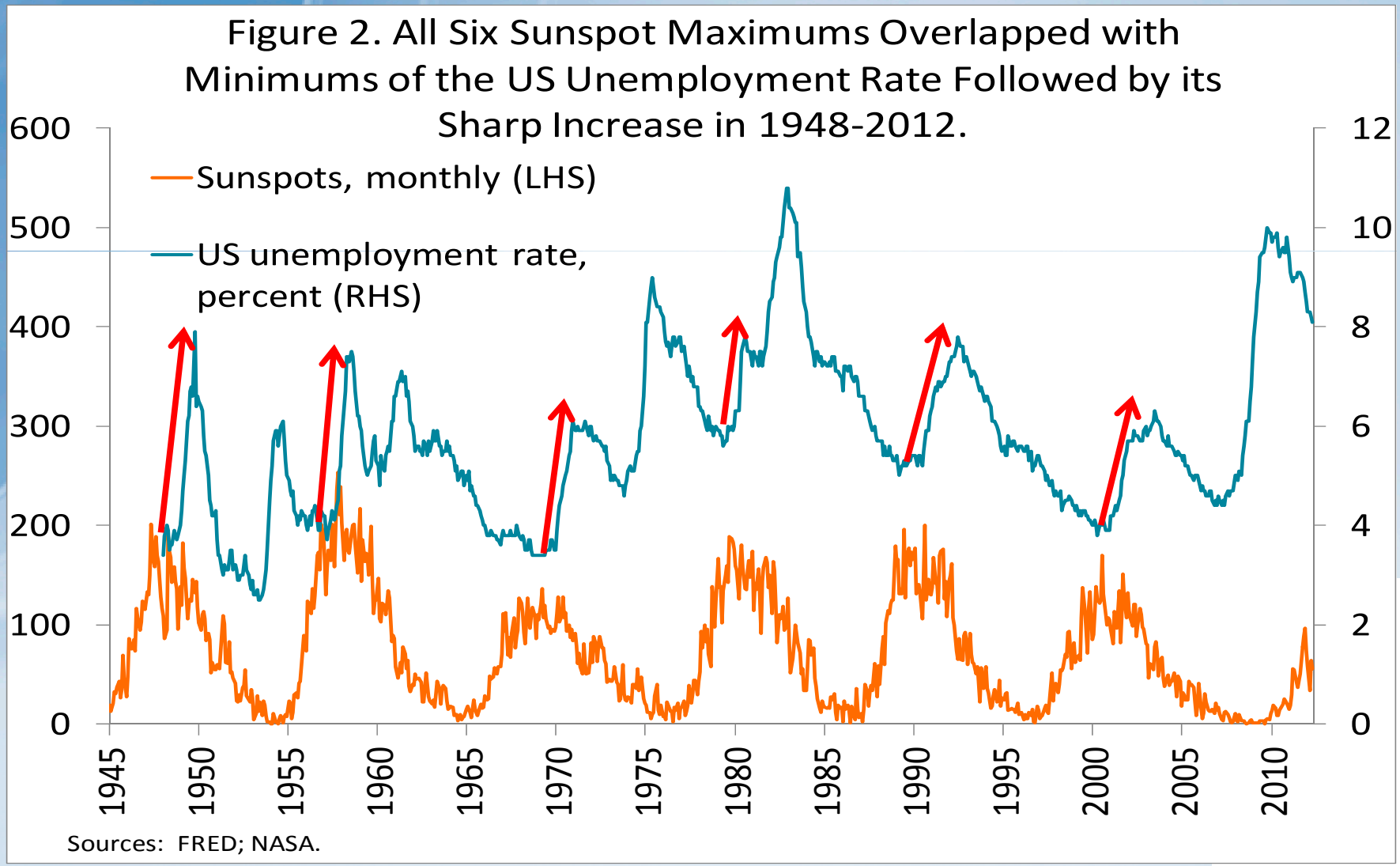
The portions of the solar cycle with the highest number of sunspots are “solar maximums”, and the portions with the lowest number of sunspots are “solar minimums”.


Monthly Averaged Sunspot Numbers
SUNSPOT NUMBER
DATE
Complete Months
Missing 1-10 Days
Missing 11-20 Days
Missing > 20 Days
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
HATHAWAY/NASA/MSFC 2012/06

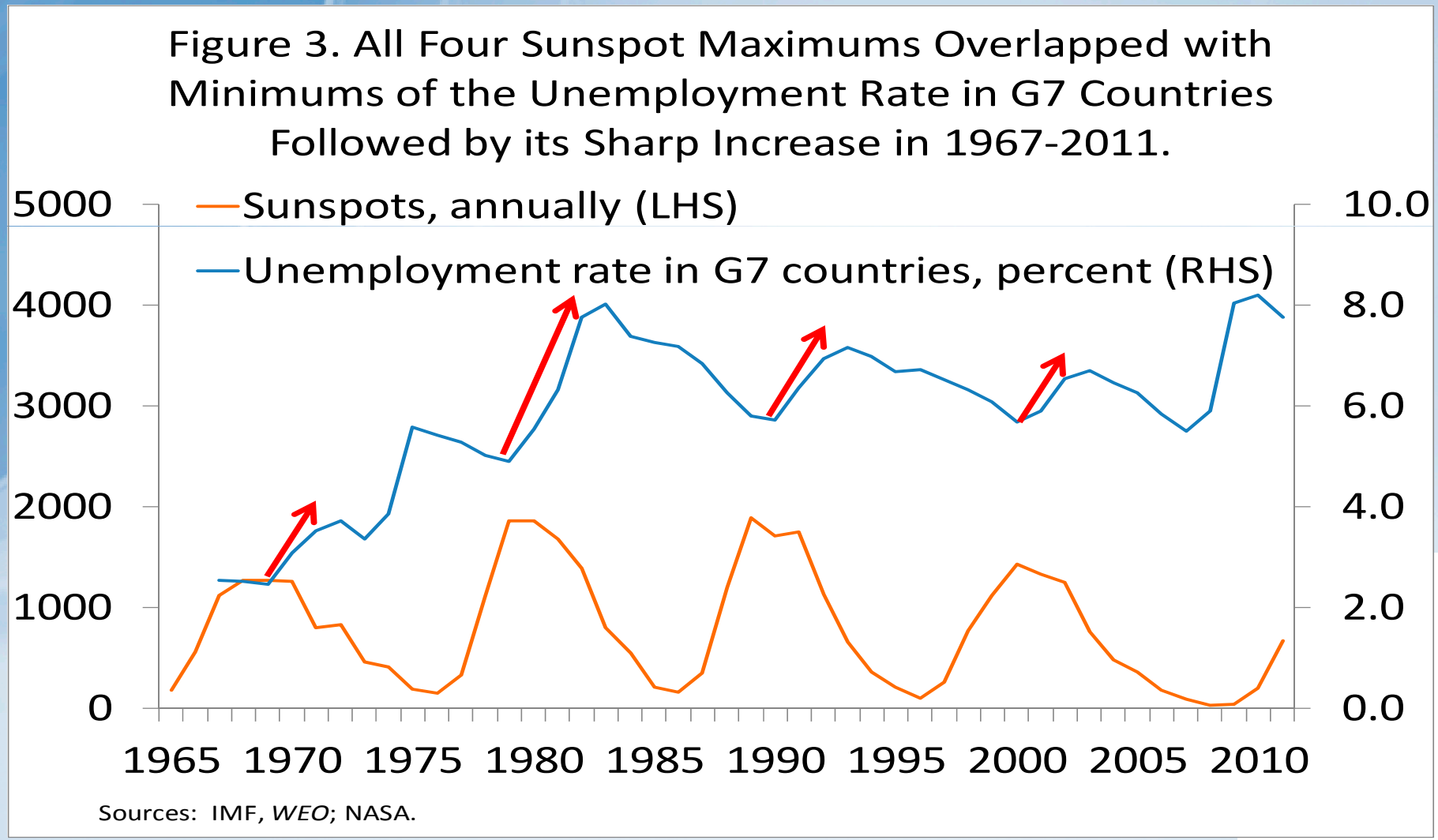
Fascinating charts: Sunspot maximums overlap with the US recessions!



… and with troughs in the US unemployment rate, before it increases!



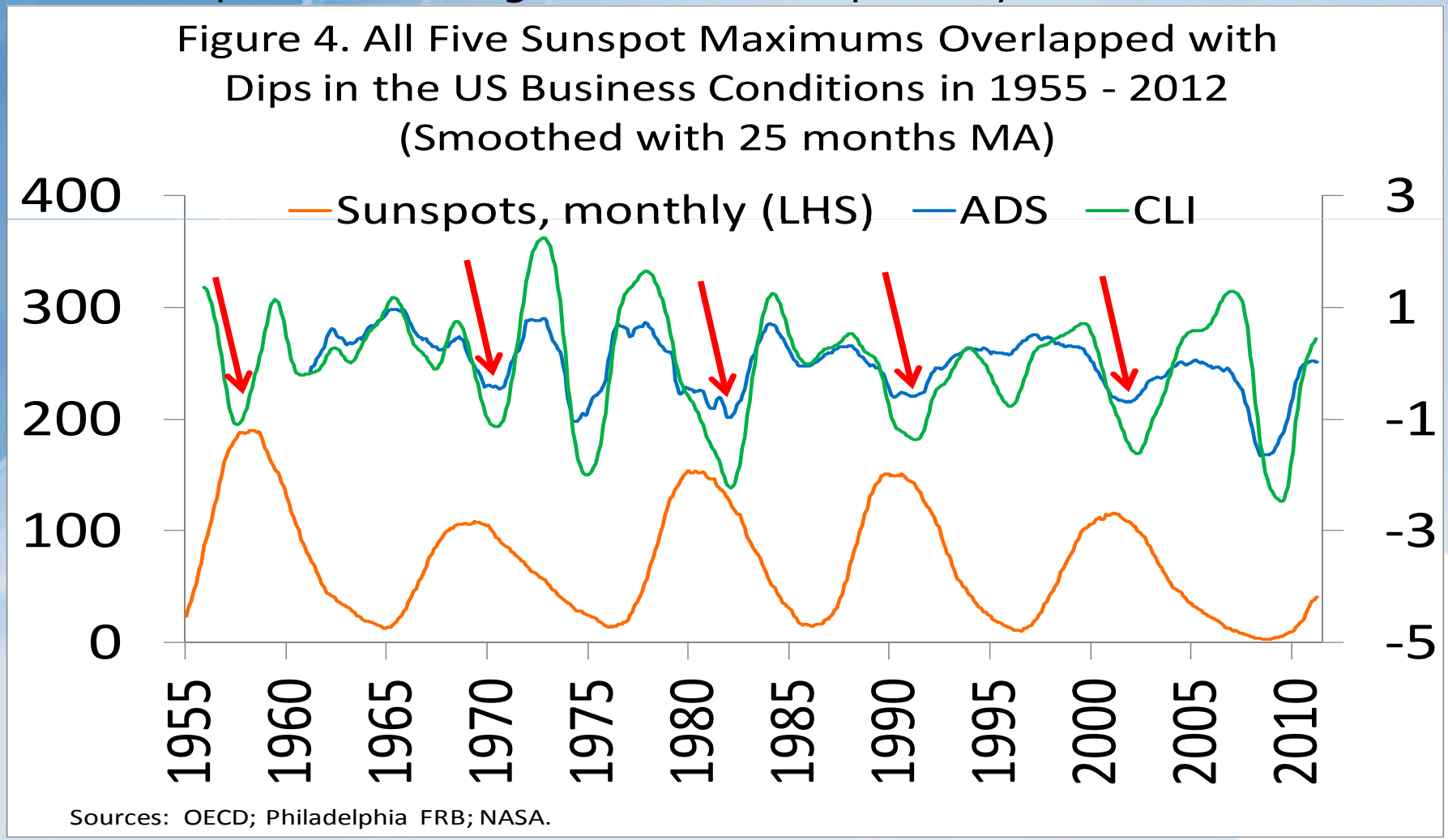
… and with troughs in the G7 unemployment rate!



The US business conditions deteriorate around sunspot maximums!

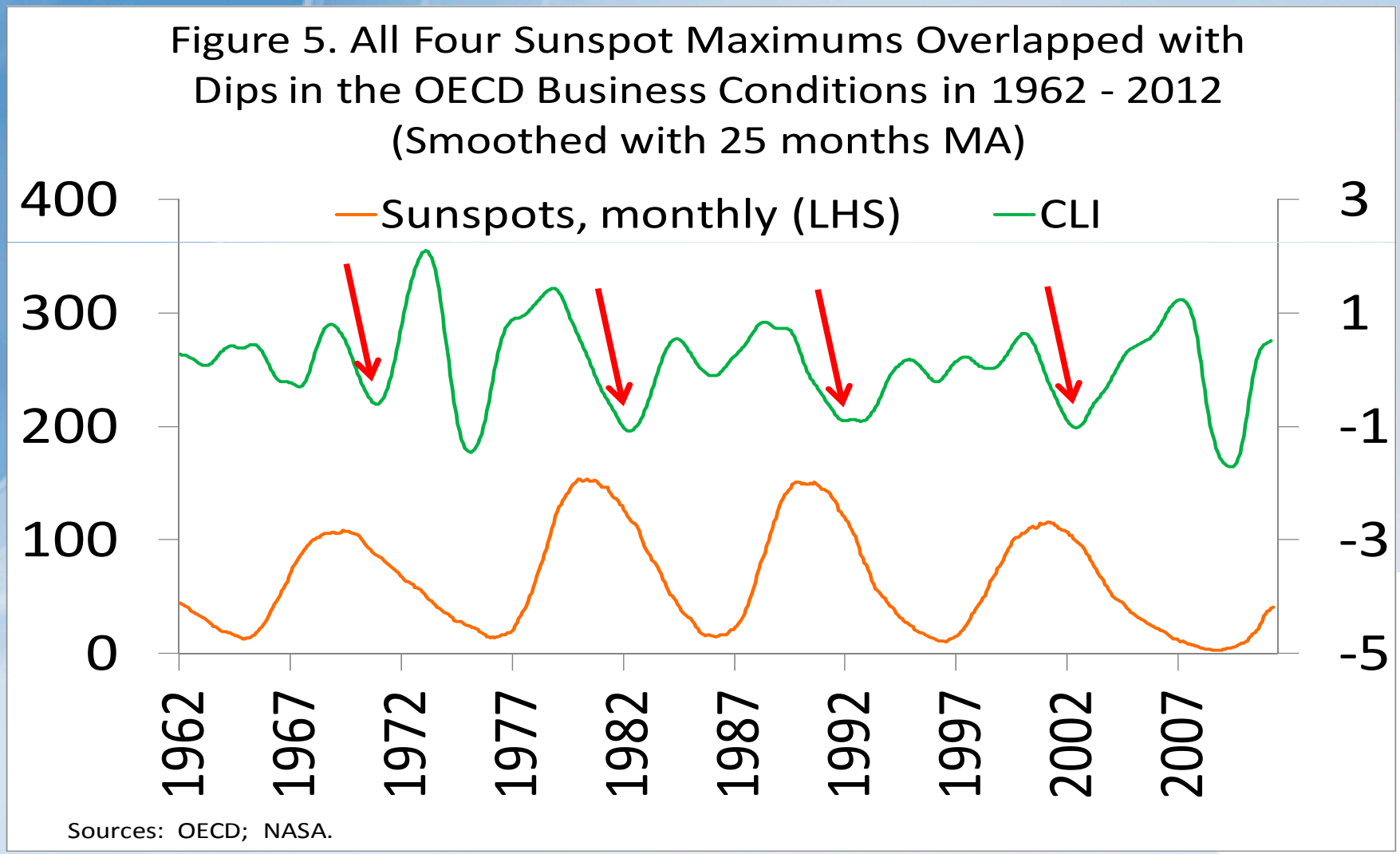
ADS: Aruoba-Diebold-Scotti Business Conditions Index

CLI: Composite Leading Indicator (compiled by OECD)



Moreover, entire OECD business conditions deteriorate as well!

CLI: Composite Leading Indicator (compiled by OECD)



Statistical tests: Do the sunspot maximums affect economic series?

Let's define a dummy variable (named "MAX_ONLY"): "1" for the periods around sunspot maximums (about ¼ of the solar cycle), "0" for other times

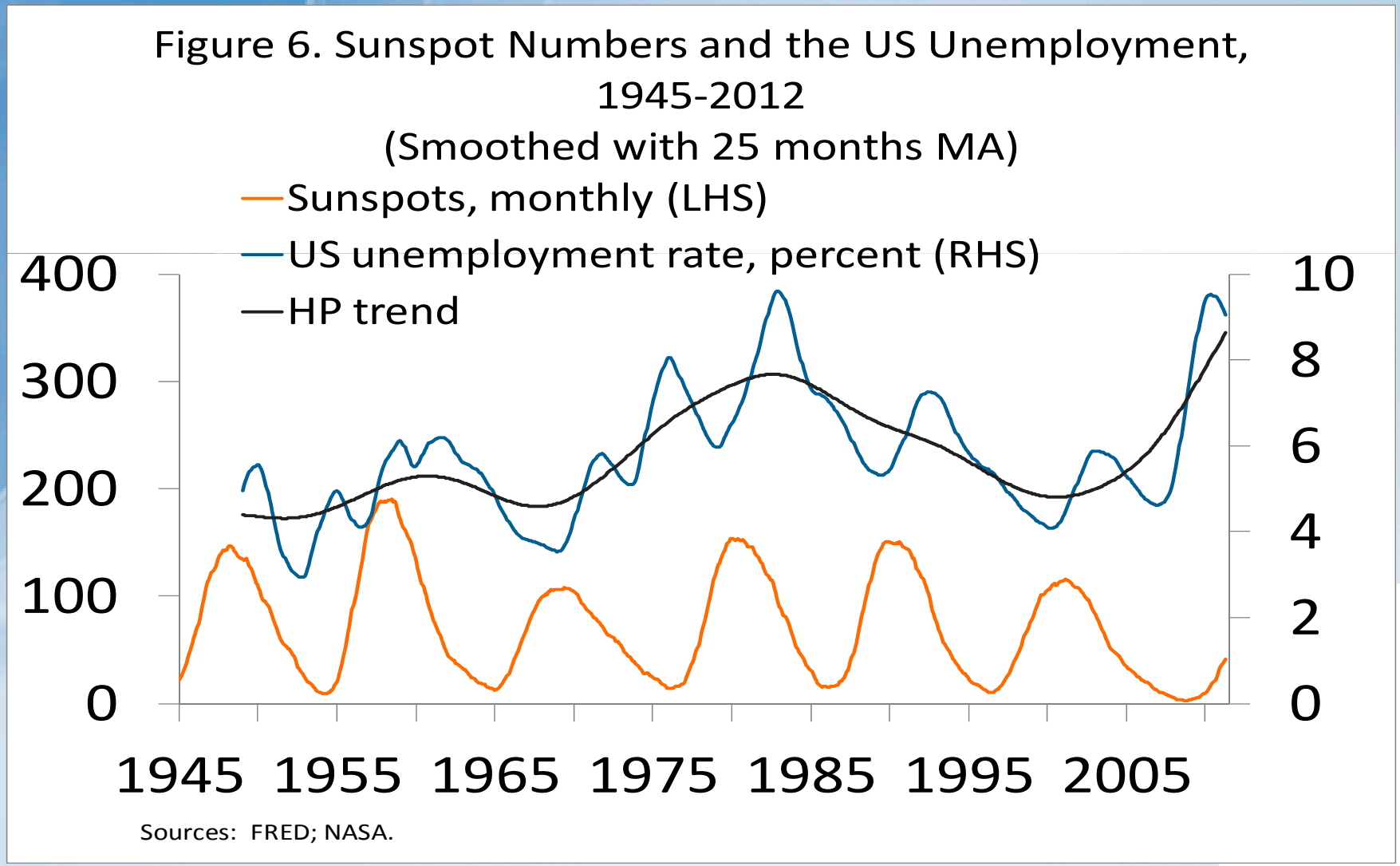
To smooth series, use 25 months moving average for monthly data, 9 quarter moving average for quarterly data

Look at significance of the lagged serial correlations and Granger causality tests

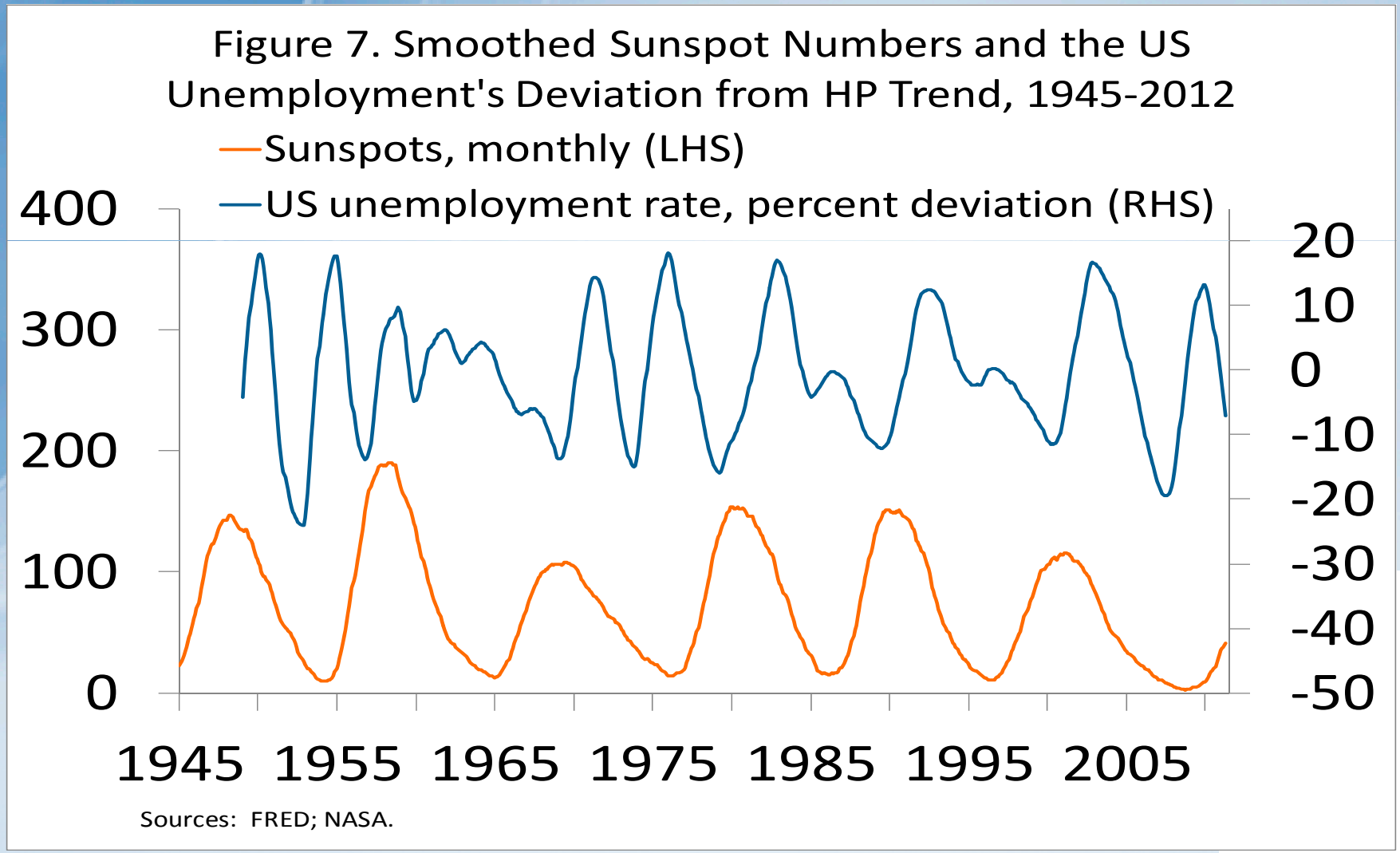
When there is a trend in the series, use first difference or deviations from the HP trend

In our tests, the null hypothesis of no causality between the sunspot maximums and selected economic series exhibiting cycle fluctuations is rejected at 1 percent or even stronger probability level!

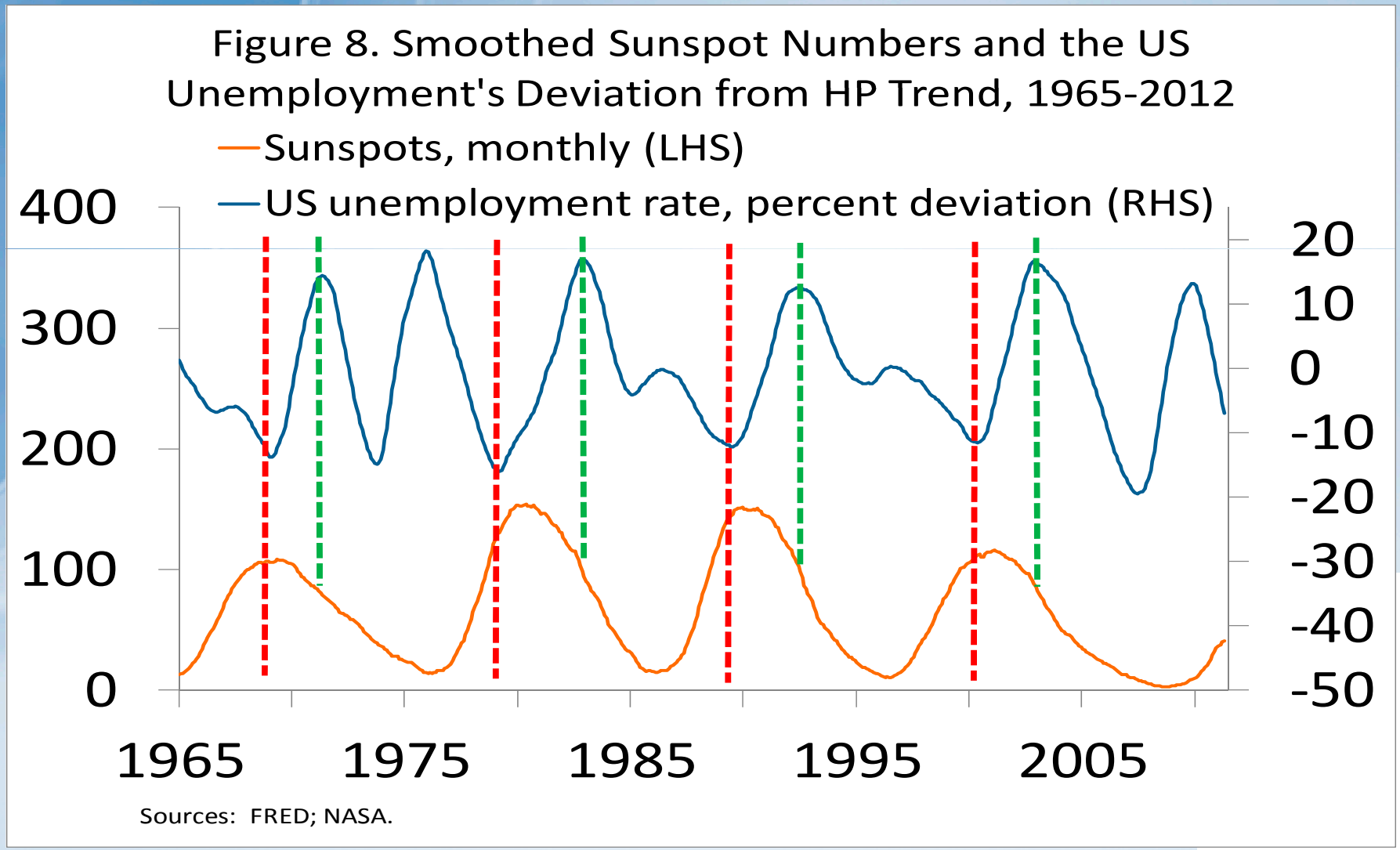
Smoothed sunspots series and US unemployment (with HP trend)



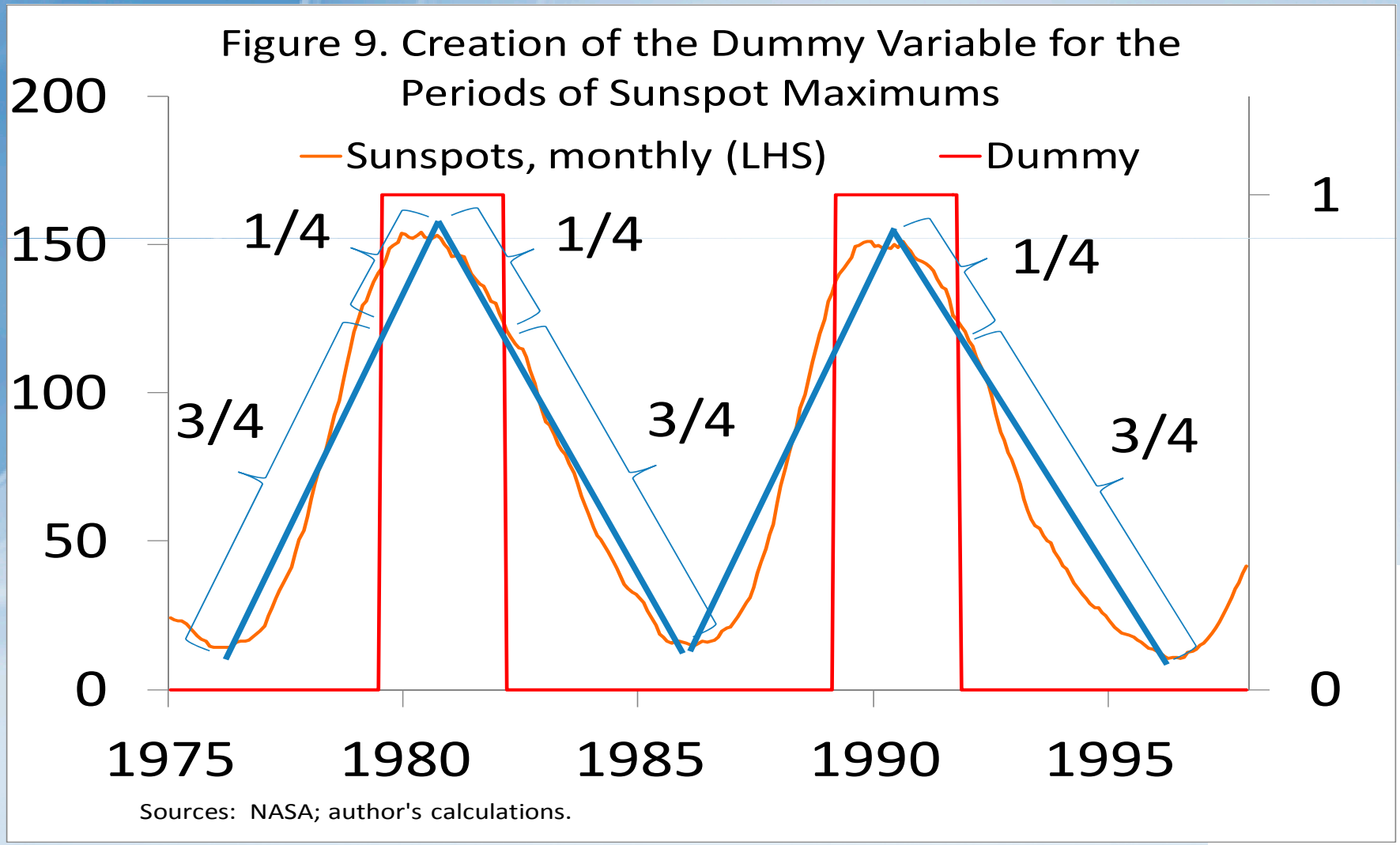
Smoothed sunspots series and US unemployment deviation from HP trend



The same chart, from 1965: we are down to two highly regular patterns!

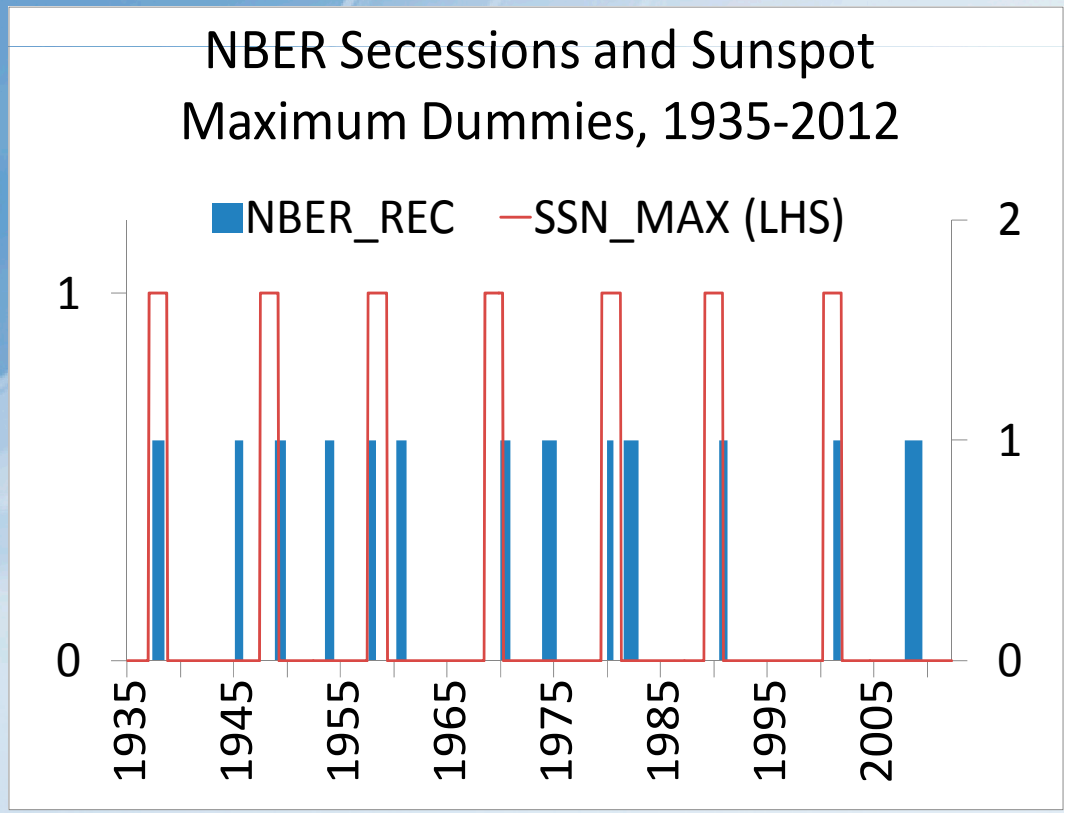


Creation of the dummy variable for the sunspots maximum periods



Sunspot maximums (MAX_ONLY) and the US recessions (NBER_REC)

Pairwise Granger Causality Tests	Lags: 1	Sample: 1935M01 2012M04	
Null Hypothesis:	Obs	F-Statistic	Prob.
MAX_ONLY does not Granger Cause NBER_REC	927	6.09266	0.0138
NBER_REC does not Granger Cause MAX_ONLY		0.23578	0.6274

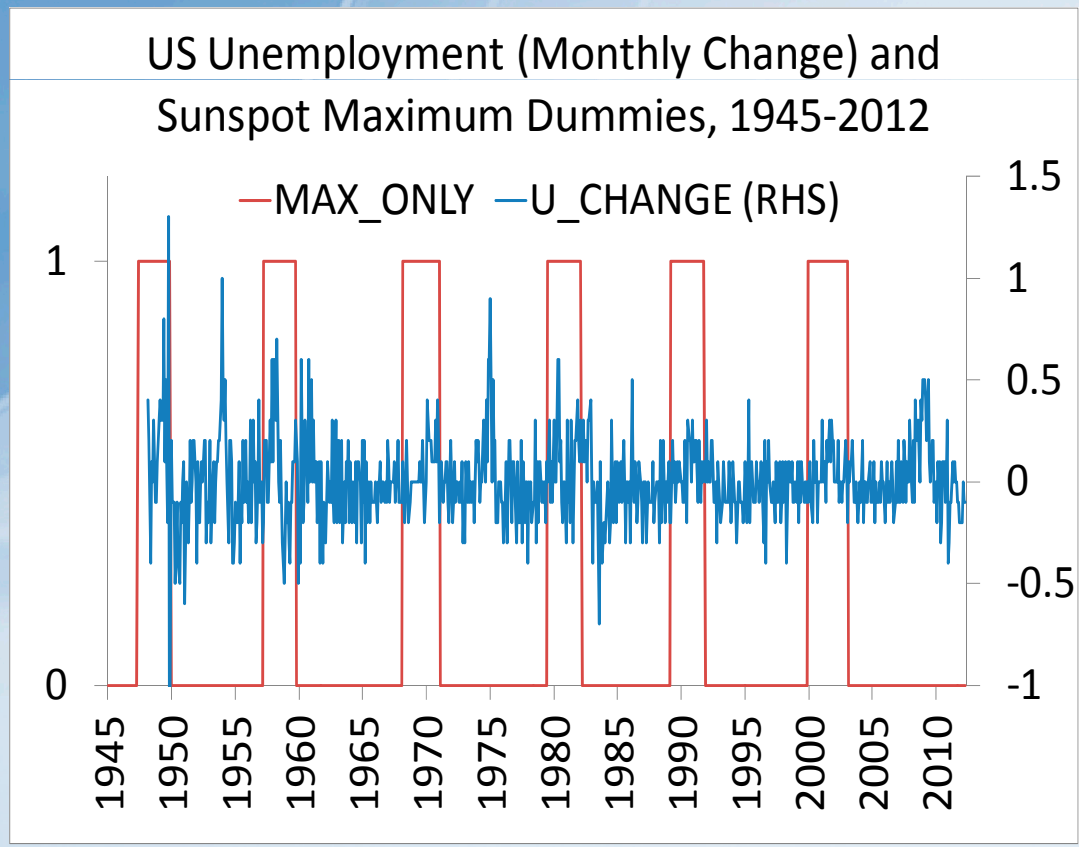


Sample: 1935M01 2012M04
Included observations: 928
Correlations are asymptotically consistent approximations

NBER_REC,MAX_ONLY(-i)	NBER_REC,MAX_ONLY(+i)	i	lag	lead
		0	0.2728	0.2728
		1	0.2792	0.2659
		2	0.2856	0.2523
		3	0.2920	0.2321
		4	0.2983	0.2118
		5	0.2981	0.1916
		6	0.2911	0.1713
		7	0.2842	0.1511
		8	0.2773	0.1242
		9	0.2703	0.1040
		10	0.2567	0.0837
		11	0.2431	0.0635
		12	0.2296	0.0432
		13	0.2160	0.0230
		14	0.2090	0.0094
		15	0.2088	-0.0108
		16	0.2018	-0.0311
		17	0.1882	-0.0447
		18	0.1680	-0.0649
		19	0.1477	-0.0785
		20	0.1275	-0.0988
		21	0.1073	-0.1190
		22	0.0870	-0.1392
		23	0.0601	-0.1595
		24	0.0332	-0.1731
		25	0.0063	-0.1855
		26	-0.0139	-0.1980
		27	-0.0342	-0.1972
		28	-0.0544	-0.2030
		29	-0.0730	-0.2022
		30	-0.0916	-0.2013
		31	-0.1035	-0.2005
		32	-0.1154	-0.1996
		33	-0.1273	-0.1988
		34	-0.1326	-0.1913
		35	-0.1312	-0.1822
		36	-0.1299	-0.1730

Sunspot maximums (MAX_ONLY) and US unemployment rate's growth (U_CHANGE)

Pairwise Granger Causality Tests	Lags: 1	Sample: 1945M01 2012M04	
Null Hypothesis:	Obs	F-Statistic	Prob.
MAX_ONLY does not Granger Cause U_CHANGE	770	21.4711	4.00E-06
U_CHANGE does not Granger Cause MAX_ONLY		2.99498	0.0839

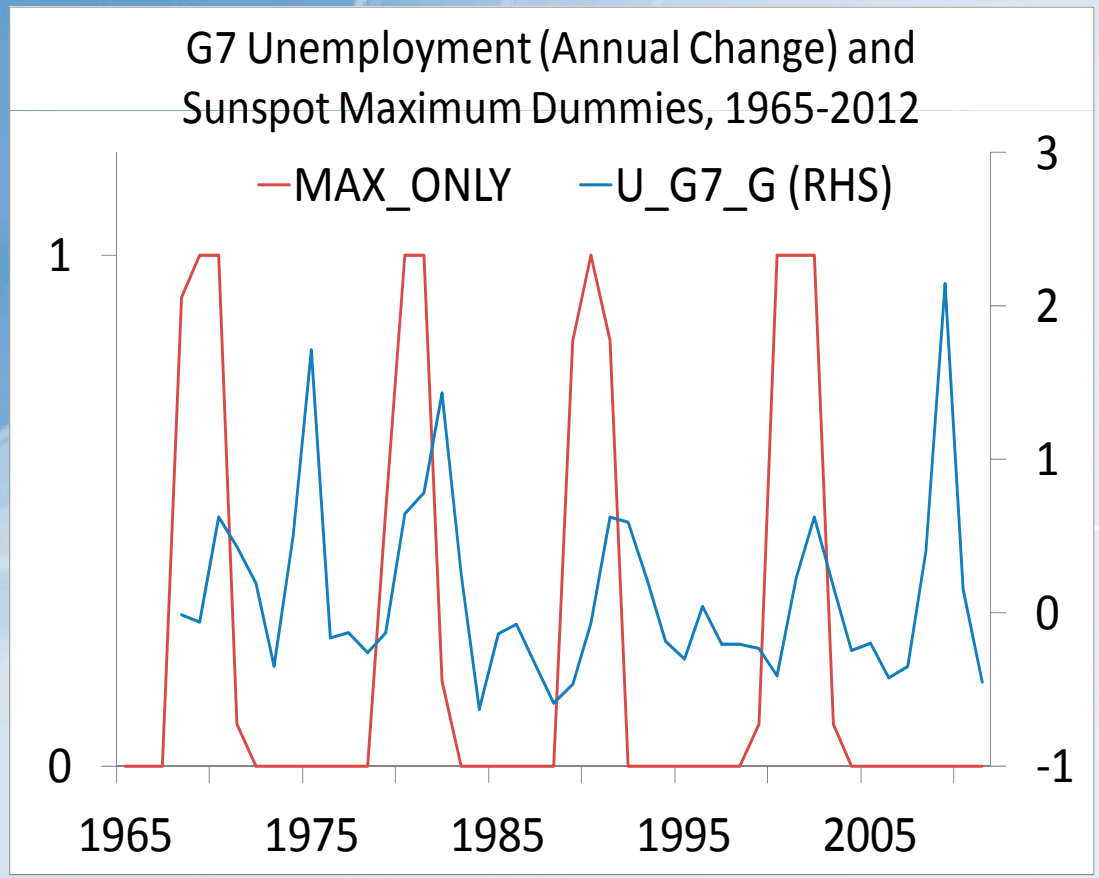


Sample: 1945M01 2012M04
Included observations: 771
Correlations are asymptotically consistent approximations

U_CHANGE,MAX_ONLY(-i)	U_CHANGE,MAX_ONLY(+i)	i	lag	lead
		0	0.1730	0.1730
		1	0.1827	0.1825
		2	0.1820	0.1528
		3	0.1760	0.1388
		4	0.1788	0.1368
		5	0.1750	0.1221
		6	0.1763	0.1145
		7	0.1689	0.1016
		8	0.1686	0.1041
		9	0.1556	0.0901
		10	0.1461	0.0832
		11	0.1187	0.0724
		12	0.0987	0.0739
		13	0.0959	0.0701
		14	0.0717	0.0600
		15	0.0671	0.0555
		16	0.0586	0.0391
		17	0.0365	0.0378
		18	0.0340	0.0248
		19	0.0259	0.0207
		20	0.0224	-0.0034
		21	0.0017	-0.0128
		22	0.0147	-0.0377
		23	-0.0043	-0.0594
		24	-0.0187	-0.0703
		25	-0.0275	-0.0798
		26	-0.0362	-0.0924
		27	-0.0422	-0.1033
		28	-0.0559	-0.1166
		29	-0.0675	-0.1251
		30	-0.0689	-0.1254
		31	-0.0791	-0.1332
		32	-0.0864	-0.1283
		33	-0.0900	-0.1350
		34	-0.0998	-0.1280
		35	-0.1023	-0.1361
		36	-0.1016	-0.1217

Sunspot maximums (MAX_ONLY) and the G7 unemployment rate's growth (U_G7_G)

Pairwise Granger Causality Tests	Lags: 1	Sample: 1965 2016	
Null Hypothesis:	Obs	F-Statistic	Prob.
MAX_ONLY does not Granger Cause U_G7_G	43	7.22116	0.0104
U_G7_G does not Granger Cause MAX_ONLY		7.3327	0.0099

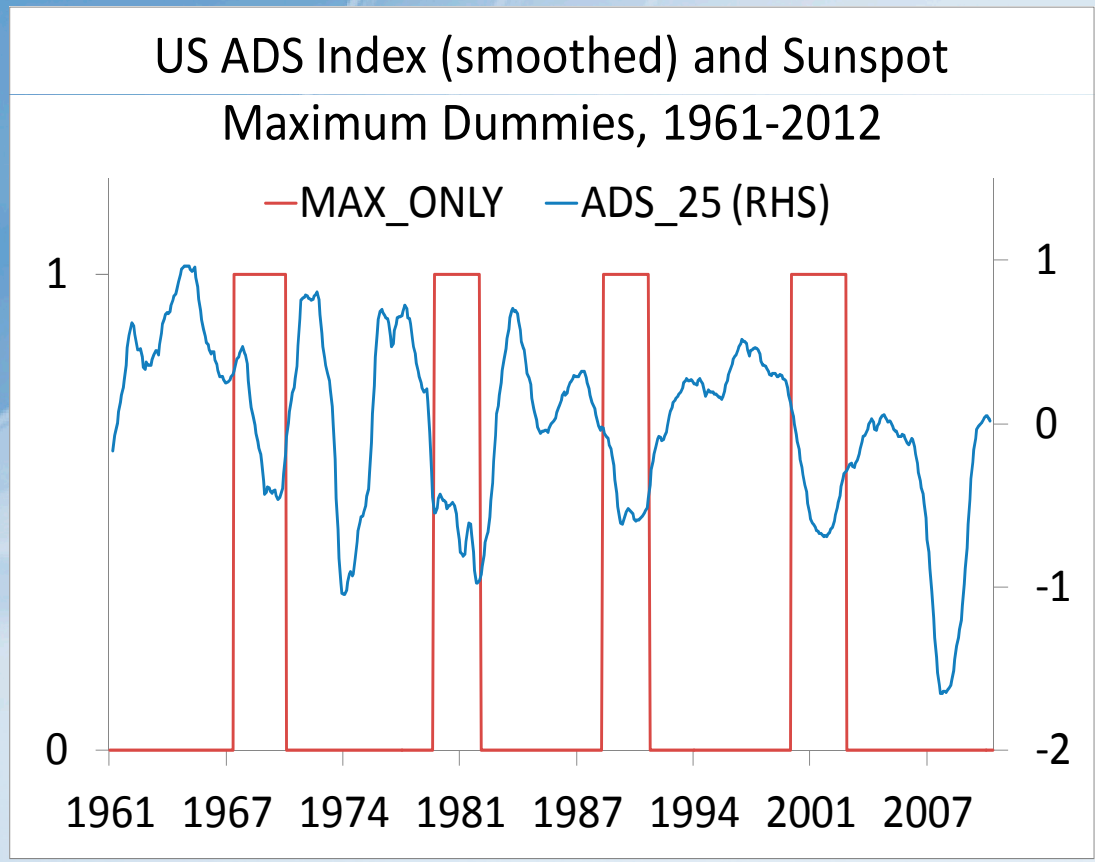


Sample: 1965 2016
Included observations: 44
Correlations are asymptotically consistent approximations

U_G7_G,MAX_ONLY(-i)	U_G7_G,MAX_ONLY(+i)	i	lag	lead
		0	0.1268	0.1268
		1	0.4028	-0.2178
		2	0.3378	-0.3544
		3	-0.0373	-0.2539
		4	-0.2401	-0.0850
		5	-0.1206	-0.0090
		6	-0.0467	0.0234
		7	0.0784	0.0344
		8	-0.0497	0.2007
		9	-0.0861	0.3647
		10	-0.0555	0.2419
		11	0.1727	0.0107
		12	0.3887	-0.2300
		13	0.2399	-0.2622
		14	-0.0121	-0.0680
		15	-0.1664	0.0438
		16	-0.1973	-0.0100
		17	-0.1531	-0.1118
		18	-0.0041	0.0270
		19	0.0165	0.2391
		20	-0.0119	0.2714

Sunspot maximums (MAX_ONLY) and ADS index for US, smoothed (ADS_25)

Pairwise Granger Causality Tests	Lags: 1	Sample: 1955M01 2012M04		
Null Hypothesis:		Obs	F-Statistic	Prob.
MAX_ONLY does not Granger Cause ADS_25		601	12.5905	0.0004
ADS_25 does not Granger Cause MAX_ONLY			0.00458	0.946

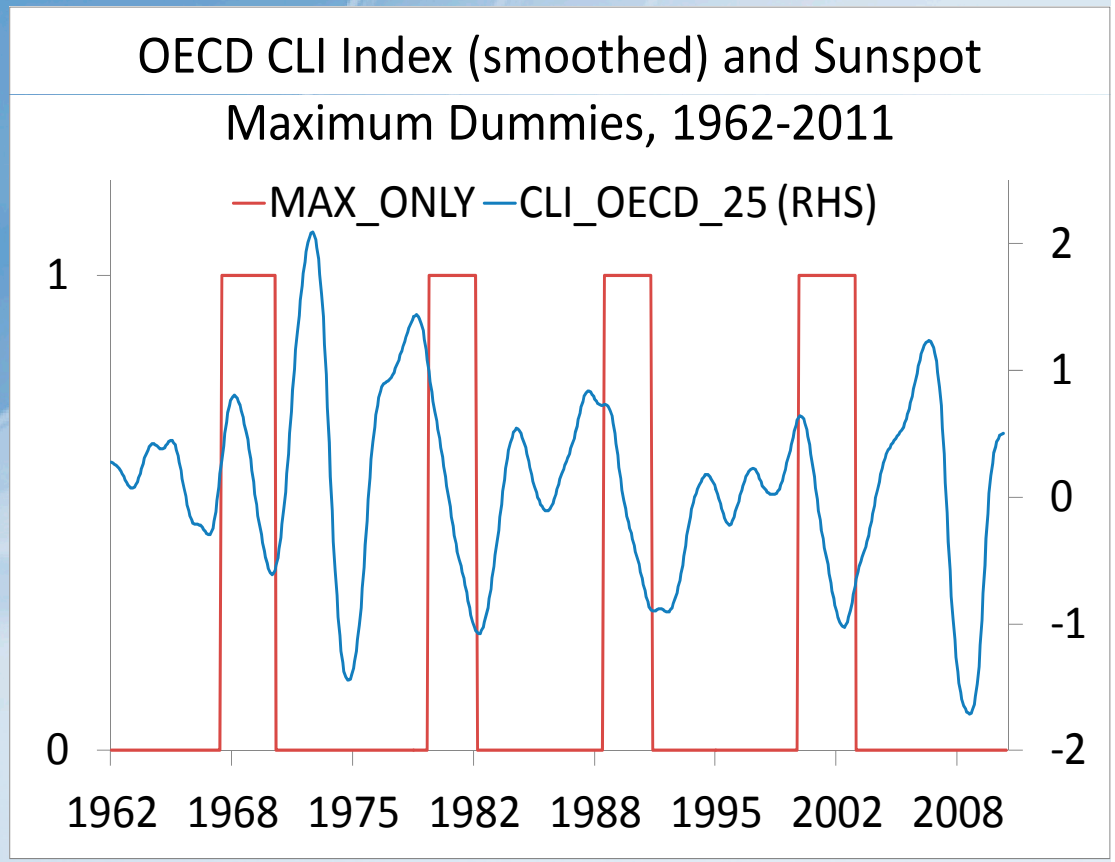


Sample: 1955M01 2012M04
Included observations: 602
Correlations are asymptotically consistent approximations

ADS_25,MAX_ONLY(-i)	ADS_25,MAX_ONLY(+i)	i	lag	lead
		0	-0.3832	-0.3832
		1	-0.3946	-0.3694
		2	-0.4037	-0.3530
		3	-0.4112	-0.3334
		4	-0.4171	-0.3119
		5	-0.4218	-0.2895
		6	-0.4253	-0.2673
		7	-0.4265	-0.2449
		8	-0.4251	-0.2220
		9	-0.4206	-0.1981
		10	-0.4118	-0.1727
		11	-0.3987	-0.1460
		12	-0.3821	-0.1186
		13	-0.3638	-0.0907
		14	-0.3438	-0.0621
		15	-0.3222	-0.0340
		16	-0.2994	-0.0065
		17	-0.2749	0.0198
		18	-0.2489	0.0457
		19	-0.2217	0.0717
		20	-0.1933	0.0977
		21	-0.1633	0.1230
		22	-0.1320	0.1476
		23	-0.1011	0.1717
		24	-0.0715	0.1947
		25	-0.0426	0.2166
		26	-0.0142	0.2368
		27	0.0135	0.2555
		28	0.0408	0.2720
		29	0.0679	0.2874
		30	0.0949	0.3029
		31	0.1208	0.3192
		32	0.1443	0.3351
		33	0.1652	0.3498
		34	0.1828	0.3634
		35	0.1965	0.3746
		36	0.2060	0.3840

Sunspot maximums (MAX_ONLY) and the OECD CLI index, smoothed (CLI_OECD_25)

Pairwise Granger Causality Tests	Lags: 1	Sample: 1962M01 2011M03	
Null Hypothesis:	Obs	F-Statistic	Prob.
MAX_ONLY does not Granger Cause CLI_OECD_25	590	69.5509	5.00E-16
CLI_OECD_25 does not Granger Cause MAX_ONLY		5.89655	0.0155

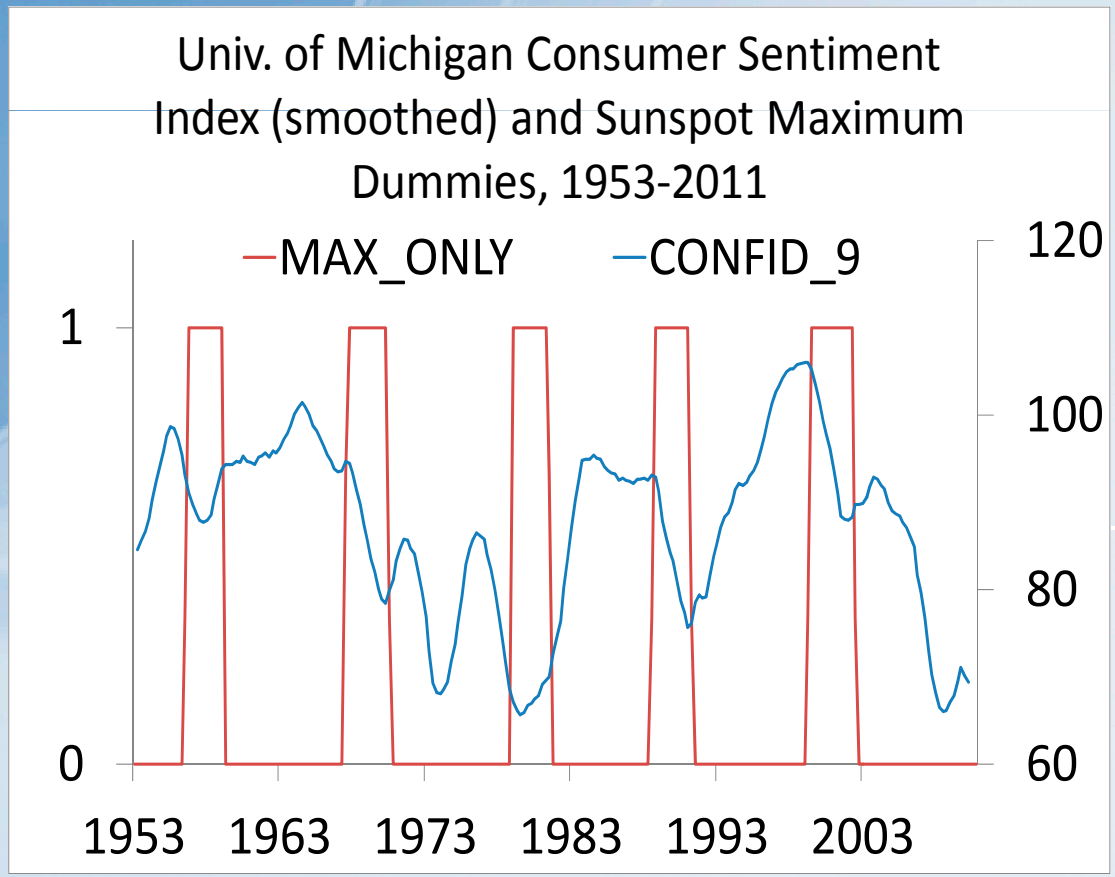


Sample: 1957M12 2012M03
Included observations: 591
Correlations are asymptotically consistent approximations

OECD,MAX_ONLY(-i)	OECD,MAX_ONLY(+i)	i	lag	lead
		0	-0.1318	-0.1318
		1	-0.1634	-0.0994
		2	-0.1946	-0.0672
		3	-0.2251	-0.0353
		4	-0.2547	-0.0041
		5	-0.2829	0.0263
		6	-0.3096	0.0558
		7	-0.3342	0.0843
		8	-0.3566	0.1116
		9	-0.3763	0.1376
		10	-0.3930	0.1623
		11	-0.4066	0.1854
		12	-0.4168	0.2068
		13	-0.4237	0.2262
		14	-0.4271	0.2436
		15	-0.4273	0.2588
		16	-0.4241	0.2717
		17	-0.4178	0.2824
		18	-0.4083	0.2909
		19	-0.3959	0.2973
		20	-0.3804	0.3017
		21	-0.3621	0.3041
		22	-0.3410	0.3049
		23	-0.3173	0.3041
		24	-0.2912	0.3019
		25	-0.2630	0.2985
		26	-0.2330	0.2939
		27	-0.2014	0.2885
		28	-0.1687	0.2821
		29	-0.1352	0.2750
		30	-0.1013	0.2672
		31	-0.0674	0.2587
		32	-0.0341	0.2495
		33	-0.0017	0.2396
		34	0.0294	0.2291
		35	0.0587	0.2180
		36	0.0859	0.2063

Sunspot maximums (MAX_ONLY) and the US consumer confidence, smoothed (CONFID_9)

Pairwise Granger Causality Tests	Lags: 1	Sample: 1953Q4 2010Q4	
Null Hypothesis:	Obs	F-Statistic	Prob.
MAX_ONLY does not Granger Cause CONFID_9	228	14.8233	0.0002
CONFID_9 does not Granger Cause MAX_ONLY		2.11499	0.1473



Sample: 1952Q4 2011Q4
Included observations: 229
Correlations are asymptotically consistent approximations

CONFID_9,MAX_ONLY(-i)	CONFID_9,MAX_ONLY(+i)	i	lag	lead
		0	-0.1415	-0.1415
		1	-0.1814	-0.0974
		2	-0.2096	-0.0464
		3	-0.2253	0.0091
		4	-0.2278	0.0675
		5	-0.2189	0.1234
		6	-0.1978	0.1754
		7	-0.1677	0.2224
		8	-0.1298	0.2631
		9	-0.0878	0.2949
		10	-0.0445	0.3177
		11	-0.0045	0.3311
		12	0.0281	0.3351
		13	0.0518	0.3305
		14	0.0702	0.3180
		15	0.0809	0.2994
		16	0.0839	0.2756
		17	0.0799	0.2480
		18	0.0711	0.2156
		19	0.0602	0.1810
		20	0.0491	0.1468
		21	0.0417	0.1112
		22	0.0401	0.0743
		23	0.0424	0.0391
		24	0.0488	0.0081
		25	0.0580	-0.0236
		26	0.0691	-0.0530
		27	0.0798	-0.0788
		28	0.0885	-0.1039
		29	0.0940	-0.1285
		30	0.0950	-0.1513
		31	0.0863	-0.1734
		32	0.0753	-0.1975
		33	0.0702	-0.2245
		34	0.0609	-0.2525
		35	0.0470	-0.2810
		36	0.0279	-0.3076

What is in the literature about it? Not much, and in the "wrong" places

William Stanley Jevons, 1870s: There is a relationship between sunspots and business cycle crises! Sunspots affect earth's weather, which influences crops and economy (Jevons, 1875, 1878).

Alexander Chizhevsky, 1920s-30s: The entire human history is influenced by the solar cycles! A significant percent of the "most important historical events" occurred around sunspot maximum. Epidemic diseases intensify and death rate increases around them. Proposed to divide the 11-year solar cycle into four periods: (1) a three year period of minimum activity; (2) a two year period during which people "begin to organize"; (3) a three year period of "maximum excitability"; (4) a three year period of gradual decrease in excitability until the people are apathetic (Chizhevsky, 1924, 1936).

Carlos Garcia-Mata and Felix I. Shaffner, 1934: There is a statistical correlation between the cycles of non-agricultural business activity in the US and the solar cycle! (Garcia-Mata and Shaffner, 1934)

Literature: More recent studies

Edward Dewey, 1968: Cycles of 43 activities fluctuated with the Sun's 11-year cycle! These included commodity and stock prices, banking and business activity, industrial production and agricultural productivity (Dewey, 1968).

Bryan Walsh, 1993: Changes in earth's geomagnetic field caused by solar activity correlate with economic and financial indicators! (Walsh, 1993).

There is a significant negative correlation between sunspot numbers and unemployment rate in Japan in 1971-2001! (Otsu et al., 2006).

The cyclical fluctuations of the banking interest rate ("prime-rate") closely followed the solar activity cycle from 1968! (Poluyakhtov and Belkin, 2011).

Related studies: Behavioral theory of the business cycle

Prof. Arthur Cecil Pigou: "the varying expectations of business men ... and nothing else, constitute the immediate cause and direct causes or antecedents of industrial fluctuations." (Pigou, 1926)

John Maynard Keynes : "the market will be subject to waves of optimistic and pessimistic sentiment, which are unreasoning and yet in a sense legitimate where no solid basis exist for reasonable calculation" (Keynes, 1936).

Nir Jaimovich, Sergio Rebelo, 2007: "Both overconfidence and expectations shocks can be potentially useful sources of volatility but are not, by themselves, sufficient to produce a successful theory of the business cycle" (Jaimovich, and Rebelo, "Behavioral theories of the business cycle", 2007).

Solar activity and business cycle: In search of the missing link

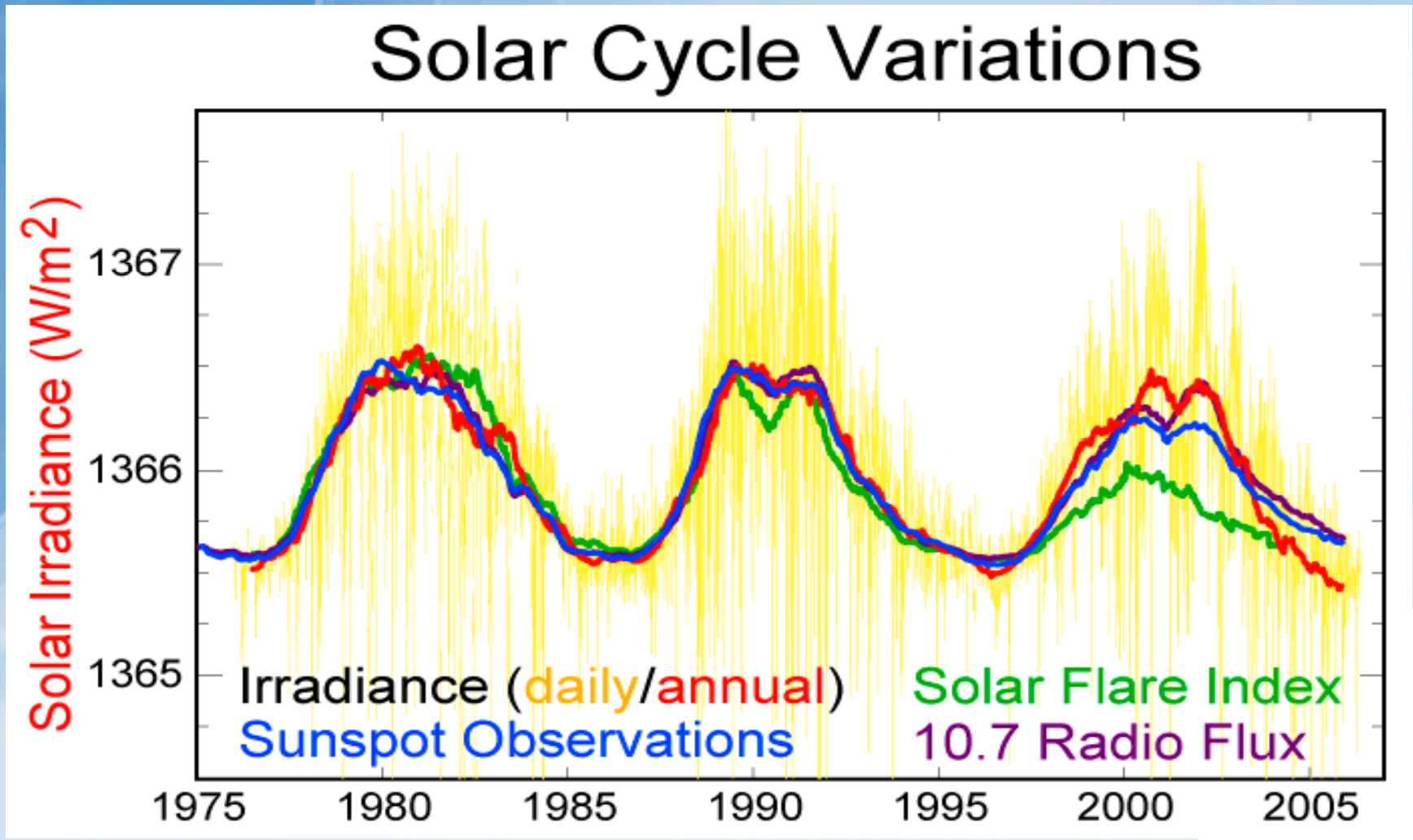
Appearance of sunspots is a visible sign of the underlying processes on the sun that can affect the earth through various channels.

Following the works of Chizhevsky, we believe that these processes can impact not only the physical conditions on the earth (like sun storms triggering magnetic storms disrupting telecommunications), but also affect human behavior. The latter can lead to changes in economic conditions, including labor productivity, consumer confidence, and unemployment.

Emission from the Sun at centimetric (radio) wavelength, at a wavelength of 10.7 cm, fluctuates along with the solar cycle. Records of its observation extend back to 1947, and is the longest direct record of solar activity available, other than sunspot-related quantities.

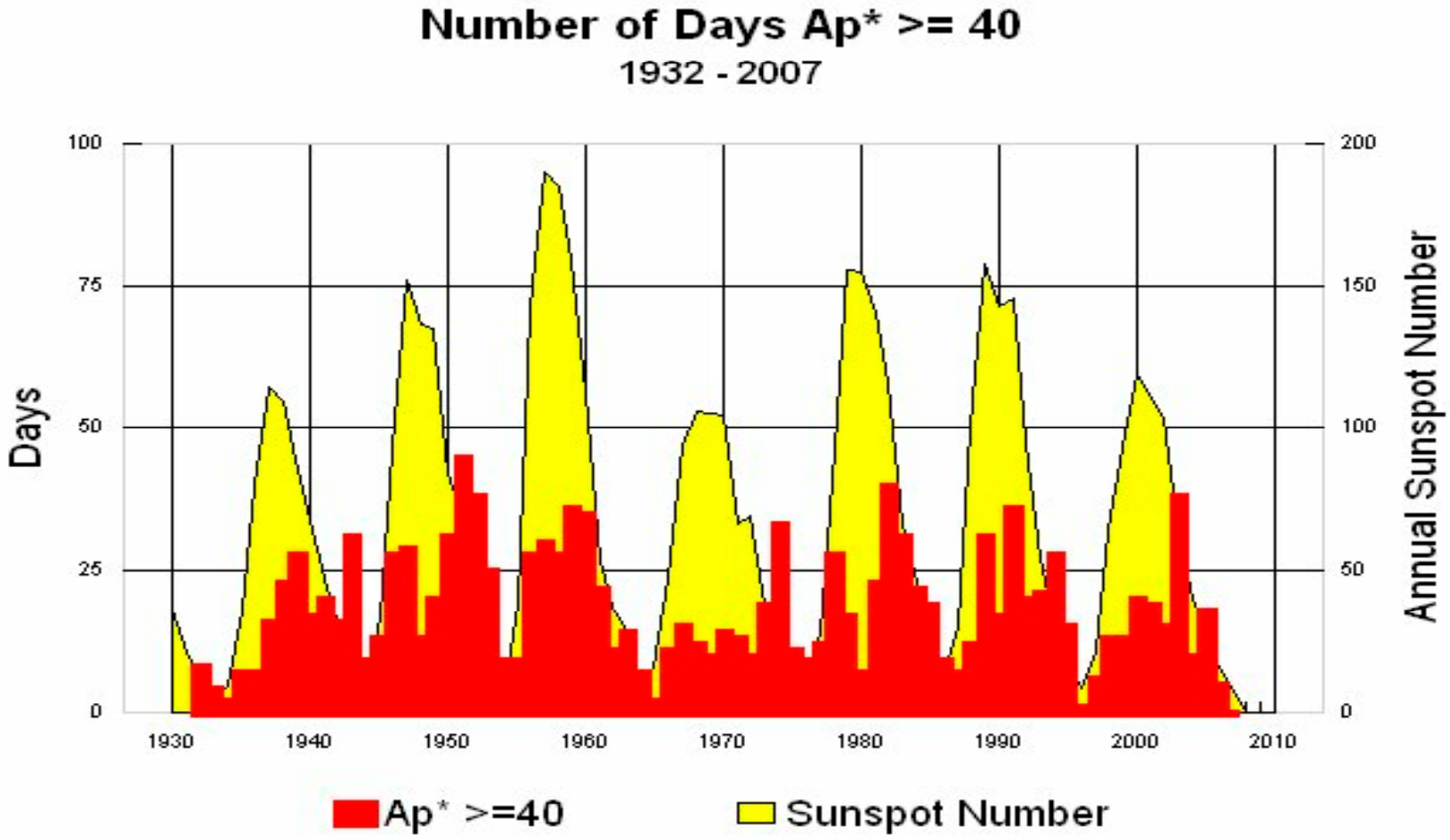
Changes in the geomagnetic field (measured by Aa, Ap, and Kp indices) closely follow solar cycle. However, the measurable impact of these changes on the economic variables is not that robust.

Solar flare, radio flux and irradiance fluctuate along with the sunspot cycle



Source: Wikipedia, http://en.wikipedia.org/wiki/Solar_cycle

Solar activity causes cyclical fluctuations in the geomagnetic field



Source: NOAA, www.ngdc.noaa.gov/stp/geomag/apstar.html

Policy and Research Implications

US recessions are very likely during the sunspot maximum periods. Recessions in other G7 countries can occur shortly after them.

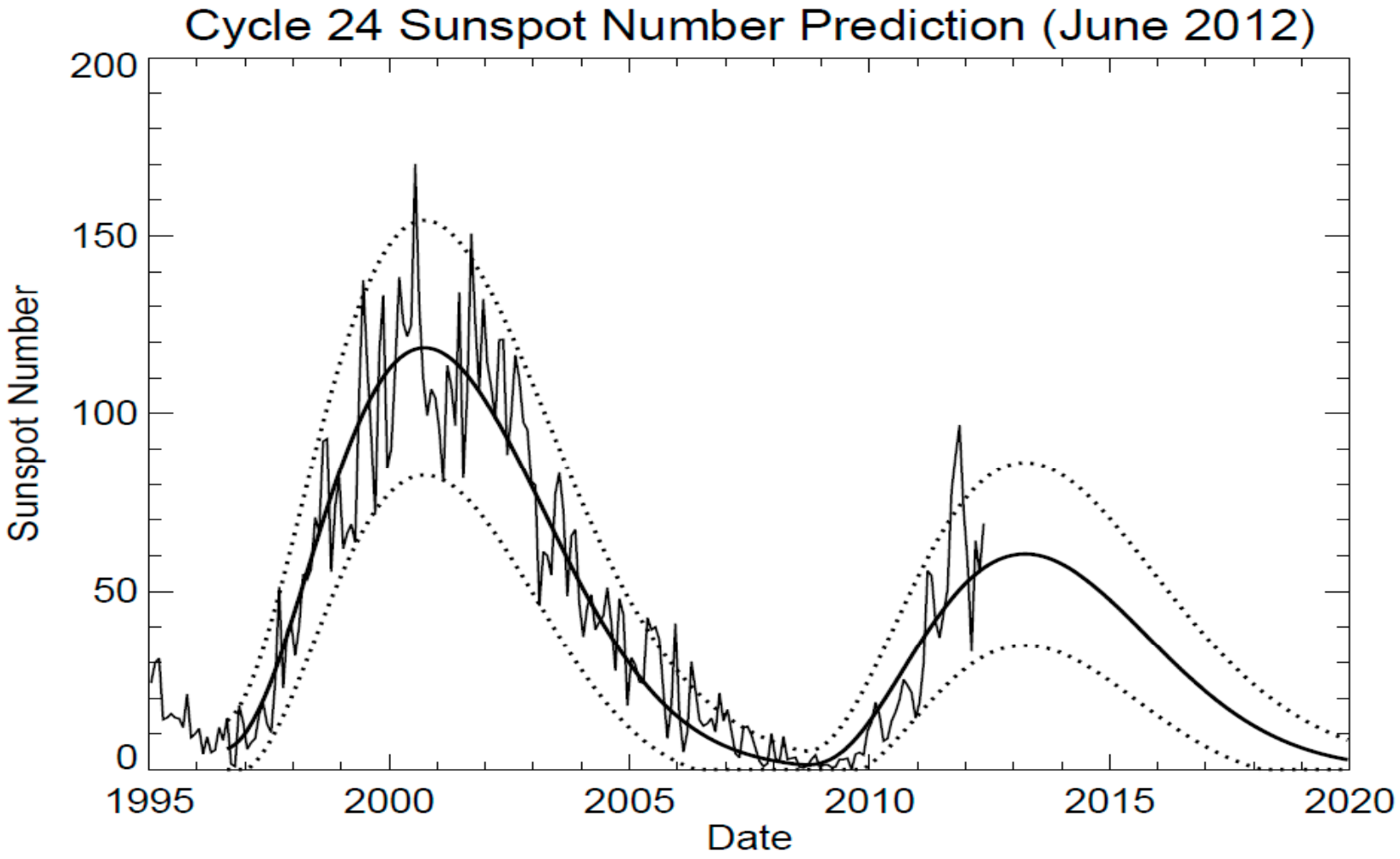
The turning point in the US unemployment rate precedes sunspot maximum by 11 months (but with a wide variation of +/- 1 year). The low points in the G7 unemployment rate can occur around those maximums.

We can link about 2/3 of the US recessions to the sunspot maximums! What about other recessions, especially those overlapping with sunspot minimums? Can we classify the US recessions by their position relative to the solar cycle?

What about using sunspot numbers in the economic cycle models?

Different economic conditions and policies for various phases of the solar cycle?

According to NASA, the unfolding 24th solar cycle will reach its maximum in Spring 2013



Source: NASA, solarscience.msfc.nasa.gov/predict.shtml