MAGYAR TUDOMÁNYOS AKADÉMIA
Közgazdaság- és Regionális Tudományi Kutatóközpont

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Centre for Economic and Regional Studies
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MŰHELYTANULMÁNYOK DISCUSSION PAPERS

MT-DP – 2017/29

Ambient temperature and sexual activity:

Evidence from time use surveys

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Discussion papers
MT-DP – 2017/29

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October 2017

ISBN 978-615-5754-08-1

ISSN 1785 377X

Ambient temperature and sexual activity: Evidence from time use surveys

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Abstract

Previous research has found that unusually hot temperature in a given month reduces birth rates 8-10 months later. We examine one of the potential mechanisms behind this relationship. Using three waves of the Hungarian Time Use Survey we analyze the relationship between ambient temperature and sexual activity. We show that on a cold day sexual activity is significantly lower, but hot temperatures do not have an effect. Performing placebo tests using temperature data one year ahead or several years before we provide evidence that supports the causal interpretation of our results. Studying the dynamics of this relationship, we could not rule out the possibility that after the immediate decline, sexual activity revives over the next few days resulting in a zero total effect.

Keywords: weather, temperature, sexual activity, time use

JEL classification: J13, J22, Q54

Acknowledgments

This work was supported by the Hungarian National Research Development and Innovation Office (grant no. FK 124310) and the Horizon 2020 Twinning project EdEN (grant no. 691676). The funding sources had no role in study design; in the collection, analysis and interpretation of data; in the writing of the articles; and in the decision to submit it for publication.

Hőmérséklet és szexuális aktivitás: eredmények időmérleg adatok alapján

Hajdu Tamás – Hajdu Gábor

Összefoglaló

Korábbi kutatások eredményei szerint a szokatlanul magas hőmérsékletű hónapokat a születések számának csökkenése követi 8-10 hónappal később. Elemzésünkben ennek az összefüggésnek egy potenciális magyarázatát vizsgáljuk meg. A magyarországi időmérleg-felvételek három hullámának segítségével elemezzük a hőmérséklet és a szexuális aktivitás közti kapcsolatot. Megmutatjuk, hogy a hideg napokon a kérdezettek kisebb eséllyel számolnak be szexuális tevékenységről, míg a meleg napoknak nincs hatása. Későbbi és korábbi évek hőmérsékleti adatait felhasználó placebo modellekkel támasztjuk alá az eredmények oksági jellegét. A kapcsolat dinamikájának elemzése azt mutatja, hogy egy adott napi hideg hőmérséklet negatív hatását ellensúlyozhatja a következő napok növekvő szexuális aktivitása, összességében egy zéró teljes hatást eredményezve.

JEL kódok: J13, J22, Q54

Tárgyszavak: időjárás, hőmérséklet, szexuális aktivitás, időmérleg

1. Introduction

Past research has shown that extremely or unusually hot temperature in a given month reduces birth rates 8-10 months later (Barreca et al., 2015; Lam and Miron, 1996; Seiver, 1989). Three independent mechanisms might explain this relationship (Lam et al., 1994). First, temperature shocks could decrease sexual activity. Second, an extreme temperature could affect the probability of conception, e.g. by reducing semen quality. Third, the extreme ambient temperature could influence the development of the fertilized embryos or the physical condition of the pregnant woman leading to a higher rate of spontaneous fetal loss during the very early stage of the pregnancy.

In this paper we examine the first channel: the relationship between ambient temperature and sexual activity. Although a couple of previous papers have studied the seasonal variation in sexual activity (Fortenberry et al., 1997; Levin et al., 2002; Rodgers et al., 1992; Udry and Morris, 1967), our paper is among the firsts that analyze the effect of ambient temperature explicitly. To our knowledge, only Wilde, Apouey and Jung (2017) have analyzed the temperature-induced changes in sexual behavior. They used monthly-level data and showed that both sexual activity and internet searches of sexually-themed words decrease with increasing temperature in sub-Saharan Africa.

Our paper contributes to this scarce literature offering several advantages. First, we use daily-level time use and weather data. In this way we can estimate the immediate and the delayed effects of temperature on sexual activity. Second, unlike Wilde, Apouey and Jung (2017) who estimate a linear effect, we model the relationship between temperature and sexual activity in a flexible way. Third, we use placebo tests to check the credibility of our results.

2. Data and empirical method

We use the individual-level datasets of three waves of the Hungarian Time Use Survey (HTUS) administered by the Hungarian Central Statistical Office. The waves used in this analysis are from 1986/1987, 1999/2000 and 2009/2010. Table 1 shows the most important features of the surveys. All waves spread over a full 1-year-long period and follow an open diary design. The sampling units are the households, but only one person per households fills out the time use diary that starts at 4 am and covers 24 hours.

Our dependent variable is a binary indicator for whether sexual activity was reported in a diary. In the first two waves of the HTUS, sexual activity was measured with (or included in) a single activity code that was labeled as “dating, intimacy”. In the third wave, these two

activities are separated, there are different activity codes for “dating” and “intimacy”. To get comparable data we created a new variable in the third wave that measures sexual activity similarly to the first two waves, that is, our sexual activity variable takes the value 1 if the respondent reports any activity coded as “dating” or “intimacy”.

Table 1

The main characteristics of the three waves of Hungarian Time Use Survey

	1986/1987	1999/2000	2009/2010
Survey time span	01/03/1986-07/03/1987	01/09/1999-06/09/2000	01/10/2009-30/09/2010
Age range	15-79	15-84	10-84
Number of activity codes	480	508	548
Number of diaries	39,600	43,200	8,400
Diaries per person	4 (1 per season)	4 (1 per season)	1
Type of diary	Open diary	Open diary	Open diary

The weather data come from the European Climate Assessment & Dataset project that provides daily weather measures for five large Hungarian cities from different parts of the country (Budapest, Szeged, Debrecen, Szombathely, Pécs; see Figure A1 in the Appendix) between 1901 and 2016. The dataset includes information on maximum, minimum and average temperatures, precipitation, and sunshine hours. Using these data, we estimated the daily weather conditions for every Hungarian settlement applying an inverse square distance interpolation method. Weather conditions were linked to the time use surveys at the diary day-settlement level.

We estimated the following regression:

$$Y_{ist} = \alpha + \beta_1 T_{st}^{<0} + \beta_2 T_{st}^{10-20} + \beta_3 T_{st}^{>20} + \gamma' X_{ist} + m_t + w_t + \varepsilon_{ist}, \quad (1)$$

where *i* denotes the individual, *s* denotes the settlement (place of residence), and *t* denotes the time (diary day). Y is a dummy variable that indicates sexual activity of individual *i*. Ambient temperature is captured by four dummy variables, $T^{<0}$, $T^{0\text{-}10}$, $T^{10\text{-}20}$, and $T^{>20}$ indicating average daily temperature <0, 0-10, 10-20, and >20°C on the diary day in settlement *s*. In the regression $T^{0\text{-}10}$ is the omitted category. X is the vector of the additional control variables. It includes a series of dummy variables for personal characteristics: gender, age (measured in years), marital status, education level, labor force status, household size and county of residence. It also includes an indicator variable whether the survey day was a public holiday in Hungary and binary indicators for day-of-week. Month fixed effects (m)

adjust for time-invariant seasonality of sexual activity, whereas survey wave fixed effects (w) help to account for the change in sexual behavior over time.

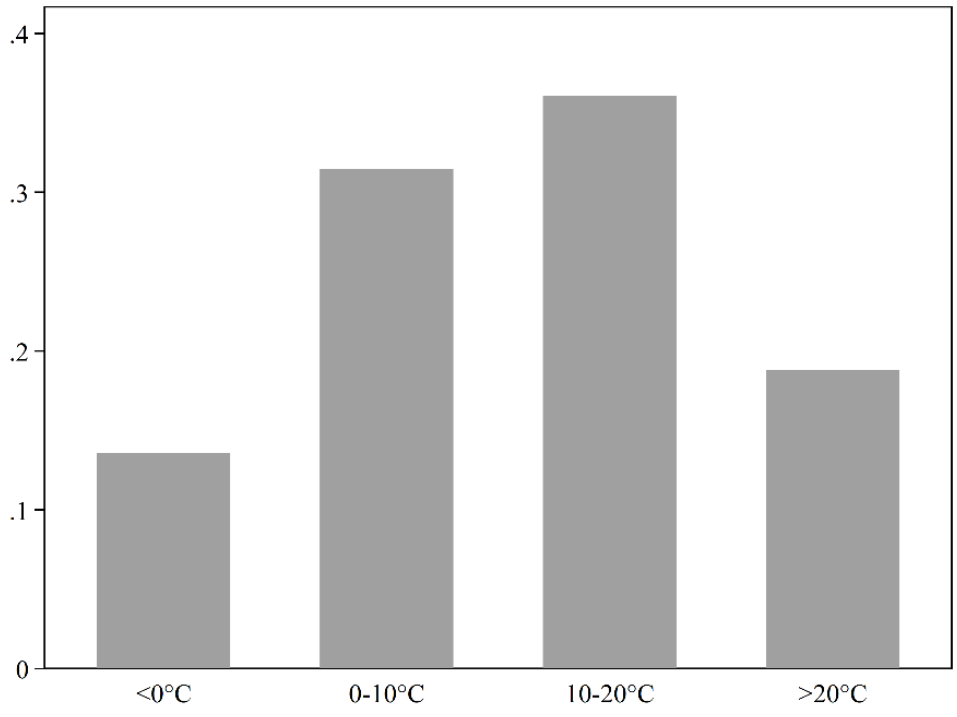
We restrict our analysis to the population aged 18-40 (the potential parents). In the period of 1986-2010, 96% of the mothers and 94% of the fathers of the newborns were between the ages of 18 and 40. The final sample size is 34 312.

We estimate Eq. (1) using a Probit regression, and report average marginal effects throughout the paper. Standard errors are clustered at the diary day level. We use individual weights that adjust for the unequal inclusion probabilities (provided by the HTUS) combined with another weight that transforms every wave's N equal. Dummies are included for missing control variables.

In the final sample, on average, 2.4% of the respondents reported having sexual activity on the diary day. As Figure 1 shows, 14% of the survey days have a mean temperature below 0°C, and 19% of the survey days have a mean temperature above 20°C.

Figure 1

The distribution of the daily mean temperature on the diary days

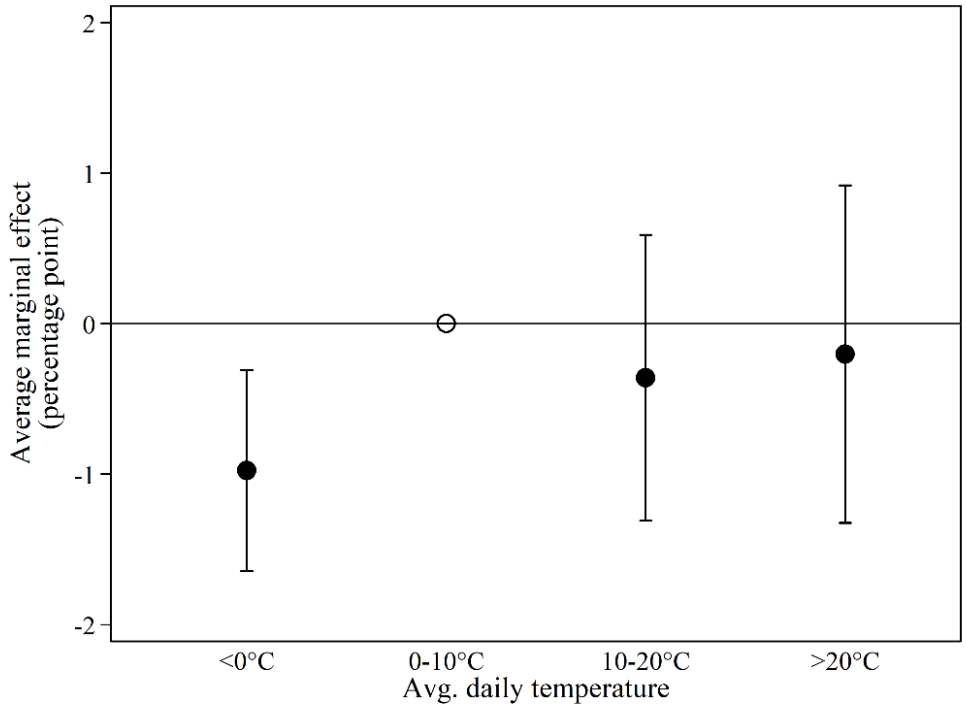


3. Results

The average marginal effects calculated from the Probit regressions are shown in Figure 2. We get a significant effect only for the coldest days. On a day with an average temperature below 0°C there is a 0.98 percentage points lower chance of sexual activity (compared to a day with a temperature between 0-10°C). This is a substantial effect given that 2.4% of the diaries recorded any sexual activity. For the days with higher temperatures we found not only insignificant, but much weaker effects.[1]

Figure 2

The effect of the ambient temperature



Note: The dots are the point estimates and brackets represent 95% confidence intervals.

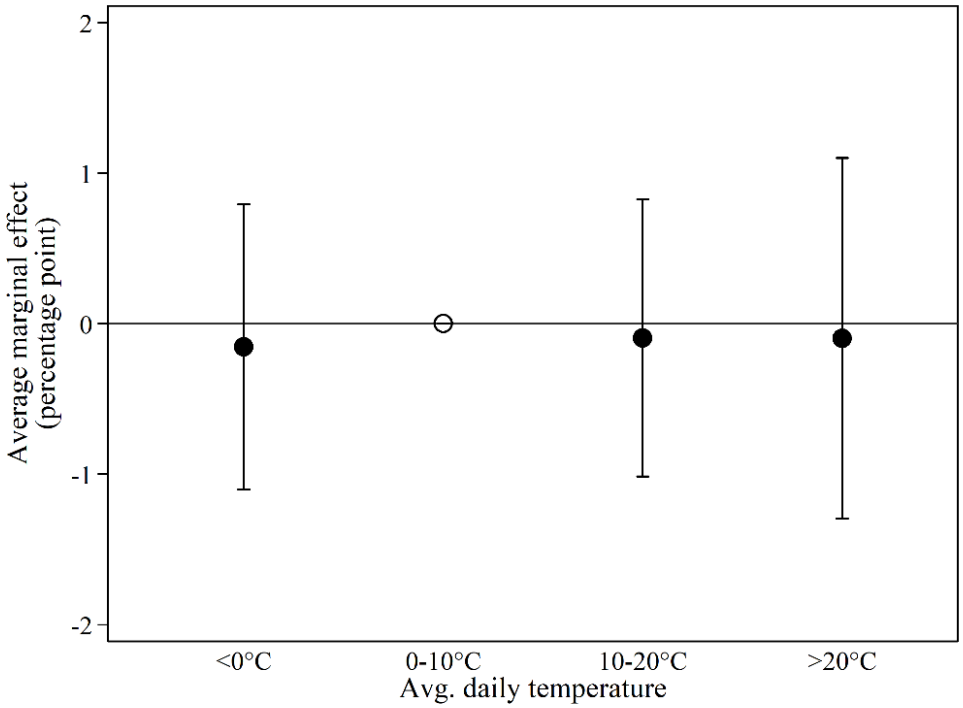
To strengthen the causal interpretation of our results we performed two placebo tests. First, we changed the temperature on the diary day to the temperature exactly one year ahead. To each diary we linked future temperature data on that specific day of the year (running from 1 to 365).[2] Since future temperature can not influence the present-day activities we expected to see not only insignificant but zero effects. The results of this exercise

[1] For some robustness tests see ***Table A1*** in the Appendix.
[2] In the second wave of the HTUS February 29, 2000 is coded as February 28 for the placebo tests.

are depicted in Figure 3. The average marginal effects are very close to 0, they range between −0.15 and −0.09 percentage points.

Figure 3

The results of the placebo test using future temperature data



Note: The dots are the point estimates and brackets represent 95% confidence intervals.

In the second robustness test, we used historical weather data. Although past events might influence present-day outcomes, it is reasonable to assume that temperature observed several years before could not have such an effect on sexual activity. Specifically, we estimated 50 models with the weather data observed exactly 5 to 54 years before each time use diary.[3] Table 2 summarizes the results. The mean value of the average marginal effects from the 50 estimations is practically zero for all temperature bins. It is not surprising given that we linked "random" weather data to the time use surveys. Next, we calculated the share of the point estimations of the placebo models that are (i) lower (more negative) and (ii) higher in absolute value than the main estimations shown in Figure 2. These figures can be considered as empirical p-values. Considering the lowest temperature bin (<0°C), only 4% of the placebo results was lower than -0.98. In other words, past weather decreases more intensively the current sexual activity than the current weather only in 2 out of 50 cases (Column 3). If we take into account the positive estimations as well, the corresponding figure is 6% (Column 4).

[3] The distribution of these coefficients are shown in ***Figure A2*** in the Appendix.

For the higher temperature bins these estimations are much higher. These results mean that it is not very likely that the significant effect of a very cold day is the result of pure chance or model misspecification. In sum, the placebo tests support the causal interpretation of our results.

Table 2

The results of the placebo test using historical temperature data

	(1)	(2)	(3)	(4)
	Mean AME	AME estimations from the main model (Figure 2)	% lower (more negative) than (2)	% higher (in absolute value) than (2)
Daily temperature: below 0°C	−0.06	−0.98	4%	6%
Daily temperature: 0-10°C	ref. cat.	ref. cat.	-	-
Daily temperature: 10-20°C	−0.13	−0.36	36%	58%
Daily temperature: above 20°C	−0.04	−0.20	52%	82%

Note: (1)-(2) average marginal effects (percentage points)

Finally, to test the dynamic nature of the temperature-sexual activity relationship we ran a model including not only the weather indicators on the diary day (t), but also the weather indicators one day before (t-1). It is possible that extreme temperatures influence the sexual activity on a given day but there might be a "rebound" on the subsequent day, which could result in a zero total effect. The total effects are calculated for each temperature category by summing up the average marginal effects: $\sum_{i=0}^{1} T_{t-i}^{AME}$. It can be interpreted as the cumulative effect of temperature on today's and tomorrow's sexual activity. The main finding of this exercise is that the marginal effects of the previous day's temperature are insignificant but positive for all temperature bins (0, 10-20, and >20°C). In addition, the 2-day cumulative effects are close to zero and highly insignificant (Table 3). We also experimented with longer lag structures. It does not alter the main conclusion. We can not rule out the possibility that after the immediate effect of the ambient temperature on sexual activity there is a rebound effect over the next few days.

Table 3

The dynamic nature of the temperature-sexual activity relationship

	(1) 2-day cumulative effects	(2) 3-day cumulative effects	(3) 4-day cumulative effects
Daily temperature: below 0°C	−0.28 (0.59)	−0.35 (0.68)	−0.32 (0.77)
Daily temperature: 0-10°C	ref. cat	ref. cat	ref. cat
Daily temperature: 10-20°C	0.05 (0.61)	−0.06 (0.66)	−0.05 (0.74)
Daily temperature: above 20°C	0.34 (0.78)	0.25 (0.83)	0.08 (0.92)

Note: Average marginal effects (percentage points). Standard errors are in parentheses.

4. Conclusions

Using individual-level time use surveys we examined the relationship between ambient temperature and sexual activity. We found that on days with an average temperature below 0°C there is a significantly lower chance of sexual activity, but hot temperatures do not have an effect. Studying the dynamic nature of this relationship, we could not rule out that after the immediate decline, sexual activity revives over the next few days resulting in a zero total effect. Our results suggest that the relationship between temperature and sexual activity might be a mechanism of minor importance in the relationship between the temperature and birth rates shown by past research (Barreca et al., 2015; Lam and Miron, 1996; Seiver, 1989), at least in Central Europe. Our findings are in contrast with the results of Wilde, Apouey and Jung (2017), however, we note that not only our methodology differs substantially from theirs, but we analyze data from a country where the typical range of daily mean temperature is much lower than in the sub-Saharan Africa.

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Appendix

Figures

Figure A1

Weather stations in the European Climate Assessment & Dataset (Hungary)

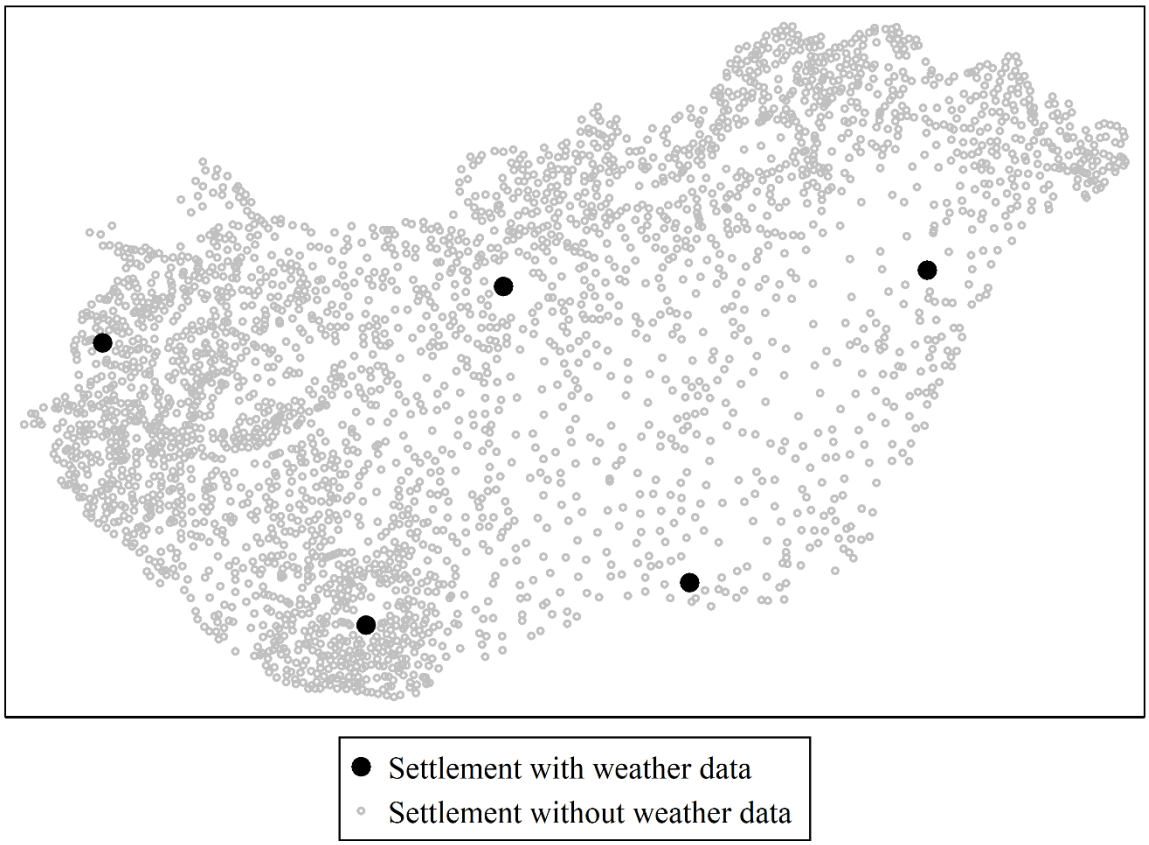
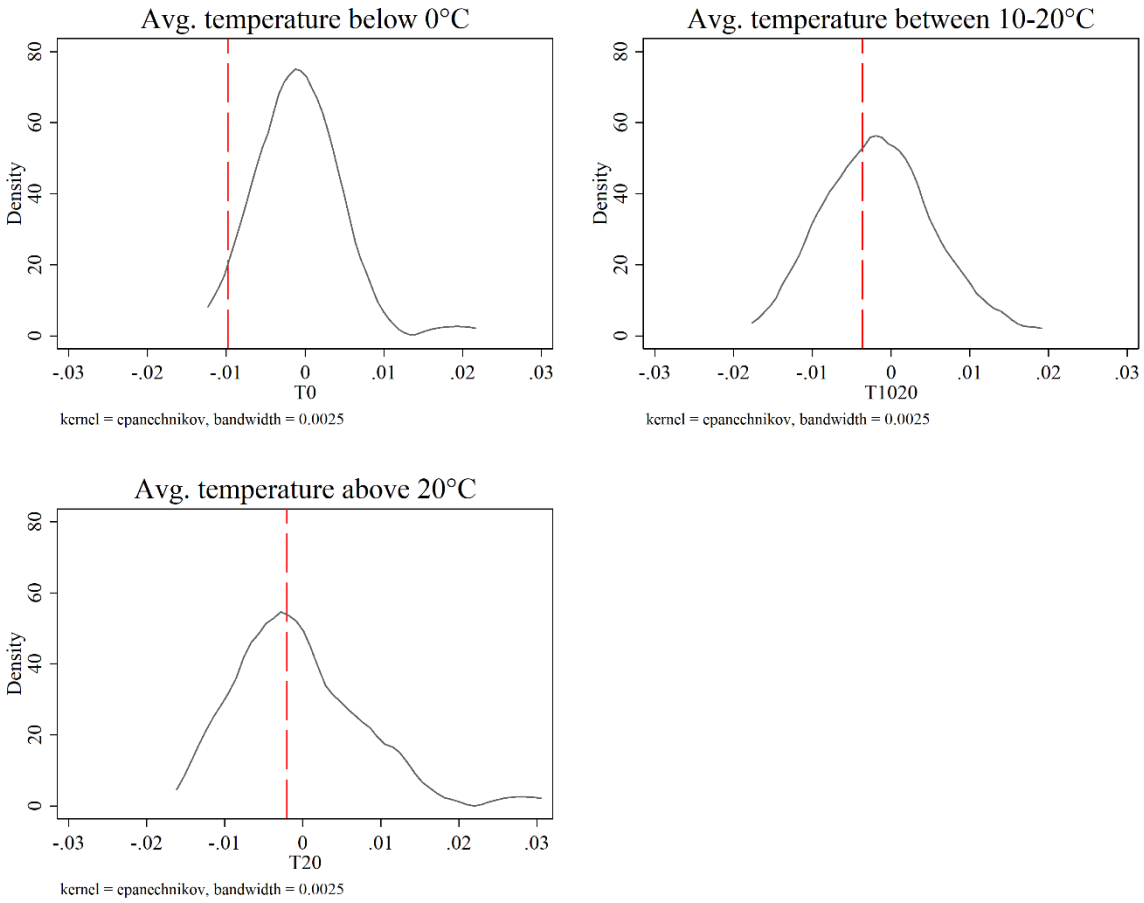


Figure A2

The results of the placebo test using historical temperature data (average marginal effects)



Notes: The dashed red lines represent the results of the main estimation. The solid lines show the distribution of the average marginal effects obtained from the placebo reform test using historical temperature data.

Tables

Table A1

The results of the robustness tests

	(1) Baseline	(2) Population aged 20-34	(3) With precipitation and sunshine	(4) Country-level temperature data	(5) Settlements within 30 km
Daily temperature: below 0°C	-0.010** (0.003)	-0.012** (0.004)	-0.010** (0.003)	-0.007* (0.004)	-0.019** (0.004)
Daily temperature: 0-10°C	ref. cat.	ref. cat.	ref. cat.	ref. cat.	ref. cat.
Daily temperature: 10-20°C	-0.004 (0.005)	-0.005 (0.007)	-0.004 (0.005)	-0.002 (0.005)	0.004 (0.009)
Daily temperature: above 20°C	-0.002 (0.006)	-0.003 (0.008)	-0.002 (0.006)	0.001 (0.007)	0.005 (0.012)
Sample mean (dep. var.)	0.024	0.028	0.024	0.024	0.026
pseudo R-squared	0.110	0.114	0.110	0.109	0.129
N	34312	21773	34312	34312	11004

Average marginal effects.
Dependent variable: Binary indicator for whether sexual activity was reported in the diary.
Column 1: Baseline results (see Figure 1 also)
Column 2: The sample is restricted to the population aged 20-34.
Column 3: Information on precipitation and sunshine are added.
Column 4: Country-level temperature data are used, instead of the settlement-level data.
Column 5: Only settlements located within a 30-km radius of the weather stations are included.
Robust standard errors clustered at the survey day level are in parentheses.
+ p<.10, * p<.05, ** p<.01