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Numerological preferences, timing of births and the long-term effect on schooling

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Abstract

Cultural beliefs may affect demographic behaviors. According to traditional Chinese astrology, babies born on auspicious days will have good luck in their lifetime, whereas those born on inauspicious days will have bad luck. Using administrative data from birth certificates in Guangdong, China, we provide empirical evidence on the short-term effects of such numerological preferences. We find that approximately 3.9% extra births occur on auspicious days and 1.4% of births are avoided on inauspicious days. Additionally, there is a higher male/female sex ratio for births on auspicious days. Since such manipulation of the birthdate is typically performed through scheduled C-sections, C-section births increase significantly on auspicious days. Moreover, we use a second dataset to examine the long-term effect of numerological preferences and find that people born on auspicious days are more likely to attend college.

Keywords Numerological preferences · Birthdate · Timed births · Chinese astrology

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1 Introduction

In East Asian countries, a person's destiny is traditionally thought to be determined by his/her birth date and time. Such cultural beliefs could have a salient influence on demographic outcomes. For example, Chinese superstition holds that women born in a year of the goat in the zodiac system will bring misfortune to their husbands. Therefore, goat years are inauspicious for women in China.[1] This has made women born in goat years unpopular in the marriage market (Zhang and Zhang 2015). In contrast, individuals born in dragon years are viewed as powerful and having good fortune, especially in Hong Kong and Taiwan, where the number of births has been found to increase significantly during these years (Goodkind 1991, 1993; Yip et al. 2002; Vere 2008). Japanese believe that being born in the year of the Fire Horse (Hinoeuma) is ominous for women, causing the country's fertility rate to drop sharply in 1966 (Kaku and Matsumoto 1975; Akabayashi 2008). Similar behavior can be observed in Korea, where parents strive to avoid horse-year babies through timed birth or even abortion (Lee and Paik 2006).

This paper extends the study on the effect of zodiac animal years to numerological preferences, namely shifting a baby's birth time toward (away from) an auspicious (inauspicious) day in China. We first confirm the short-term effects of such preferences on birth timing and then evaluate the long-term impact of such manipulation of birth timing.

Choosing an auspicious day (*Huangdao Jiri*) for any significant event is rather prevalent in Chinese society. This practice is based on Chinese astrology and deeply rooted in cultural beliefs. Chinese astrology holds that the day and hour of birth can determine the fate of newborns. Many pregnant women seek advice from astrologers and fortunetellers about the best delivery time. Anecdotal evidence indicates that some women even undergo a caesarean section (hereafter C-section) to ensure an auspicious day for their deliveries, although no previously published studies have confirmed this behavior. In addition to auspicious days, the number 8 is considered a lucky number in Chinese culture, whereas the number 4 is considered as unlucky. Pregnant women may try to give birth on dates containing the number 8 and to avoid dates containing the number 4.

Our empirical results, based on administrative data from birth certificates in Guangdong Province, China, confirm our predictions of the deliberate shifting of birthdates. Guangdong is one of the regions most noted for adherence to Chinese traditional culture, such as the wide prevalence of geomancy or ancient cosmology and astrology. Thus, it is very suitable for this analysis.

We find that approximately 3.9% extra births occur on auspicious days and 1.4% of births are avoided on inauspicious days. Similar to Almond et al. (2015), we also detect 1.8% "too many" births occurring on the 8th, 18th, and 28th days of the solar month. Additionally, we find an even stronger impact, with 3% extra births, on the dates containing an 8 in lunar months.

[1] The Chinese zodiac (*Shengxiao*) is based on the lunar calendar, in which each year is symbolized by a zodiacal sign that follows a 12-year mathematical cycle of 12 animals, namely the Rat, Ox, Tiger, Rabbit, Dragon, Snake, Horse, Goat, Monkey, Rooster, Dog, and Pig.

Timed births are mainly performed through elective C-section. The C-section rate increases by 2.4% on auspicious days but decreases by 1.1% on inauspicious days. These results suggest that nonmedical C-sections are in part determined by patient choice, not solely by financial or convenience considerations on the part of physicians[2]. That is, traditional cultural beliefs in Chinese societies may give patients more bargaining power vis-a-vis physicians and obstetricians regarding when to perform a C-section.

We further examine the heterogeneous characteristics of babies born on (in)auspicious days as well as their mothers. First, there is a higher male/female sex ratio for births on auspicious days, which is consistent with the son preference in China. Second, compared with babies born on regular days, babies born on auspicious days weighed 2.3 grams more, whereas those born on an inauspicious day weighed 2.3 grams less. Women with healthy pregnancies or more financial resources may be more likely to successfully schedule a specific C-section date. In contrast, women facing complications or emergencies with their pregnancies that lead to lower birth weight may have less control over when they give birth

In addition to the short-term effects of such manipulation, the more important question is whether numerological preferences have a long-lasting impact on child development. To answer this question, we use the nationally representative Chinese General Social Survey (CGSS) data and restrict the sample to Guangdong Province to examine numerological preferences' long-term effects. We find that babies born on auspicious days are associated with a higher likelihood of attending college, which we postulate to be due to self-fulfilling prophecy on the part of parents.

Two recent studies utilize the Chinese zodiac animal years to examine self-fulfilling prophecy. Johnson and Nye (2011) find that in the USA, Asian immigrants born in the dragon year (in 1976) are more educated than those from non-dragon years. Babies born in the dragon year are also associated with greater investment in human capital. Mocan and Yu (2017) further analyze the mechanism of the self-fulfilling prophecy. Using province-level panel data in China, they show that the number of marriages goes up during the 2 years preceding a dragon year, and then births jump in a dragon year. They note that parents of children born in dragon years have higher expectations for their children's success. Thus, parents' belief in their children's success and the ensuing parental investment are the determining factors of the actual success.

To our knowledge, ours is the first study to systematically analyze the effects of numerological preferences regarding birthdates in China. Lo (2003) is one of the few studies covering a similar topic. However, Lo's study mainly focuses on the relationship between the choice of a non-clinically required C-section

[2] Although many studies analyze the determinants of the C-section, most of them focus on the financial incentives or demand for leisure by physicians. For example, Brown (1996) indicates that time-dependent dummy variables related to leisure are significant predictors of both total and unplanned C-sections. On the basis of a survey data from three hospitals in Greece, Mossialos et al. (2005) find health insurance, socio-economic status (proxied by ethnic background), and physician convenience increase the occurrence of C-sections. In a recent study, Long et al. (2012) investigate the association between the use of C-sections and insurance coverage by the New Co-operative Medical Scheme in rural China. They document that health insurance facilitates the overuse of non-emergency C-section.

and numerological preferences. The author finds that C-sections are more likely to be performed on auspicious days and less likely on inauspicious days in Taiwan. Similarly, Chu et al. (2015) find that C-section deliveries before 39 weeks of gestation are associated with the Chinese cultural preferences for selecting an auspicious time for birth. In addition, Lin et al. (2006) show that C-sections are significantly lower in Taiwan during the ghost month (lunar July). Almond et al. (2015) examine numerological preferences and demographic behaviors of Chinese immigrants in California and find that 2.3% of extra births occur on dates containing the number 8.

This paper is also related to previous studies analyzing the effect of economic incentives on the timing of births. Dickert-Colin and Chandra (1999) conduct the pioneering study in this field, in which they find considerable birth shiftings from the first week of January to the last week of December because of tax benefits in the USA. Gans and Leigh (2009) estimate that approximately 16.2% of births moved from June to July in Australia following the introduction of the baby bonus on July 1, 2004. Neugart and Ohlsson (2013) find that Germany's parental leave benefit reform introduced in 2006/2007 caused 7.8% of births to be strategically delayed. Although all these studies demonstrate women's ability and desire to shift birth timing to suit personal preferences, they focus exclusively on the effects of financial incentives. Numerological preferences are deeply rooted in Chinese culture and may exert a long-lasting influence on women's decisions regarding birth timing. In addition, some of the shifts estimated in previous studies are potentially due to the manipulation of the reported birthdates, e.g., parents intentionally misreport their children's birthdates due to financial or other incentives. Shigeoka (2015) shows the existence of manipulation of self-reported birthdates of the children among Japanese parents who want their children to start primary school at older ages. In our study, however, it is unlikely that manipulation of reported birthdates accounts for the shifts since shifting the birthdate is merely due to cultural belief that people being born in certain days are auspicious and the parents lack the incentive to intentionally misreport their children's birthdates.

The rest of this paper is organized as follows. Section 2 describes the data. Section 3 provides our results regarding the effects of numerological preferences on the timing of births. Section 4 presents the second set of data and the long-term effects of numerological preferences. Robustness checks are presented in Section 5. Section 6 concludes the paper.

2 Data Sources

Our data come from two sources. The primary data are from birth certificates in Guangdong Province of China. We use these data to estimate the effects of numerological preferences on the timing of births. We then further use the CGSS to examine the long-term effects of people's birthdates on their educational attainment and health. To avoid confusion, the following discussion pertains to the primary data from Guangdong Province. The CGSS data are discussed later in Section 4.

In China, there are no national birth data. The data used in this study are collected by the Women and Children's Hospital of Guangdong Province and cover the population of newborns in Guangdong during 2014–2016[3]. Guangdong is located in southern China, with a GDP per capita of 74,016 yuan (about 10,698 U.S. dollars) in 2016, it is one of the country's most developed provinces. Guangdong also has the largest population among China's 31 provinces. At 110 million, it comprises approximately 8% of the nation's total population (National Bureau of Statistics 2017).

The birth certificate data contain rich information of newborns. The information included in the birth certificate comes from a standardized form completed by families at the time of hospital registration and later by physicians immediately after the delivery. The information listed includes parental demographic characteristics, such as age and education, the child's date of birth, gender, birth weight, Apgar scores[4], and delivery mode (C-section versus vaginal). The detailed description is also provided elsewhere (see Yao et al. 2018).

The key variable on the birth certificate is the exact date of birth, which is used to define numerological preferences. Auspicious and inauspicious days are based on the lunar calendar and vary by year and month, according to the Chinese almanacs[5]. We have to translate the solar birthdate on the birth certificate into the lunar date, obtaining the information in almanacs from *Baike* (China's Wikipedia, which is developed by Baidu. Inc., the Chinese version of Google). We treat days that are considered suitable for childbearing according to this system as auspicious days (*Yi Qiusi* in Chinese), while days that are not suitable for marriage, opening, ceremonies, etc. are considered inauspicious days (*Zhushi Buyi* in Chinese). In this way, we generate the variables of auspicious and inauspicious days.

There are 1096 day-level observations, 2 years with 365 days, and 1 year with 366 days. The data used in this study contains 5,037,334 newborns, and all of them have accurate birthdate information. The proportions of auspicious days and inauspicious days are 23.5% and 13%, respectively. We present an example of a calendar indicating auspicious days and inauspicious days in the Appendix. As far as we know, there is no variation on the intensive margin regarding auspicious days and inauspicious days. In other words, there is no particular auspicious day that is better than other auspicious days. Most of the variables are complete, with the following exceptions: (1) The data on Apgar scores and delivery mode are not available in 2014; (2) the information of delivery mode is missing on 5.9% of birth certificates; and (3) mothers' education is observed on less than 10% birth certificates. Thus, the empirical results referring to mothers' educations are only suggestive. The descriptive statistics are shown in Table 1.

[3] More than 99% of births in Guangdong Province take place in hospitals.

[4] APGAR is the abbreviation of Activity, Pulse, Grimace, Appearance, and Respiration, which is tested immediately (e.g., 1 min) after delivery to assess neonatal health. Each item is scored from 0 to 2; thus, a total score is 10. In general, a total score between 7 and 10 is considered normal.

[5] Although modern China has adopted the solar calendar, the lunar calendar is still used for traditional festivals and cosmology and astrology. In general, the lunar calendar lags 3 to 6 weeks behind the Western solar calendar (Lin et al. 2006).

Table 1 Descriptive statistics (birth data)

Variables	Mean	Std. dev.	Min	Max
Daily number of births	4596	618.2	3309	7075
Boy	2460	333.7	1765	3815
Girl	2136	289.1	1527	3259
Birth weight (in grams)	3154	15.86	3106	3206
Apgar score	9.541	0.229	8.473	9.850
C-section rate	0.268	0.037	0.176	0.381
Proportion of mothers aged > 30	0.241	0.027	0.192	0.350
Proportion of mothers with a bachelor's degree	0.128	0.043	0.039	0.256
Auspicious day	0.235	0.424	0	1
Inauspicious day	0.130	0.337	0	1
Solar calendar: dates contain 8	0.099	0.298	0	1
Solar calendar: dates contain 4	0.099	0.298	0	1
Lunar calendar: dates contain 8	0.101	0.302	0	1
Lunar calendar: dates contain 4	0.101	0.302	0	1

The data come from pooled 2014–2016 birth certificates in Guangdong Province. There are 1096 day-level observations, and the total number of births is 5,037,334. Delivery type and Apgar score are collected since 2015; thus, the observations decrease by 731. There are 5.9% missing observations for delivery type and approximately 93% for mothers' education

3 Effect on short-term manipulation

3.1 Econometric model

We use birth data to estimate the short-term effects of numerological beliefs. The unit of observation[6] is at the day level. The econometric model can be written as follows:

$$B_{dy} = \alpha_0 + \alpha_1 Ausp_{dy} + \alpha_2 Inasup_{dy} + \alpha_3 Solar8_{dy} + \alpha_4 Solar4_{dy} + \alpha_5 Lunar8_{dy} + \alpha_6 Lunar4_{dy} + \alpha_7 Week_{dy} + Holiday_{dy} + \theta_y + \delta_m + \varepsilon_{dy} \tag{1}$$

where B_{dy} is the number of births (or the natural logarithm of births) on day d of year y; α_1 and α_2 represent the effects of auspicious days and inauspicious days, respectively. Because auspicious days are considered fortunate and inauspicious day unfortunate, we expect $\alpha_1 > 0$ and $\alpha_2 < 0$.

Following Almond et al. (2015), we include the variables $Solar8_{dy}$ and $Solar4_{dy}$, dates of birth containing the number 8 or 4 based on the solar calendar. In addition, we add these numerological preferences based on the lunar calendar, i.e., $Lunar8_{dy}$and $Lunar4_{dy}$. In Chinese culture, the number 8 is considered a lucky number, especially in

[6] To reduce the computational burden, we take the day level as the unit of observation but use the number of observations as a weight. Estimation at the mean of each birthdate produces the same results as the individual level.

Guangdong Province, because 8 is homophonic with prosper in Cantonese, the major dialect in Guangdong Province. The number 4 is considered an unlucky number, especially in Mandarin speaking regions, because 4 is homophonic with death in Mandarin. Therefore, superstitious people in Guangdong might select a birthdate that contains the number 8 but not necessarily avoid the number 4[7]. We expect $\alpha_3 > 0$ and $\alpha_5 > 0$.

Finally, we include weekend ($Week_{dy}$), holiday ($Holiday_{dy}$), year (θ_y), and month (δ_m) dummies in the model. Previous studies, such as Brown (1996) and Mossialos et al. (2005), have shown that holidays and weekends are negatively associated with the number of births or the C-section rate in hospitals. Here, $Week_{dy}$ is a binary indicator, taking 1 if the birthdate d occurs on the weekend and 0 otherwise. $Holiday_{dy}$ denotes a set of holidays, including Chinese New Year, National Day, Mid-Autumn Festival, Duanwu Festival, and Qingming Festival, the five national holidays in China.

3.2 Empirical results

In this subsection, we first present the estimation results regarding the effects of numerological preferences on the timing of births. Then, we analyze the mechanisms behind scheduled births, i.e., whether the unusual use of C-sections on auspicious/inauspicious days can be observed. Finally, we present newborn health outcomes associating with such shifts and characteristics of newborn babies and their mothers' characteristics on auspicious/inauspicious days.

3.2.1 Birth timing

Consistent with our predictions, the results in column (1) in Table 2 suggest that, on average, 189 "too many" daily births occurred on auspicious days and 64 "too few" on inauspicious days. These coefficients are statistically significant, especially for auspicious days ($p < 0.01$). This implies that people with numerological preferences will strategically alter the timing of births. Column (2) uses the natural log of the number of births as the dependent variable. The results show that there are approximately 3.9% extra births on auspicious days, and 1.4% births are avoided on inauspicious days.

Furthermore, we find significant excessive births (1.8%) on the 8th, 18th, and 28th days of the solar month. This timing effect is even stronger when using a lunar month calendar, with 3% extra births on days containing "8." This difference suggests that more Chinese people hold numerological beliefs based on the lunar calendar, which motivates them to alter the timing of births. Although births on days containing the number 4 are decreased, the difference is not statistically significant.

Finally, we report the results for births on weekends and holidays. To the best of our knowledge, no previous study has rigorously examined such effects based on a large sample in mainland China. Our results show that births are significantly reduced, by

[7] Some studies have demonstrated that numerological preferences relate to many aspects of life for Chinese people. For example, Brown and Mitchell (2008) detected that the prices of A-shares (mainly held by Chinese individuals) traded on the Shanghai stock exchange were more than twice as likely to end in 8 than 4. Fortin et al. (2014) found that in a North American market with many Chinese residents, houses with an address number ending in four sold for a price 2.2% lower and those ending in 8 sold for a price 2.5% higher compared with other houses.

Table 2 The effect of numerological preferences on the timing of births

Variables	(1) Number of births	(2) ln(number of births)
Auspicious day	188.66***	0.039***
	(28.30)	(0.006)
Inauspicious day	− 63.87**	− 0.014**
	(29.77)	(0.006)
Solar8	84.50**	0.018**
	(40.25)	(0.008)
Solar4	− 3.89	− 0.000
	(35.76)	(0.007)
Lunar8	144.43***	0.030***
	(39.31)	(0.008)
Lunar4	− 21.45	− 0.004
	(35.28)	(0.007)
Weekend	− 306.80***	− 0.067***
	(23.10)	(0.005)
Chinese New Year	− 160.48**	− 0.042**
	(81.04)	(0.020)
National Day	− 525.94***	− 0.093***
	(100.76)	(0.019)
Qingming Festival	− 188.61**	− 0.053**
	(89.19)	(0.022)
Duanwu Festival	− 260.70**	− 0.059**
	(111.97)	(0.025)
Mid-Autumn Festival	− 195.36	− 0.036
	(131.72)	(0.028)
Observations	1,096	1,096
R-squared	0.669	0.679

Dummy variables for year and month are included. Robust standard errors are reported in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

6.7%, on weekends. In addition, “too few” births occur on most holidays, especially on the National Day (October 1), and the discrepancy reaches − 9.3%. We believe, as noted by previous studies, that the low number of births on weekends and holidays is related to the (in)convenience of physicians (Brown 1996; Mossialos et al. 2005).

3.2.2 C-sections

In the previous sections, we have already established that numerological preferences lead to a considerable number of birthdate shifts. Not surprisingly, the shifts were mainly accomplished by scheduling non-medically necessary C-sections. Such practice is well documented by previous studies. Lumbiganon et al. (2010) indicate that during the years 2007 and 2008, 40% of C-sections in China were reported to have no clinical indications. Li et al. (2017) have similar findings. Using county-level data on the number of live births and C-section deliveries between 2008 and 2014 in China, they find that the annual rate of C-section deliveries increased to 34.9%[8]. Next, we examine whether cultural beliefs contribute to such an increase in C-sections.

We report these results in Table 3. In line with the results mentioned above, column (1) shows that C-section births significantly increase on auspicious days and dates with the number 8. Similarly, fewer births occur on inauspicious days. Column (2) shows that vaginal birth does not statistically significantly increase in auspicious days or decrease in inauspicious days. In column (3), we can see a 2.4% increase in C-section rates on auspicious days and a 1.1% decrease on inauspicious days. These results suggest that "shifting" delivery date to an auspicious day and away from an inauspicious day is likely a major means to fulfill the numerological preference for children's birthdays.

Additional analysis, in which we control for the number of C-sections and re-estimate Eq. (1), further suggests that the manipulation of birth timing was mainly implemented through shifting of C-sections. As shown in Table 12 (columns (1) and (3) replicate the OLS estimates in Table 1), most of the estimates with adjustment for the number of C-sections become statistically nonsignificant and economically small. C-sections account for at least 80% ((188.7-37)/188.7) of the increase in births on auspicious days, which is consistent with the findings of previous studies, such as Gans and Leigh (2009) and Borra et al. (2017), who show that C-sections and inductions account for most of the shifting in births in response to economic incentives in Australia and Spain, respectively.

It is worthy to note that we do not have sufficient evidence to support "switching," that is, pregnant women change delivery mode from vaginal delivery to C-section delivery due to numerological preferences. Changing delivery method not only increases economic burden but also may have direct impact on infant health. As a related study, Schulkind and Shapiro (2014) do not find evidence of switching time of births for tax benefits in the USA. Hence, it is difficult to imagine that a significant proportion of women would change the type of delivery (from labor to C-section) in response to superstitious beliefs. To what extent, if any, "switching" may also play a role in our context merits further research.

The fact that 5.9% of the data on delivery mode are missing could cause a problem. People are likely to misreport when the timing of birth was moved for nonclinical reasons. To address this concern, we run a regression where the dependent variable is a binary indicator taking 1 if the delivery mode is missing and 0 otherwise. The regression results in column (4) of Table 3 suggest that being missing for delivery mode is random for auspicious/inauspicious days or dates with the number 8 or 4.

The results on weekends and holidays are also worth noting. The C-section rate dropped by 4% during weekends, 2.2% during Chinese New Year, and 3.5% during Duanwu Festival. These results are consistent with previous studies, suggesting that the leisure demand of physicians may be one determinant of C-section timing. It is also interesting to observe that the numbers of C-section and vaginal births significantly decrease during weekends and on the National Day. As explained by Levy et al. (2011), vaginal births

[8] They also find a large geographic variation in C-section rates: Tibet had the lowest at 4%, Jilin the highest at 62.5%, and Guangdong Province was in the middle at 25.9% in 2014. The time trend is steady in Guangdong, with 23.2%, 24.1%, 25.4%, 25.2%, 25.9%, and 26.4% from 2008 to 2013. Our birth certificates contain information on delivery type only in 2015 and 2016. The rates are 27.2% and 26.5%, respectively, very close to the rate calculated for 2014.

Table 3 The effect of numerological preferences on C-sections

Variables	(1) No. of C-section births	(2) No. of vaginal births	(3) C-section rate	(4) C-section missing
Auspicious day	152.17***	31.43	0.024***	0.002
	(20.12)	(20.04)	(0.003)	(0.002)
Inauspicious day	− 56.60***	0.38	− 0.011***	0.003
	(21.35)	(25.61)	(0.003)	(0.003)
Solar8	84.44***	19.28	0.013***	0.000
	(27.57)	(28.65)	(0.004)	(0.003)
Solar4	− 15.61	5.21	− 0.003	0.000
	(26.14)	(25.46)	(0.004)	(0.003)
Lunar8	116.56***	25.72	0.018***	0.000
	(29.16)	(26.99)	(0.004)	(0.003)
Lunar4	− 10.73	− 0.36	− 0.002	0.001
	(27.01)	(24.90)	(0.004)	(0.003)
Weekend	− 241.76***	− 42.17**	− 0.040***	− 0.003
	(15.35)	(18.20)	(0.002)	(0.002)
Chinese New Year	− 123.88*	− 56.19	− 0.022*	0.006
	(65.34)	(35.59)	(0.012)	(0.011)
National Day	− 110.61*	− 222.22***	− 0.005	− 0.002
	(66.50)	(76.93)	(0.009)	(0.002)
Qingming Festival	− 143.99*	− 78.41*	− 0.026*	0.022***
	(79.31)	(39.97)	(0.014)	(0.008)
Duanwu Festival	− 222.64***	− 53.95	− 0.035***	0.000
	(76.74)	(111.95)	(0.009)	(0.013)
Mid-Autumn Festival	− 67.07	26.70	− 0.012	− 0.006
	(87.94)	(59.06)	(0.012)	(0.004)
Observations	731	731	731	731
R-squared	0.507	0.800	0.406	0.870

The sample comes from the years of 2015 and 2016. Dummy variables for year and month are included. Robust standard errors are reported in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

might still be controllable by pregnant women. Certain holidays (here, the National Day) may motivate them to resist giving birth, which could influence hormone secretions that control birth timing.

3.2.3 Heterogeneous characteristics of newborn babies and their mothers

We now examine the heterogeneous characteristics of newborn babies and their mothers by estimating a version of Eq. (1) but use mother and child characteristics as the dependent variables. The first column of Table 4 shows the results for the (male/female) sex ratio at birth. It is well known that Chinese people have a preference

Table 4 Heterogeneous characteristics of mothers and children

Variables	(1) Male/female sex ratio	(2) Mother's age > 30	(3) Mother has bachelor's degree	(4) Mother's education missing
Auspicious day	0.009***	0.007***	0.002	0.001
	(0.003)	(0.001)	(0.002)	(0.001)
Inauspicious day	− 0.004	− 0.002*	− 0.005	0.000
	(0.003)	(0.001)	(0.003)	(0.001)
Solar8	− 0.002	0.004**	0.005	0.000
	(0.004)	(0.002)	(0.003)	(0.001)
Solar4	− 0.001	− 0.002	− 0.003	0.000
	(0.004)	(0.002)	(0.003)	(0.001)
Lunar8	0.001	0.006***	0.000	− 0.000
	(0.003)	(0.002)	(0.003)	(0.001)
Lunar4	− 0.003	− 0.001	− 0.004	0.000
	(0.004)	(0.002)	(0.003)	(0.001)
Observations	1096	1096	1096	1096
R-squared	0.120	0.696	0.518	0.277

Dummy variables for weekend, holiday, year, and month are included. Robust standard errors are reported in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

for sons. Expecting parents could use prenatal diagnostic ultrasound technologies to tell the gender of their baby. Those who expect a boy are more likely to deliberately select an auspicious day for their son's birth. Indeed, in Guangdong Province, we detected a 0.9% increase in the male to female ratio born on auspicious days, a difference that is highly precise. Other variables are not statistically significant.

Column (2) shows that the proportion of mothers 30 years or older is 0.7% higher on auspicious days but 0.2% lower on inauspicious days. Mothers older than 30 years of age are also more likely to select dates containing the number 8 for their child's birth. One possible explanation is that to ensure the survival of their babies, older pregnant women are more inclined to choose and/or require C-sections than younger pregnant women are. They would thus pick a "lucky" day when they schedule the surgery. It could also be that superstitious beliefs are more prevalent among older parents, thus also contributing to an increase in the selection of certain birthdates by these parents.

We do not find any significant result for the proportion of mothers with a bachelor's degree, as shown in column (3). Moreover, column (4) clarifies that this result is not driven by nonrandom missing data on mothers' education because all variables related to numerological preferences are statistically nonsignificant.

Table 5 presents children's health outcomes[9]. We find a significant influence on birth weights in column (1): Infants born on an auspicious day or a date containing an 8

[9] Both birth weight and Apgar scores are often used as important proxy variables for initial health at birth in the literature, especially for birth weight, which is associated with various child outcomes (see, for example, Black et al. 2007; Figlio et al. 2014).

(lunar calendar) are approximately 2.3 and 4.7 g heavier, respectively. Infants born on an inauspicious day are 2.3 g lighter. The average effects appear to be quite small, given that the average birth weight is 3154 g. However, such effects are driven by the small proportion of shifted births, as shown in Table 2. Thus, we could infer that the average birth weight of babies whose birthdates are shifted is likely to be much larger than other babies. Column (2) further reports that the proportion of newborns whose birth weight is less than 2500 g is 0.7% higher on inauspicious days. While even using data on many scheduled births, we do not find any significant results for Apgar scores in column (3).

It is not surprising that these results could reflect a positive selection effect. Usually, physicians and patients will consider whether it is appropriate to shift the timing of birth. In general, healthier pregnant women are more likely to select an auspicious day through elective C-sections, while women with risky pregnancies, e.g., expected low birth weights, would find it more difficult to do so. They may even have to give birth on an emergency or spontaneous basis, regardless of whether it is an inauspicious day.

While delaying births seem more difficult medically than hastening births, we try to determine whether mothers are delaying or hastening births in response to numerological preferences. To do so, we run a statistical analysis to further check it. Specifically, we use data on gestational age as the dependent variable and re-estimate Eq. (1). Since the magnitude of the effect of shifting births on gestational age could be as small as one or few days, we use gestational length in days instead of weeks.

From Table 6, it is obvious that the coefficient on auspicious day is, on average, 0.06 day shorter in gestation age than those born on "common" days and statistically significant at 1% level, which imply that hastening births are more likely to occur compared to delaying births in our sample.

Previous studies indicate that a small shift to an earlier delivery date, even at full term, could lead to many adverse health outcomes for newborns, in terms of birth weight, Apgar scores, and hospitalization rates in the first 2 months of life (Schulkind and Shapiro 2014; Borra et al. 2016, 2017). Suppose a pregnant woman's due date falls on the day after an auspicious day and the newborn's potential birth weight is 3300 grams. If the mother moves the delivery day to the auspicious day before the due date through elective C-section, then the newborn's birth weight could be lowered to 3200 g. Although this study cannot identify the causal effects, we suspect that the potential health costs induced by shifting the timing of births in response to cultural beliefs may be nonnegligible.

4 The long-term impact

The analysis of birth certificate data demonstrates that numerological preferences are associated with the timing of births. A question that follows naturally is whether these preferences will have a long-lasting impact on child development, especially when a considerable number of births in Guangdong have been shifted. To investigate the long-term effects of numerological preferences on child quality, we estimate the following econometric model[10]:

[10] All the specifications in this analysis use linear probability model where the dependent variable is a binary indicator. Our results are also robust to if we estimate with a *probit* model.

Table 5 The effect of numerological preferences on children's health

Variables	(1) Birth weight	(2) Birth weight	(3) Apgar score
		< 2500 g	
Auspicious day	2.254***	− 0.0000	0.007
	(0.715)	(0.0003)	(0.019)
Inauspicious day	− 2.283***	0.0007*	0.016
	(0.871)	(0.0004)	(0.027)
Solar8	1.916*	− 0.0007*	− 0.001
	(0.999)	(0.0004)	(0.023)
Solar4	− 1.433	0.0000	0.010
	(1.090)	(0.0004)	(0.025)
Lunar8	4.658***	− 0.0004	0.004
	(0.938)	(0.0004)	(0.020)
Lunar4	− 0.446	− 0.0001	0.022
	(1.021)	(0.0004)	(0.021)
Observations	1,096	1,096	731
R-squared	0.606	0.339	0.594

Dummy variables for weekend, holiday, year and month are included. Robust standard errors are reported in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

Table 6 The effect of numerological preferences on gestational age

Variables	Gestational age (in days)
Auspicious day	− 0.06***
	(0.02)
Inauspicious day	0.00
	(0.03)
Solar8	− 0.01
	(0.03)
Solar4	0.02
	(0.03)
Lunar8	− 0.03
	(0.03)
Lunar4	0.02
	(0.03)
Observations	1096
R-squared	0.827

Dummy variables for month and year are included. Robust standard errors are reported in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

$$Y_i = \beta_0 + \beta_1 Ausp_i + \beta_2 Inasup_i + \Gamma X_i^{'} + \epsilon_i \tag{2}$$

where Y_i is individual $i's$ long-term outcome, measured as the probability of attending college (it takes 1 if the student attended college, and 0 otherwise) and body mass index (BMI). BMI is indicative of healthy nutrition and is thus proxied in our study for health status. We have seen that the shifted babies have higher birth weight, but we do not know whether this initial advantage persists and then translates to a higher BMI. $Ausp_i$ and $Inasup_i$ are dummy variables denoting whether the individual was born on an auspicious or an inauspicious day. X_i is a vector of controls, including gender, parental education, and occupations[11]. ϵ_i is the error term.

The micro data are drawn from the CGSS, conducted by Renmin University of China and the Survey Research Center of Hong Kong University of Science and Technology. Launched in 2003, the CGSS is a national representative continuous survey. We use its data pooling surveys in 2010, 2011, 2012, 2013, and 2015. These waves contain the precise date of birth of the respondents, which allows us to define the variables of interest.

In selecting a sample for our analysis, we first confine our attention to the respondents born after 1990. We exclude respondents born before 1990 because any activity connected with superstition was strictly forbidden during the period of Cultural Revolution (between 1966 and 1976). However, along with the opening of Chinese economy, these traditional cultural beliefs began to recover in the 1990s (Goodkind 1991). Furthermore, the technology on C-section surgery was not yet refined, and thus, relatively few women chose to have C-section in the 1980s in China, especially elective C-section. Fu et al. (2003) investigate the changing trend of C-section rates from 1985 to 2002 in Guangdong Province. They estimate that C-section rates are less than 15% in 1985 and increase to 31% in 1994. Obviously, as the C-section procedure became safer and easier to access in the 1990s, parents could more easily manipulate the timing of their children's birth.

Second, we exclude respondents younger than 18 at the time of the interview, the age that most students graduate from high school. Finally, we restrict the sample to individuals born in Guangdong Province because the findings on short-term manipulation are from Guangdong. After these exclusions, our effective sample has only 134 observations left. The descriptive statistics are reported in Table 7.

The empirical results are shown in Table 8. We find a significant association between being born on auspicious days and the probability of attending college, even with a small sample size. Specifically, people born on auspicious days are 19.6% more likely to attend college than those born on common days.

[11] Note that variables indicating birthdates containing the number four or eight are not included in the regression because (1) we do not find any significant response to number 4 on the birth timing results mentioned above and (2) adding these variables will further decrease the degrees of freedom, given the relatively small sample size ($N = 134$) in this analysis. Our findings are robustness to alternative specifications, i.e., the number variables are included progressively in Eq. (2).

Table 7 Descriptive statistics (CGSS data)

Variables	*N*	Mean	Std. dev.	Min	Max
Attended college	134	0.254	0.437	0	1
Body mass index (BMI)	132	20.23	2.493	15.06	28.09
Male	134	0.545	0.500	0	1
Father's education	134	9.821	3.036	0	16
Mother's education	134	8.299	3.600	0	16
Auspicious day	134	0.269	0.445	0	1
Inauspicious day	134	0.090	0.287	0	1

The data are from the China General Social Survey (CGSS) 2010–2015, and the sample is restricted to individuals born after 1990. We also include parental occupations, which has eight categories (four for mother and four for father). They are not shown here due to space limitations

5 Robustness Checks

In this section, we perform a series of robustness checks. First, we try different specifications for Eq. (1). Second, we modify the sample used to perform the long-term analysis.

To see whether the effect on birth timing is related to physicians' schedule, we include two new variables, "aubf" and "inaubf," in Eq. (1), which respectively denote auspicious and inauspicious days abutting a holiday (before or after). For the purpose of comparison, columns (1) and (3) of Table 9 replicate the OLS estimates in Table 1. We can see that the magnitude of estimates remains unchanged on auspicious days and is slightly reduced on inauspicious days. The robustness of the point estimates to these alternative specifications provides some reassurance that our results are less likely to be driven by other factors.

We also check whether the results will change if we include the full set of year-month dummies. For the purpose of comparison, columns (1) and (3) of Table 10 replicate the OLS estimates in Table 1. We can see that the magnitude of the estimates of auspicious day and inauspicious day are similar, while the remaining variables are almost unchanged. Overall, our results are robust to including the full set of year-month variations.

Table 8 Long-term effects of numerological preferences

	= 1 if the student attended college	BMI
Variables	(1)	(2)
Auspicious day	0.196**	0.524
	(0.078)	(0.534)
Inauspicious day	0.155	− 0.144
	(0.122)	(0.724)
Observations	134	132
R-squared	0.291	0.137

Control variables for gender, parental education, and occupation are included. Robust standard errors are reported in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

Table 9 Robustness checks: physicians' scheduling

Variables	(1) Number of births	(2) Number of births	(3) ln(number of births)	(4) ln(number of births)
Auspicious day	188.66***	187.54***	0.039***	0.039***
	(28.30)	(28.75)	(0.006)	(0.006)
Inauspicious day	− 63.87**	− 57.04*	− 0.014**	− 0.012*
	(29.77)	(30.03)	(0.006)	(0.006)
aubf		25.32		0.009
		(105.70)		(0.023)
inaubf		− 195.46		− 0.049
		(148.25)		(0.034)
Solar8	84.50**	83.35**	0.018**	0.017**
	(40.25)	(40.30)	(0.008)	(0.008)
Solar4	− 3.89	− 2.80	− 0.000	0.000
	(35.76)	(35.80)	(0.007)	(0.007)
Lunar8	144.43***	145.20***	0.030***	0.030***
	(39.31)	(39.49)	(0.008)	(0.008)
Lunar4	− 21.45	− 22.27	− 0.004	− 0.004
	(35.28)	(35.32)	(0.007)	(0.007)
Weekend	− 306.80***	− 307.83***	− 0.067***	− 0.068***
	(23.10)	(23.16)	(0.005)	(0.005)
Chinese New Year	− 160.48**	− 161.80**	− 0.042**	− 0.042**
	(81.04)	(80.94)	(0.020)	(0.020)
National Day	− 525.94***	− 526.08***	− 0.093***	− 0.093***
	(100.76)	(100.87)	(0.019)	(0.019)
Qingming Festival	− 188.61**	− 192.72**	− 0.053**	− 0.054**
	(89.19)	(89.54)	(0.022)	(0.023)
Duanwu Festival	− 260.70**	− 263.27**	− 0.059**	− 0.060**
	(111.97)	(112.29)	(0.025)	(0.025)
Mid-Autumn Festival	− 195.36	− 192.97	− 0.036	− 0.036
	(131.72)	(131.98)	(0.028)	(0.028)
Observations	1096	1096	1096	1096
R-squared	0.669	0.669	0.679	0.680

Dummy variables for month and year are included. Robust standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

In the long-run analysis, our final sample is quite small, with only approximately 130 children. To check whether the results change when we enlarge the sample size, we include data from Fujian, the neighboring province of Guangdong. In columns (1) and (2) of Table 11, we report the baseline results for the sample drawn from Guangdong Province. Columns (3) and (4) add the observations from Fujian Province, which geographically abuts Guangdong and shares similar cultural beliefs. Based on this

Table 10 The effect of numerological preferences on the timing of births: including year-by-month dummies

Variables	(1) Number of births	(2) Number of births	(3) ln(number of births)	(4) ln(number of births)
Auspicious day	188.66***	196.70***	0.039***	0.041***
	(28.30)	(23.54)	(0.006)	(0.005)
Inauspicious day	− 63.87**	− 81.74***	− 0.014**	− 0.018***
	(29.77)	(24.93)	(0.006)	(0.005)
Solar8	84.50**	84.62**	0.018**	0.018**
	(40.25)	(35.74)	(0.008)	(0.007)
Solar4	− 3.89	− 4.12	− 0.000	− 0.000
	(35.76)	(31.82)	(0.007)	(0.007)
Lunar8	144.43***	139.15***	0.030***	0.029***
	(39.31)	(32.19)	(0.008)	(0.006)
Lunar4	− 21.45	− 23.18	− 0.004	− 0.005
	(35.28)	(30.74)	(0.007)	(0.007)
Weekend	− 306.80***	− 308.68***	− 0.067***	− 0.068***
	(23.10)	(19.83)	(0.005)	(0.004)
Chinese New Year	− 160.48**	− 151.82*	− 0.042**	− 0.040**
	(81.04)	(77.97)	(0.020)	(0.019)
National Day	− 525.94***	− 525.40***	− 0.093***	− 0.093***
	(100.76)	(103.54)	(0.019)	(0.019)
Qingming Festival	− 188.61**	− 180.44**	− 0.053**	− 0.051**
	(89.19)	(87.68)	(0.022)	(0.022)
Duanwu Festival	− 260.70**	− 270.53***	− 0.059**	− 0.061***
	(111.97)	(99.08)	(0.025)	(0.022)
Mid-Autumn Festival	− 195.36	− 212.35*	− 0.036	− 0.040
	(131.72)	(119.76)	(0.028)	(0.025)
Observations	1096	1096	1096	1096
R-squared	0.669	0.761	0.679	0.767
Year dummies	Yes	No	Yes	No
Month dummies	Yes	No	Yes	No
Year-month fixed effect	No	Yes	No	Yes

Robust standard errors in parentheses

$*p < 0.1$, $**p < 0.05$, $***p < 0.01$

specification, the sample size is increased by 170. We can see that the point estimates of auspicious day are slightly decreased and still statistically significant at the 5% level[12].

[12] We also include Jiangxi, Guangxi, and Hainan Provinces that abut Guangdong but have different cultural beliefs. However, all the results are statistically insignificant. Because Guangdong is regarded as one of the areas most noted for belief in Chinese traditional culture, the numerological preferences may be more prevalent among people of Guangdong (the short-term results also support this predication). Consequently, the findings regarding birth manipulations are not necessarily applicable nationwide.

Table 11 Long-term effects of numerological preferences: individuals born after 1990

Variable	Baseline		Including Fujian	
	= 1 if the student attended college (1)	BMI (2)	= 1 if the student attended college (3)	BMI (4)
Auspicious day	0.196**	0.524	0.144**	0.311
	(0.078)	(0.534)	(0.072)	(0.507)
Inauspicious day	0.155	− 0.144	0.089	− 0.285
	(0.122)	(0.724)	(0.119)	(0.720)
Observations	134	132	170	163
R-squared	0.291	0.137	0.224	0.123

Control variables for gender, parental education, and occupation are included. Robust standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

6 Conclusions

This paper has systematically examined the effect of numerological preferences on babies' delivery dates. The data are high-quality administrative data from birth certificates between 2014 and 2016 in Guangdong Province, China. Our study shows that a considerable number of births are shifted to (away from) auspicious (inauspicious) days, especially among babies born to older mothers. Superstitious families also strategically select dates that contain the number 8, especially based on the lunar calendar. In addition, we found a significantly higher sex ratio (male/female) for births on auspicious days.

The manipulation mentioned above is performed using C-sections. Such practice is consistent with previous studies. For example, Lo (2003) and Lin et al. (2006) demonstrated that a mother's own choice of birthdate may be an important driving force of C-section use, in addition to financial considerations or convenience on the part of physicians. In terms of birth weight, babies born on auspicious days are heavier than those born on common days, which may be due to a selection effect such that physicians are less likely to permit pregnant women facing potential risks such as underdeveloped fetus to alter the timing of birth.

Finally, we use a second dataset to examine the long-term effect of numerological preferences. We find that individuals born on auspicious days are 19.6% more likely to attend college, even after controlling for rich family background variables. We are inclined to interpret this positive association as self-fulfilling prophecy by parents, i.e., parents with numerological preferences invest more in their children born on auspicious days. Similarly, Mocan and Yu (2017) find that the dragon superstition in China leads many women to give birth in a dragon year. Moreover, the "dragon" children have higher test scores in middle school and higher chance to receive college education. They further argue that the mechanism behind the "dragon" effect could be that parents of dragon children have higher expectations on their children and invest more heavily in their children in terms of time and money.

Traditional superstitions as cultural beliefs are widespread and persistent over long periods of time across many countries. Such cultural preferences have important impacts on economic development by affecting behaviors. For example, in a recent study, Gershman (2016) documented a negative association between witchcraft beliefs and a range of social capital attributes, such as trust, charitable giving, and participation in religious activities in Sub-Saharan Africa. Our empirical results further add to the existing literature suggesting that superstition-based preferences not only alter birth timing but also might affect human capital investment later in life. Overall, we believe that studying cultural beliefs and preferences can provide a better understanding of demographic behaviors and economic development.

Our findings should be interpreted with caution. Although we controlled for parent's occupation and education, some unobserved factors may be confounding the results. For example, the parents choosing auspicious/inauspicious days may be more likely able to afford a C-section (in the 1990s, the C-section was not covered by the health insurance in Guangdong Province). If so, the long-term effect on college entry should not be completely driven by self-fulfilling prophecy, it would also reflect the fact that wealthier families have more resources available to invest in their children. It merits future investigation with appropriate instruments or "natural experiments" to solve the potential omitted variable bias problem.

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Compliance with ethical standards

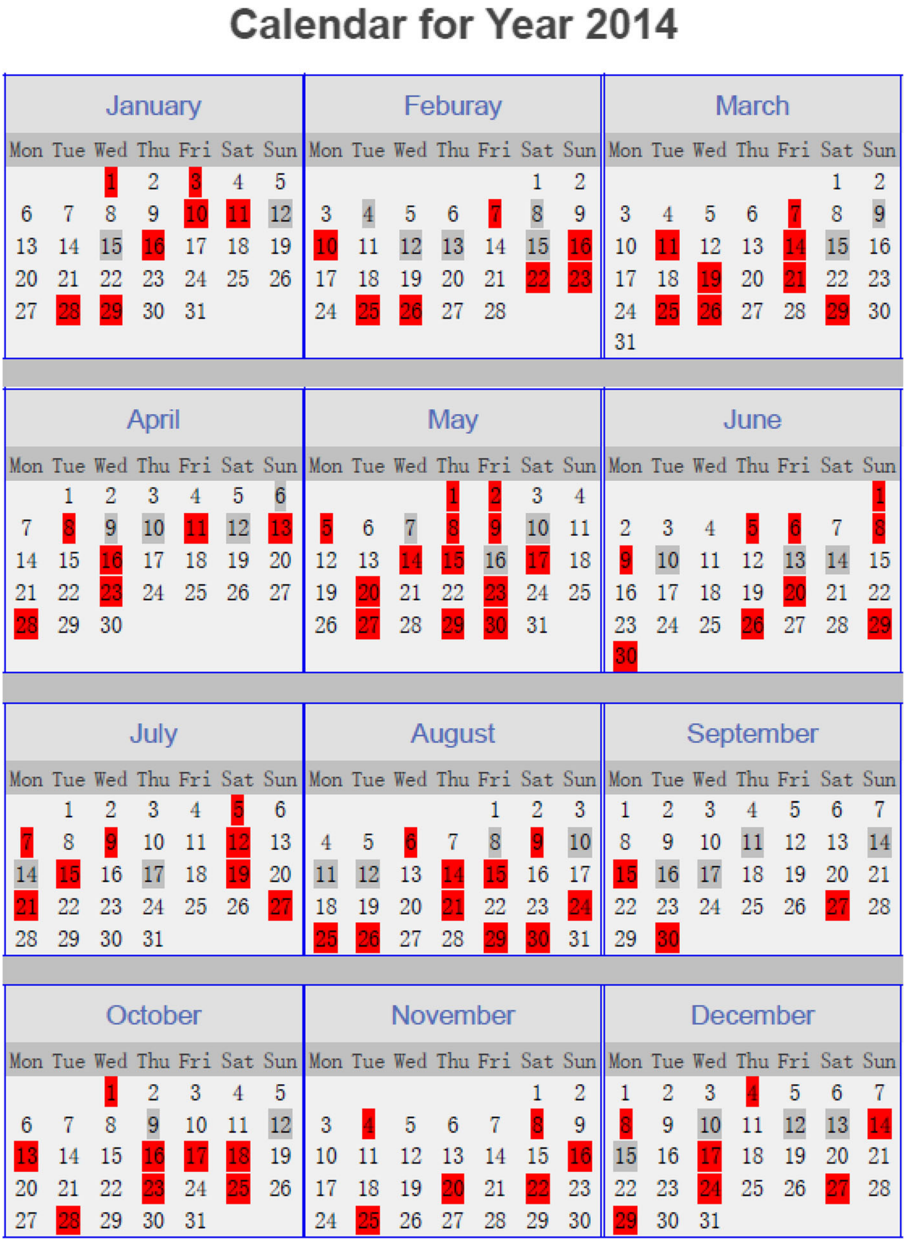
Conflict of interest The authors declare that they have no conflict of interest.

Appendix. An example of auspicious days and inauspicious days

Auspicious days: September 2014

Inauspicious days: September 2014

Auspicious days (in red) and inauspicious days (in gray) in 2014



The screenshots above are from http://huangli.baishibaike.com/.

Table 12 Test the birth timing mechanism

Variables	(1) Number of births	(2) Number of births	(3) ln(number of births)	(4) ln(number of births)
Auspicious day	188.66***	37.04*	0.039***	0.007*
	(28.30)	(20.73)	(0.006)	(0.004)
Inauspicious day	− 63.87**	− 21.08	− 0.014**	− 0.005
	(29.77)	(22.49)	(0.006)	(0.005)
N. of C-section		1.42***		0.000***
		(0.04)		(0.000)
Solar8	84.50**	1.78	0.018**	0.000
	(40.25)	(28.13)	(0.008)	(0.006)
Solar4	− 3.89	15.77	− 0.000	0.004
	(35.76)	(25.40)	(0.007)	(0.005)
Lunar8	144.43***	18.79	0.030***	0.004
	(39.31)	(27.63)	(0.008)	(0.005)
Lunar4	− 21.45	2.84	− 0.004	0.001
	(35.28)	(23.09)	(0.007)	(0.005)
Weekend	− 306.80***	− 51.14***	− 0.067***	− 0.013***
	(23.10)	(19.22)	(0.005)	(0.004)
Chinese New Year	− 160.48**	− 59.24	− 0.042**	− 0.021*
	(81.04)	(52.11)	(0.020)	(0.012)
National Day	− 525.94***	− 395.72***	− 0.093***	− 0.066***
	(100.76)	(75.92)	(0.019)	(0.014)
Qingming Festival	− 188.61**	− 31.38	− 0.053**	− 0.020
	(89.19)	(95.84)	(0.022)	(0.021)
Duanwu Festival	− 260.70**	− 60.59	− 0.059**	− 0.017
	(111.97)	(86.64)	(0.025)	(0.019)
Mid-Autumn Festival	− 195.36	− 128.60	− 0.036	− 0.022
	(131.72)	(96.70)	(0.028)	(0.021)
Observations	1096	1096	1096	1096
R-squared	0.669	0.840	0.679	0.853
Year dummies	Yes	Yes	Yes	Yes
Month dummies	Yes	Yes	Yes	Yes
Robust standard errors in parentheses				

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

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