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Thomas K. Bauer, Stefan Bender, Jörg Heining, and Christoph M. Schmidt[1]

Brother Sun, Sister Moon: The Lunar Cycle, Sunspots and the Frequency of Births

Abstract

Based on multivariate linear regression models, we analyze the effect of the lunar cycle and the number of sunspots occurring on a particular day on the number of births using social security data and controlling for a number of other potential confounders. The daily number of births between 1920 and 1989 have been calculated from the full sample of individuals who have been registered at least once in the German social security system. While the lunar cycle does not affect the number of births, the number of sunspots has a positive, albeit small effect on the number of births which is decreasing over time. The empirical results may be explained by medical technological progress making natural influences on births less important over time. This interpretation is supported by the results on the intertemporal influence of weekends and holidays on the frequency of daily births.

JEL Classification: I12, J13

Keywords: Daily frequency of births; lunar cycle; sunspots

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Introduction

Many people, uneducated or educated, believe that there is something sinister about the full moon. Tales about monsters, werewolves, and vampires raised by the full moon to pursue their evil deeds still belong to traditional folklore, not only in Transylvania. Even otherwise quite sober people sometimes blame the full moon for the bad behavior of kids or for sleepless nights. One popular and persistent superstition even among nurses in obstetrics wards holds that the lunar cycle affects the onset of labor and that, consequently, the full moon raises the number of births. If this were indeed the case, it should be of considerable interest for the managers of hospitals, since then they could easily adjust the staffing to the variable workload occurring in different phases of the lunar cycle.

Among other motives, this interest has inspired researchers to investigate the effect of the lunar cycle and other natural phenomena such as, for example, precipitation, temperature variations, and barometric pressure on pregnancy and labor. (1) (2) (3) (4) (5) (6) (7) (8) Closely related papers analyzed other potential effects of the lunar cycle, such as the effect of the full moon on animal bites (9) (10), crime (11), and urinary retention (12). All these studies, however, either rely on rather small samples, are related to a single hospital or a single region only, merely cover a short time period or employ overly simple bivariate statistical tests which are prone to generate spurious results. The overall evidence appears to be mixed, with most studies finding no or at best a weak association between the lunar cycle and the frequency of births.

Natural phenomena that have been investigated less extensively are the role of geomagnetic disturbances and radiation on human health outcomes. Existing evidence indicates, for example, that solar activity is correlated with human conceptions (13) (14) (15) (16), human lifespan (17) (18) and other health outcome variables (see (13) for a review).

This paper examines the effect of the lunar and solar cycle on the daily frequency of births in Germany using a large data source covering the birth years from 1920 to 1990. We employ multivariate regression analysis in order to account for confounding factors, such as seasonal and weekly birth patterns as well as the effect of public holidays.

Data and Methods

We use the full sample of the German employment register – an administrative data set covering all persons with German nationality who have paid social security contributions for at least one day during the period from 1975 to 2008 and described in detail by (19). We excluded foreigners from the analysis because they show an unnatural clustering of birthdays at specific days, such as the first day of each month. From this sample we use the exact birthdays for more than 61.4 million individuals to calculate the number of births on each day in the period from 1920 to 1989, providing us with a total of 25,568 observations. We merged this data with the daily number of sunspots, obtained from the webpage of the Solar Influences Data Analysis Center (http://sidc.oma.be/sunspot-data/dailyssn.php), and with information on the lunar cycle, obtained from the The Munich Astro Archive (http://www.maa.mhn.de/StarDate/mondphasen.html). In total, our sample period covers about 866 repetitions of the lunar cycle.

Figure 1: Daily number of sunspots, 1920 – 1989

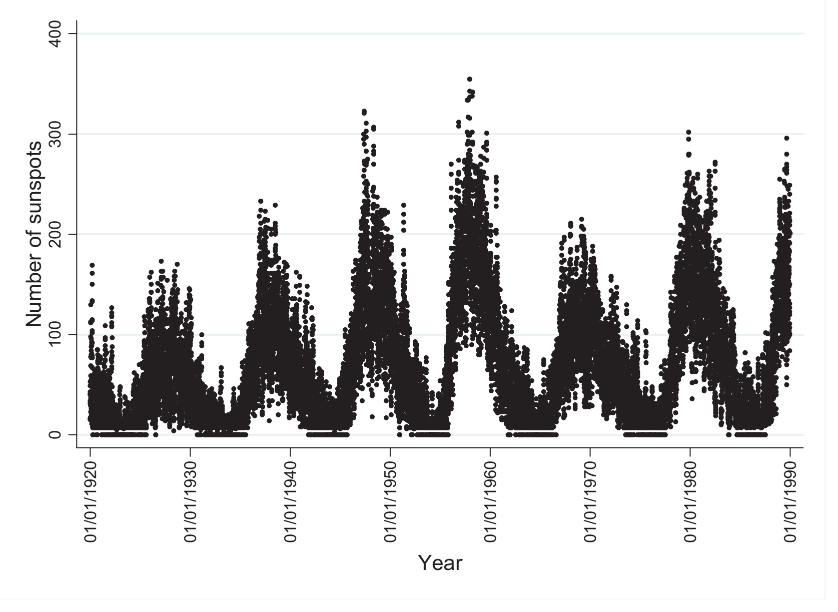

Figure 2: Daily number of births

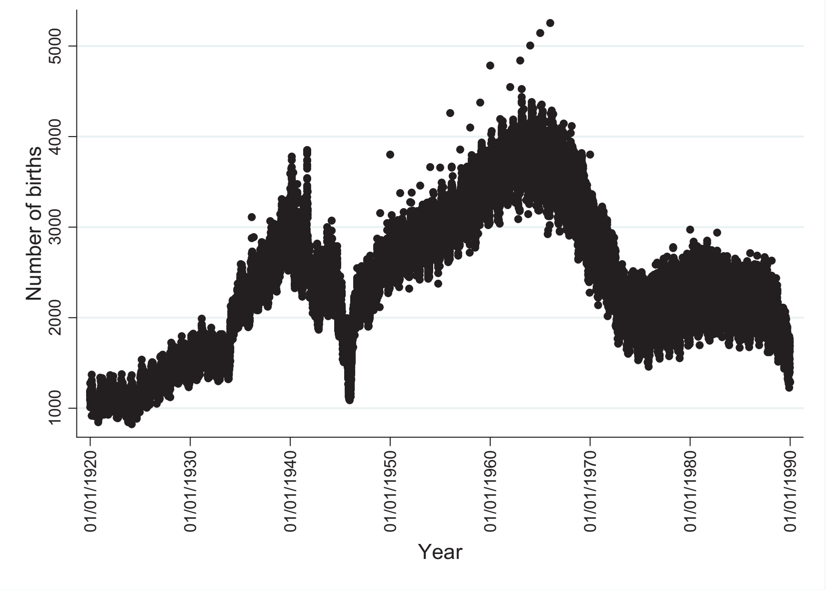

Figure 1 shows the number of sunspots for every day covered by the data. It clearly shows the well documented 11-year cycle of sunspots, double-peaking for about three years in every cycle. [20] The average daily number of sunspots in our data is 66, ranging from no sunspots on 2589 days to a maximum of 355 sunspots occurring on the 24th and 25th of December 1957. Figure 2 depicts the development of the number of daily births in our sample period. It shows the increasing number of births until 1940, the drop in births at the end of World War II, the increasing fertility thereafter, culminating in the baby boom in the 1960s, and finally the drop in the number of births associated, among others, with the invention of the oral contraceptive pill. The mean number of daily births in our sample is 2400, ranging from a minimum number of 823 to a maximum number of 5250.

To determine the effect of the lunar and solar cycle on the frequency of births, we estimate linear multivariate regression models by ordinary least squares using the logarithm of the daily number of births as dependent variable and the logarithm of the number of sunspots as well as a series of dichotomous variables indicating three of the four states of the lunar cycle (new moon, first quarter and full moon, with last quarter acting as reference group) as explanatory variables. In the multivariate regression models we also control for a number of potential confounding factors. It appears to be important, for example, to take potential effects due to the clustering of induced labors and elective C-sections on particular days or weekend effects into account. [21] The model therefore includes a series of dichotomous variables indicating the day of the week, with Wednesday being the reference group, as well as dichotomous variables for the most important German holidays. We further include a series of indicator variables for the month of birth as well as 69 dummies for the respective years of birth, to control for potential seasonal patterns within a particular year as well as the long-term development of fertility in our sample period.

Results

Box-Plots [22] of the relationship between the logarithm of daily births and the lunar cycle (figure 3) indicate that there is no evident relationship between the moonphases and the number of births. The predicted relationship (and a 95 % confidence interval) between the daily number of births and the daily number of sunspots resulting from a bivariate regression together with a scatter plot of the two variables is shown in figure 4. By contrast to the lacking association with the lunar cycle there is a statistically significant positive association between the two variables.

In order to explore whether the association between the number of births and the lunar and solar cycle documented in figures 3 and 4 are confirmed when controlling for other potential confounding factors for the number of births, table 1 shows the results from multivariate regression models for our full sample of births between 1920 and 1989 (column (1)) as well as the subsample of births occurring between 1920 and 1949, 1950 and 1969, and 1970 and 1989 (columns (2) to (4)). The estimation results confirm the exploratory statistical analysis of figures 3 and 4. The estimated coefficients of the three dichotomous variables describing the lunar cycle are not statistically significantly different from zero for any period considered. According to the results of the appropriate F-test, the null hypothesis that the estimated coefficients of these three variables are jointly zero is not rejected for any of these samples at conventional levels of significance.

Figure 3: Logarithm of Daily Number of Births and Moonphases

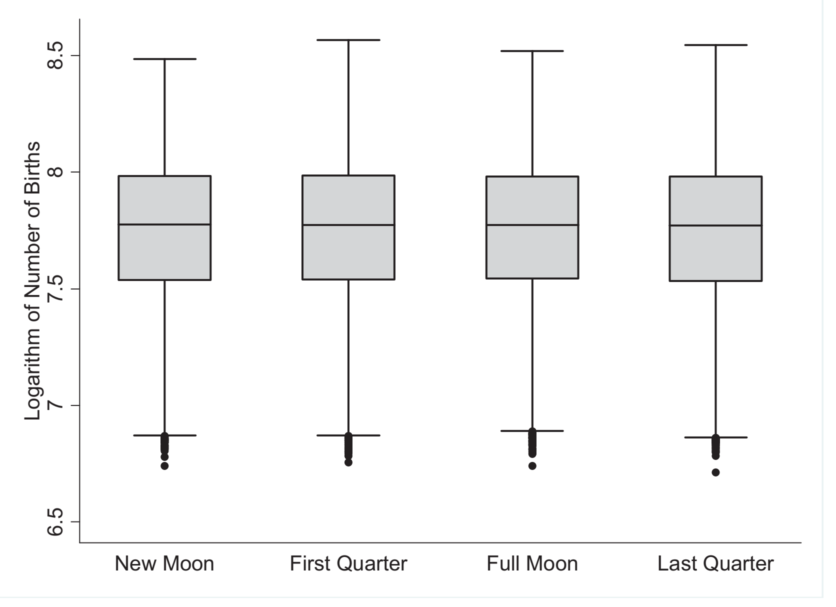

Figure 4: Logarithm of Daily Number of Births and Sunspots

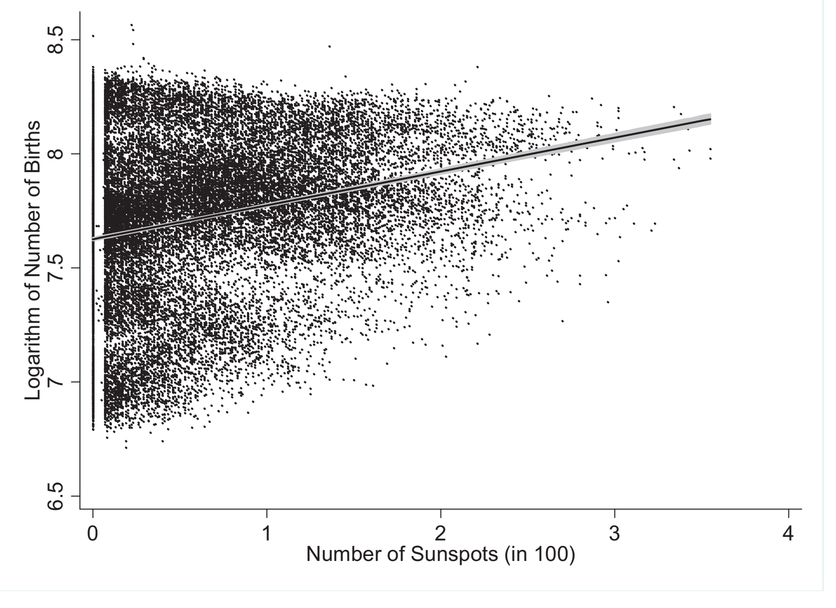

Table 1: Regression Results; Dependent Variable: Logarithm of Daily Number of Births

Column	(1)	(2)	(3)	(4)
Sample	All Years	1920-1949	1950-1969	1970-1989
Number of Sunspots	0.0031**	0.0068***	0.0008	0.0008
	(0.0015)	(0.0024)	(0.0015)	(0.0017)
Moonphases				
First Quarter	-0.0005	-0.0015	-0.0010	0.0013
	(0.0013)	(0.0020)	(0.0015)	(0.0016)
Full Moon	-0.0001	-0.0017	-0.0009	0.0030*
	(0.0013)	(0.0020)	(0.0015)	(0.0016)
Last Quarter	-0.0013	-0.0011	-0.0024*	0.0002
	(0.0013)	(0.0020)	(0.0015)	(0.0016)
Weekdays				
Sunday	-0.0455***	0.0476***	-0.0233***	-0.2074***
	(0.0017)	(0.0026)	(0.0019)	(0.0021)
Monday	-0.0088***	-0.0114***	-0.0026	-0.0111***
	(0.0017)	(0.0026)	(0.0019)	(0.0021)
Tuesday	-0.0004	-0.0173***	-0.0026	0.0272***
	(0.0017)	(0.0026)	(0.0019)	(0.0021)
Thursday	0.0100***	0.0176***	0.0119***	-0.0028
	(0.0017)	(0.0026)	(0.0019)	(0.0021)
Friday	0.0169***	0.0161***	0.0194***	0.0158***
	(0.0017)	(0.0026)	(0.0019)	(0.0021)
Saturday	-0.0186***	0.0276***	0.0104***	-0.1166***
	(0.0017)	(0.0026)	(0.0019)	(0.0021)
Holidays				
New Year	0.1210***	0.1100***	0.2171***	0.0427***
	(0.0090)	(0.0135)	(0.0100)	(0.0108)
Easter	-0.0354***	-0.0005	-0.0259***	-0.0966***
	(0.0047)	(0.0071)	(0.0052)	(0.0056)
Low Sunday	-0.0269***	-0.0002	-0.0192***	-0.0751***
	(0.0053)	(0.0080)	(0.0059)	(0.0064)
Christmas	-0.0420***	0.0244***	-0.0248***	-0.1594***
	(0.0054)	(0.0081)	(0.0060)	(0.0064)
Ascension Day	-0.0323***	0.0339*	-0.0192*	-0.1067***
	(0.0102)	(0.0197)	(0.0101)	(0.0109)
Labour Day	0.0014	0.0319	0.0268***	-0.0621***
	(0.0100)	(0.0225)	(0.0100)	(0.0108)
National Day	-0.0079	0.0074	0.0065	-0.0362***
	(0.0074)	(0.0178)	(0.0074)	(0.0076)
Constant	6.9715***	6.9504***	7.9971***	7.5202***
	(0.0044)	(0.0050)	(0.0033)	(0.0044)
F(First Quarter = Full Moon = Last Quarter = 0)	0.39	0.29	0.93	1.49
[Prob<F]	[0.7610]	[0.8338]	[0.4256]	[0.2164]
Observations	25,568	10,958	7,305	7,305
Adjusted R^2	0.9569	0.9552	0.8854	0.8938

Notes: Standard errors in parentheses; ***: Statistically significant different from zero at a level of significance of 1%; **: Statistically significant different from zero at a level of significance of 5%; *: Statistically significant different from zero at a level of significance of 10%. All regressions include eleven dichotomous variables indicating the month and a series of dichotomous variables indicating the year of birth.

By contrast to the lunar cycle, the solar cycle shows a statistically significant positive, albeit small effect on the number of births. According to the estimated coefficient in column (1) of table 1, the occurrence of some 60 additional sunspots, approximately one standard deviation in the distribution of sunspots, increases the number of births by about 0.002 % or – evaluated at the average daily number of births – by almost 5 births. Most importantly, this effect appears to decrease over time. While a one-standard-deviation increase in the number of sunspots raised the daily number of births on average by more than 0.004 % before 1950, the effect decreased to less than 0.0005 % after 1950, not even being statistically significant different from zero in the later period. These results suggest that there is a natural influence of the sun on the frequency of births, but that this effect has disappeared as medical technological progress increasingly widened the gynecological possibilities to control the timing of births.

This interpretation is supported by the results for the other factors determining the frequency of births. Overall, births appear to be less likely on weekends as well as holidays (column (1) of table 1). There is, however, a remarkable intertemporal pattern. The estimated coefficients suggest that births at weekends became subsequently less likely over time. For example, before 1950 some 4.6 % more babies have been born on Sundays than on Wednesdays, while in the 1970s and 1980s some 20.7 % fewer babies have been born on Sundays than on Wednesdays. A similar pattern appears for Saturdays and most of the holidays. While 2.4 % more babies have been born on Christmas than on average between 1920 and 1949, almost 16 % fewer babies have been born on Christmas than on average between 1970 and 1989. Again this development may be explained by improved possibilities of medical treatment, increasing the options to avoid births at days with a relatively low staffing at obstetric wards.

The results for the dichotomous variables describing the month and year of birth, which are not shown in table 1 but are available from the authors upon request, are in accordance with existing evidence. Specifically, birth frequencies in our data show the usual seasonal pattern, being more likely at the beginning of the year starting in February and less likely in midsummer and at the end of the year. Furthermore the estimated coefficients of dichotomous variables describing the year of birth reflect the overall development of birth rates in Germany with lower rates in the great depression in the 1920s and the baby boom in the 1960s.

Finally, the explanatory power of our regression model decreases over time and hence, also supports our interpretation that improved medical technology decrease the impact of natural factors determining the number of births. While the adjusted R^2 indicates that we are able to explain more than 95 % of the variation of our dependent variable for persons born before 1950, the same model explains only about 89 % of the variation of the number of daily births in the 1970s and 1980s.

Discussion

Confirming existing evidence for other countries, the frequency of births in Germany does not seem to be related to the lunar cycle. However, births are apparently related significantly to the number of sunspots, even though in quantitative terms the effect of the solar cycle on births is small. Hence, while our results may help warding off the common superstitions regarding the effects of the lunar cycle, our results may support other, albeit less common beliefs about the influence of the sun on human fortune.

Our empirical analysis makes strong efforts to avoid that we just measure a statistical artifact. We use a huge sample covering almost the entire German population born between 1920 and 1989. Hence, biased estimation results due to sample selection problems do not appear to be a problem. Also, by using multivariate regression analysis that controls for a vast number of potential confounding factors, we try to avoid problems of spurious regression. Nevertheless, we may have missed some potential other determinants of the daily frequency of the number of births that might be correlated with the number of sunspots. Even though consistent scientific results are still missing, it may be the case that sunspots influence the climate, i.e. temperature, humidity or barometric pressure. To the extent that these variables also affect births, our empirical results may be biased. Overall, our results suggest that further statistical and medical investigations of the determinants of births should concentrate more on the solar and not on the lunar cycle.

Our results convey two messages, one instigating hope in human progress and the other melancholy. Most importantly, we find ample reason to strengthen our confidence in modern era health systems. Natural phenomena, it is true, shape human experience in fundamental ways, even influencing the day of birth. Since in modern societies health care is systematically organized according to the work week, with lower staffing of hospitals on weekends, the divergence between nature and human organization could generate problems. Mothers who are following nature's course which at least to some extent is influenced by the solar cycle, and go into labor on a weekend, might receive less obstetric attention, since hospital staffing is governed by human rules instead. But at the same time as the organization of health systems has adapted to the demands of a modern economy, technological capacities have improved in step, and the influence of the solar cycle on the timing of births has effectively been eliminated. But as much as we might celebrate the effective and equitable treatment which modern health systems offer their clients, this conclusion does not justify an unqualified apotheosis of progress. Better health care delivery, it seems, is unavoidably accompanied by losing yet another facet of the diversity of human existence.

References

1. **Abell, George O. and Greenspan, Bennett.** Human Births and the Phase of the Moon. N Engl J Med. 1979; 300(2): 96.

2. **Arliss, Jill M., Kaplan, Erin N. and Galvin, Shelley L.** The Effect of the Lunar Cycle on Frequency of Births and Birth Complications. Am J Obstet Gynecol. 2005; 192(5): 1462-4.

3. **Cesario, S. K.** The "Christmas Effect" and other Biometerologic Influences on Childbearing and the Health of Women. J Obstet Gynecol Neonatal Nurs . 2002; 31(5): 526-35.

4. **Joshi, R., et al.** Labor Ward Workload Waxes and Wanes with the Lunar Cycle, Myth or Reality? *Primary Care Update for OB/GYNS.* 1998; 5(4): 184.

5. **Marks, J, Church, C. K. and Benrubi, G.** Effects of Barometric Pressure and Lunar Phases on Premature Rupture of the Membranes. J Reprod Med. 1983; 28(7): 485-8.

6. **Morton-Pradhan, Susan, Bay, Curtis R. and Coonrod, Dean V.** Birth Rate and its Correlation with the Lunar Cycle and Specific Atmospheric Conditions. Am J Obstet Gynecol. 2005; 192(6): 1970-3.

7. **Nalepka, Claire D., Jones, Susan L. and Jones, Paul K.** Time Variations, Births, and Lunar Association. *Issues in Comprehensive Pediatric Nursing.* 1983; 6(2): 81-9.

8. **Witter, F. R.** The Influence of the Moon on Deliveries. Am J Obstet Gynecol. 1983; 145(5): 637-9.

9. **Bhattacharjee, Chanchal, et al.** Do Animals Bite More During a Full Moon? Retrospective Observational Analyses. *BMJ.* 2000; 321: 23-30.

10. **Chapman, Simon and Morrell, Stephen.** Barking Mad? Another Lunatic Hypothesis Bites the Dust. *BMJ.* 2000; 321: 23-30.

11. **Thakur, C. P. and Sharma, Dilip.** Full Moon and Crime. *BMJ.* 1984; 289(6460): 1789–91.

12. **Payne, S. R., et al.** Urinary Retention and the Lunisolar Cycle: Is It a Lunatic Phenomenon? *BMJ.* 1989; 299(6715): 1560–62

13. **Randall, Walter.** A statistical analysis of the annual patterns in black and white births in the Southeastern and Midwestern USA, 1969 thru 1976. *Biological Rhythm Research*, 1744-4179. 1987;18(4): 227-42

14. —. A statistical analysis of the annual pattern in white births of maternal age groups in the United States for the years 1973 thru 1980. *Biological Rhythm Research*, 1744-4179. 1988; 19(1): 1-15

15. —. The solar wind and human birth rate: A possible realtionship due to magnetic disturbances. Int J Biometeorol. 1990; 34(1): 42-48.

16. —. An eleven-year cycle in human births. Int J Biometeorol. 1991; 35(1):33-8.

17. **Lowell, Walter E. and Davis Jr., George E.** The light of life: Evidence that the sun modulates human lifespan. Med Hypotheses. 2008; 70(3):501-7.

18. —. The effect of solar cycles on human lifespan in the 50 United States: Variation in light affects the human genome. Med Hypotheses. 2010;75(1):17-25.

19. **Bender, Stefan, Haas, Anette and Klose, Christoph.** *IAB Employment Subsample 1975-1995 - opportunities for analysis provided by the anonymised subsample.* Bonn : IZA, 2000. IZA Discussion Paper No. 117.

20. **Gnevyshev, M. N.** Essential features of the 11-year solar cycle. *Solar Physics.* 1977; 51(1): 175-83.

21. **MacFarlane, A.** Variations in number of births and perinatal mortality by day of week in England and Wales. *BMJ.* 1978, Vol. 2, pp. 1670-1673.

22. **Mitchell, Michael N.** *A Visual Guide to Stata Graphics.* 2nd Edition. College Station, Texas : Stata Press, 2008.