Choosing Season of Birth: The Role of Biological and Economic Constraints*

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Abstract

We provide novel estimates of women's decision of when to have their first birth in terms of fertility timing (young vs. old) and season of birth (which quarter), for non-Hispanic white women aged 25-45 in the US in 2005-2013. The prevalence of good season (quarters 2 and 3) is very significantly related to mother's age, as well as to her education and marital status, while those who do not undergo assisted reproductive technology procedures to achieve their first birth exhibit a much higher prevalence of good season births. The frequency of good season is also higher and more strongly related to mother's age in states where cold weather is more severe, reinforcing the interpretation that season of birth is a choice outcome. Finally, we perform a structural investigation to quantify the value of good season of birth in terms of birth weight and wages.

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1 Introduction

Motivation. While the relevance of season of birth has been acknowledged at least since Huntington (1938) wrote his book "Season of Birth: Its Relation to Human Abilities", it was not until the seminal article by Angrist and Krueger (1991) –quarter of birth is shown to be related to education and earnings in the US– that season of birth became popular in economic research. Recent work has unveiled a variety of channels, beyond school cutoff laws, through which season of birth may affect adult outcomes, for example, its potential effects on birth outcomes. Indeed, a clear and consistent pattern of "good" and "bad" seasons has emerged. In the US, winter months are associated with lower birth weight, education and earnings, while Spring and Summer are found to be "good" seasons (e.g., Buckles and Hungerman, 2013; Currie and Schwandt, 2013). However, no study so far has considered season of birth as a choice outcome. The purpose of this paper is precisely to fill this gap, by considering season of birth as a decision variable and quantifying the trade-offs that mothers face (if any) when choosing season of birth. To further motivate our approach, we present several novel stylized facts in Figures 1-5 suggesting that season of birth is indeed a matter of choice.

Stylized facts. Figure 1 shows the gap between the fraction of first births to "younger" (25-39) and "older" (40-45) women by month: The gap is positive in the months representing the "good" season (April to September) and negative in the "bad" season (October to March). This finding is consistent with "younger" mothers being less biologically constrained than "older" mothers when making their fertility decision, *ceteris paribus*. Figure 2 reveals that, for "younger" women, good season is more prevalent in the North of the US than in the South. However, this pattern does not hold for "older" women, as we can see in Figure 3. Specifically, among "younger" women, a much higher proportion of good season births are observed in the northern states where the winter temperature is more severe. Interestingly, there is a North-South gradient, southern states with milder Winter exhibit lower proportion of births in good seasons. Strikingly, no such geographical pattern is observed of first births to "older" mothers, with the proportion of good season births appearing to be unrelated to geographic location of the state.

We further investigate whether the geographical differences in the prevalence of good season are due to weather conditions in Figure 4. If women choose season of birth at all, they may be more willing to give birth in the Spring or Summer, at least in states with more severe cold weather in Winter. We plot the percentage of "younger" women giving birth in the good season against the coldest monthly average by state: The pattern is spectacular. There is a strong linear negative association between these two variables (correlation coefficient = -0.729). Interestingly, we do not find such a relationship for older women (correlation coefficient = -0.115). Finally, in Figure 5, we present additional evidence that the seasonality of births is strongly related to weather: The US (Northern hemisphere) seasonality patterns of birth are completely reversed in Chile (Southern hemisphere).

Given the prominence of fertility planning in balancing people's work and family life as well as the above stylized facts, it is hard to believe that season of birth may simply be a matter of chance. In addition, far from assuming that the average woman is aware that birth weight and the child's future earnings are affected by birth timing, it is sufficient to consider that the average woman has a sense that, on the one hand, winter months may be tougher birth months because of cold weather and higher disease prevalence,[1] and on the other, work commitments make it much easier to take time off with a Spring-Summer birth.[2]

This paper. We first present novel correlates of season of birth, investigating women's decision of when to have their first birth in terms of fertility timing (young versus old) and

[1]According to the CDC (2014), from 1982-83 through 2013-14, the "peak month of flu activity" (the month with the highest percentage of respiratory specimens testing positive for influenza virus infection), has been February (14 seasons), followed by December (6 seasons) and January and March (5 seasons each): http://www.cdc.gov/flu/about/season/flu-season.htm

[2]The report on fertility, family Planning, and women's health (CDC, 1997) notes that some women do not take maternity leave due to the timing birth relative to their job schedules, and gives the example of school teachers who deliver during summer break.

season of birth (which quarter), for non-Hispanic white women aged 25-45. Using US Vital Statistics data from 2005 to 2013 on all first singleton births, we show that the prevalence of good season (quarters 2 and 3) is very significantly related to mother's age, as well as to her education and marital status. In addition, we find that women who do not undergo assisted reproductive technology (ART) are 3 percentage points more likely to give birth in the good season. This finding, which is robust to controlling for gestation length fixed effects, is consistent with season of birth being a choice outcome, if undergoing ART is associated to no longer being under control of birth timing. Moreover, if women undergoing ART cannot choose season of birth, we should expect to find no seasonality gap, and we present supportive evidence for this prediction. We then examine how birth outcomes, such as birth weight, prematurity (< 37 weeks of gestation) and APGAR scores, are related to season of birth controlling for mother's characteristics. We find that being born in the good season is positively associated to better birth outcomes.

In the second part of our investigation, we construct a structural model to examine women's decisions of *when in their life cycle* (young vs. old) and *in which season* (good vs. bad) to have the first child. On average, younger mothers deliver better birth quality also through realized good season of birth, whereas older age warrants higher wages to the possible detriment of birth quality. The structural model allows us to estimate the "value" of good season of birth as the trade-off between birth quality (proxied by birth weight) and mother's wages.

Related literature. While Currie and Schwandt (2013) explain the first quarter of birth disadvantage through the negative impact of the disease environment on birth weight and gestational weeks in cold months, Buckles and Hungerman (2013) emphasize the role of maternal characteristics in shaping the later socioeconomic disadvantage of winter-born individuals, showing that the mothers of those children are significantly less educated, less likely to be married or white, and more likely to be teenagers.[3] Apart from the work by

[3] Alba and Cáceres-Delpiano (2014) describe similar findings for Chile and Spain.

Buckles and Hungerman (2013), which may suggest the possibility that season of birth is *not* random, there is a literature on "exact" birth timing analyzing the joint decision of parents and physicians to alter the delivery of an already existing pregnancy (in response to non-medical incentives). Shigeoka (2015), focusing on the distribution of births between December and January, finds that in Japan many births are shifted one week forward around the school entry cutoff date. Dickert-Conlin and Chandra (1999) and LaLumia et al. (2015) report that in the US parents may move expected January births backwards to December to gain tax benefits, while in Australia Gans and Leigh (2009) estimate that parents moved forward June deliveries to become eligible for a newly introduced "baby bonus". Fewer births are documented on holidays (Rindfuss et al., 1979) and weekends (Gould et al., 2003), less auspicious dates (Almond et al., 2015) or on medical professional meeting dates (Gans et al., 2007). Although this body of evidence clearly shows that parents may be willing and able to manipulate birth timing, it represents a choice made well after conception occurs. To the best of our knowledge, ours is the first economic analysis of the planning of season of birth.

Structure of the paper. Section 2 describes the data sources. Section 3 presents the reduced-form estimates. Section 4 develops a structural model and provides estimates of the "value" of good season of birth. Section 5 concludes the paper.

2 Data Sources and Descriptive Statistics

2.1 Birth Data

Data on all births occurring each year in the United States are collected from birth certificate records, and publicly released as the National Vital Statistics System (NVSS) by the National Center of Health Statistics. These data are available for download for all years (inclusive) between 1968 and 2013, with all registered births in all states and the District of Columbia reported from 1984 onwards.[4] In total, more than 99% of births occurring in the country are registered (Martin et al., 2015). Our main estimation sample consists of birth years 2005-2013, and we retain all first births to white, non-Hispanic mothers aged between 25 and 45 years at the time of birth. This results in 4,863,864 records for live births, including twins but excluding triplets and above. In our main analysis, we restrict our sample to singletons, so that the estimation sample consists of 4,711,449 first births.

The birth certificate data record important information on births and their parents (mostly on mothers). For the mother, this includes age, marital status, education, smoking status during pregnancy, and assisted reproductive technology (ART) use. For the newborn, in addition to place and time of birth, measures include gestation (in weeks), birth weight, and one- and five-minute APGAR scores. However, birth certificates have gone through two important revisions in the variables reported: One in 1989 and the other in 2003. These revisions (described fully in NCHS, 2000) were implemented by states at different points in time. Prior to 2005, all states had fully incorporated the 1989 revision. In the most recent wave of birth certificate data (2013), 41 states, containing 90.2% of all births had switched to the more recent 2003 revision. Importantly, the revised data include a different measure of education, a wider range of birth outcomes, and do not include the mother's smoking status. ART use information was first released in 2012. These changes mean that we do

[4] Prior to 1984, a 50% sample was released for those states which did not submit their birth records on electronic, machine readable tape (Martin et al., 2015).

not have information for all variables over the whole period of analysis.[5]

2.2 Weather and Unemployment Data

A number of other data sources are consulted, and merged with birth data to provide time-varying coverage of local conditions at the time of conception, including measures of weather and unemployment. These are calculated at the year by month and state level, and are merged by conception (not birth) month. We are able to calculate both conception and birth month, given that gestation is reported in the birth data.

Temperature data are provided by the National Centers for Environmental Information from 1895 onwards, updated monthly. We collate measures of monthly means, maxima and minima for each state, year and month over our time period of analysis, as described in Vose et al. (2014). These are available for all states with the exception of Hawaii and the District of Columbia (DC). We assign births that take place in DC temperature data from Maryland, a contiguous state. Unemployment data at the level of the state, year and month is created from the Bureau of Labor Statistics' (BLS) online monthly time series data.[6] These data come from the Local Area Unemployment Statistics (LAUS) Series, and are available for all states plus DC for the entire time period of interest.

2.3 Descriptive Statistics

Summary statistics for white non-Hispanic mothers aged 25-45 and their children, where the unit of observation is the first birth, are presented in Table 1. The first panel of the table shows that women are on average 30 years old, 84% of them are married, and 97% are between 25 and 39 years old ("younger"). Figure 6 displays the absolute frequencies of first births by mother's age for the whole population of white Non-Hispanic first-time (biological)

[5]Complete details of missing variables are available in Table 1, and further details regarding birth certificate revisions and the effect on reported variables and representativeness of the country as a whole are provided in appendix C.

[6]Full records are available at http://download.bls.gov/pub/time.series/la.

mothers and our sample (25-45). While essentially there are no first births to women above 45, women younger than 25 represent about 30% of first births, and a substantial percentage of them includes teenage pregnancies. For those birth certificates with available mother's education information, 87% have at least some college education; for those with non-missing smoking information, 6% reported having smoked during pregnancy. Finally, for the two most recent years in our sample (2012, 2013), we have information on the use of ART procedures: 2% of the women report having used them to achieve their first birth.

In the second panel, we present very detailed information on birth outcomes. 51% of the babies are born in the good season, defined as quarters 2 and 3; taking into account gestational length, 52% of the newborns were planned for the good season. It is noteworthy that in the US none of the public holidays falls any close to the frontiers between the good and bad seasons defined above (Nationally Observed Public Holidays are: New Year's Day, Martin Luther King Jr. Day, Presidents' Day, Memorial Day, July 4, Labor Day, Columbus Day, Veteran's Day, Thanksgiving, Christmas Day). Regarding gender and multiple births, 49% are girls while 3% are twins (triplets and above where dropped from our sample); in our main analysis, we focus on singletons. Finally, we have information on birth "quality" measures, including birth weight, prematurity ($<$ 37 weeks of gestation) and APGAR score. The averages of these measures (3,309 grams, 10%, 8.8, respectively) are consistent with those from previous studies.

We focus on first births, given that higher-order births also involve the additional decision of birth spacing and the role of experience, possibly underestimating the determinants of the choice of season of birth if planning improves with higher-order pregnancies. In the same vein, we consider only singleton births, although we use second-births and twin birth data in the sensitivity analysis, along with robustness checks on school entry rules, earlier years of data, and heterogeneity by socioeconomic status.

Table 2 investigates the seasonality of birth by mother's age (young vs. old) and education (no college vs. at least some college). Panel A shows that young women are 3.2

percentage points (pp) more likely to give birth in the good season than in the bad season (51.6% good vs. 48.4% bad), whereas for older women the odds are virtually 50-50 (50.2% good vs. 49.8% bad). In Panel B we also observe that more educated women have a higher probability of giving birth in the good season (52% vs. 48%), while the gap for less educated women is 1 pp (50.6% vs. 49.4%). Finally, Panel C reveals that the difference between younger and older women appears to be largely driven by more highly educated women, a finding that will prove useful in leading our structural estimation.[7]

Figure 7 highlights the seasonality gap by age group. Two features are worth mentioning. First, there is a decreasing gap in age from 25 to 45. In particular, the relative prevalence of good season is highest (more than 3 pp) for mothers aged 25-34, while it is essentially zero (less than -0.5 pp) for mothers aged 40-45. Second, the relationship between seasonality gap and age is non-monotonic: The gap for women aged 20-24 is much smaller than that of women aged 25-34. While the former feature is consistent with biological constraints, the latter suggests that the prevalence of good season of birth cannot be entirely accounted for by the higher biological ability of young mothers to better plan their births.

[7] The same type of investigation is developed with Spanish birth certificate data for the years 2007-2013 in a country with a much more generous maternity leave environment than the US. That is, this allows us to strengthen our interpretation of the choice nature of season of birth and to examine its relationship with mothers' labor force participation and occupation, information that is not at all recorded in the US certificates.

3 Reduced-form estimates

Season of birth correlates. In Table 3 we investigate the relationship between good season of birth (quarters 2 and 3) and mother's age. In column 1 we see that "younger" women (aged 25-39) are 2 pp more likely to have their first child in the good season than "older" women (aged 40-45). This difference is robust to the addition of control variables (columns 2-4): Year fixed effects, education (an indicator for having some college or above), marital status (an indicator for being married), and (an indicator for) smoking during pregnancy. In addition, high-educated women (or married women) are at most only 1 pp more likely to have their first born child in the good season than their counterparts, which is only half of the difference between younger and older women. Women who smoked during pregnancy are at most 1 pp less likely to have their first birth in the good season. Hence, a mother's age seems to be the most relevant driving force behind season of birth. Finally, in columns 5-7, we investigate the role of undergoing an ART procedure. Since this information is available only for 2012 and 2013, we replicate column 4 with this restricted sample in column 5, finding the same results. In column 6 we include an ART indicator (1 if the birth did not happen through an ART procedure, 0 otherwise), and estimate a strongly positive significant coefficient: Women who do not undergo ART are 3 pp more likely to give birth in the good season. This finding, which is robust to controlling for gestation length fixed effects (column 7), is consistent with season of birth being a choice variable, if undergoing ART is associated to no longer being under control of birth timing.

Placebo test: ART versus non-ART users. If women undergoing ART cannot choose season of birth, we should expect to find no seasonality gap. However, women undergoing ART who are very young (20-24), well below the mean age of mother at first birth in the US (26 years in 2013; see Martin et al., 2015), are likely to suffer from serious infertility problems and may be those who end up in the bad season. These two features are precisely reported in Figure 8(a). Instead, Figure 8(b) reports the pattern described above for the non-ART users.[8] Table 4 summarizes these graphical findings in regression format.

Birth outcomes correlates. In Table 5 we investigate the correlates of birth outcomes. Babies born in the good season tend have better outcomes at birth, after controlling for mother characteristics: They are 8 grams heavier; they are 0.1 pp less likely to be LBW ($< 2,500$ grams); they have on average 0.02 more weeks of gestation; and they are 0.02 pp less likely to be premature (< 37 weeks of gestation). Younger women tend to have babies with higher "quality" at birth: Their babies tend to be 85 g heavier; they are 3 pp less likely to be LBW; 0.6 pp less likely to be VLBW ($< 1,500$ grams); they have on average 0.5 more weeks of gestation; they are 4 pp less likely to be premature; and they score 0.04 additional units in the APGAR score. In addition, high-educated (and married) women tend to have babies with better outcomes at birth. Finally, women who smoke in pregnancy have babies who are 178 grams thinner, consistent with the findings in Lien and Evans (2005), who use an instrumental variable approach and find that maternal smoking reduces mean birth weight by 182 grams.

3.1 Robustness checks

In Table 6 we replace "realized" season of birth with "intended" season of birth by using the information on gestational length. Reassuringly, results are very similar to those in Table 3, which reinforces our view of season of birth as a decision variable. We consider the additional sample of second births and run our main regressions of good season of birth on maternal characteristics, finding the same pattern of results and significance, with slightly larger estimated coefficients (Table 7). Interestingly, when we instead focus on the sample of twin first births we do not find any statistically significant association between the prevalence of good season among twins and maternal characteristics such as age or education (Table 8). Twins represent only 3% of the total of first births, and nowadays mainly arise

[8] See Figure 11 for a month-by-month comparison in the seasonality gap by ART status.

as an effect of non-ART and ART procedures in the presence of infertility problems: We believe that the above evidence is consistent with our interpretation of season of birth as a choice variable, since for women undergoing ART treatments birth timing and planning is often out of their control. Finally, including fetal deaths in our regressions does not alter our findings (Table 9).

To check the role of mother's age, we also run regressions using age (and age squared) as a continuous variable, or with an indicator of being 25-34 years old instead of 25-39 for the younger group. Tables 10-12 all provide evidence consistent with the relevant role of mother's age in determining season of birth, with the important finding that defining younger mothers as those only up to 34 years of age diminishes the age role, so that we keep 25-39 as our main younger age group. Finally, when running the birth quality regressions on the sample of second births or twins, the estimates confirm our previous findings: Good season is positively significantly associated to birth quality indicators for second births (results available upon request), but not at all for twin first births (Tables 13).

We replicate our analysis for Spain in Tables 14-18 and Figures 9-10. See Appendix.

4 A Structural Interpretation of Season of Birth Choices: The Birth Quality–Labor Market Tradeoff

4.1 A Structural Model

We turn to a structural interpretation of season of birth choices. In this model, age at first birth is viewed as a trade-off between the biological benefits of (younger) age and good season (the benefits of good season may include: better child quality, mother's satisfaction, etc.) against the costs of career delays associated with births at a younger age. The positive association between fertility delay and women's career success has been documented in both *time-series* (Caucutt et al., 2002) and in *cross-sectional* data (Hofferth, 1984). More recently, using biological fertility shocks to *instrument* for age at first birth, Miller (2011) has found that motherhood delay leads to a substantial increase in earnings of 9% per year of delay.

We begin with a young woman i endowed with completed education $Educ_i$. Each individual decides sequentially whether or not to have their first birth. The decision is made dynamically, and consists of four periods in which the woman can decide to give birth or not: Young good season (YG), young bad season (YB), old good season (OG) and old bad season (OB). A control variable denoted b_{it} describes the optimal entry rule: If $b_{it} = 0$, the woman has not yet chosen to give birth, and in the period in which she decides to give birth, b_{it} switches to 1 forever after.

Instantaneous Utilities. In each period the individual faces instantaneous utility of having a birth ($b = 1$) or not having a birth ($b = 0$) described by:

$$\begin{aligned} U_{ijt}^{b=1} &= \ln(w_{jt}^{b=1}) + \gamma q_{ijt} + \varepsilon_{ijt}^{b=1}, \\ U_{ijt}^{b=0} &= \ln(w_{jt}^{b=0}) + \varepsilon_{ijt}^{b=0}. \end{aligned}$$

In this framework, utility comes from the market wage or shadow price for home labor (w_{jt}) available to the woman in her state of residence, as well as the biological quality of the child (q_{ijt}) if a birth has been realized, and a stochastic utility shock only observed once arriving to each period (ε_{ijt}). For now, it is assumed that these stochastic shocks are jointly normally distributed each with a mean of zero, standard deviations $\sigma_{b=1}, \sigma_{b=0}$ and zero covariance. Each ε_{ijt} term is assumed to be *i.i.d.*, so past values of each utility shock have no effect on current realizations.

Wage and birth quality can be thought of as offer functions in each period, and are modelled as:

$$\ln(w_{jt}) = \alpha_1 Educ_j + \alpha_2 Exper_{jt} + \alpha_3 Exper_{jt}^2$$

and

$$q_{ijt} = \beta_0 + \beta_1 S_{ijt}^{good} + \beta_2 young_{ijt} + \beta_3 Educ_{ij}.$$

where *Educ* denotes educational attainment, *Exper* denotes labor market experience, S^{good} is an indicator for the child being born in the good season, and *young* is an indicator for the mother deciding to have their first child when "young" (if equal to 1) or when "older" (if equal to 0).

Given that wages are *not* observed in the NVSS birth data, the wage offer is considered to be the *average* market wage in the woman's state of residence for a woman with the same education and experience level (e.g., $Exper = age$ if no birth, $Exper = age - 1$ if age occur).

Bellman Equations. In each of the four periods the state variables for each individual are (time invariant) education $Educ_{ij}$, accrued labour market experience, $Exper_{ijt}$, and the utility shocks ε_{ijt}. We now denote these state variables as Ω_{ijt}. Conditional on state variables, we can express the value of remaining childless or deciding to have a child in the form of Bellman equations. The value of remaining childless, $V_{ijt}^{b=0}(\Omega_{ijt})$, can be expressed as:

$$V_{ijt}^{b=0}(\Omega_{ijt}) = U_{ijt}^{b=0} + \rho E \max[V_{ijt+1}^{b=0}(\Omega_{ijt+1}), V_{ijt+1}^{b=1}(\Omega_{ijt+1})] \quad (1)$$

where ρ is the discount rate. Similarly, the value of deciding to give birth is expressed as:

$$V_{ijt}^{b=1}(\Omega_{ijt}) = U_{ijt}^{b=1} + \rho E(V_{ijt+1}|b_t = 1). \quad (2)$$

Once the individual decides to give birth, the value function $V_{ijt+1}|b_t = 1$ consists of the discounted expected present value of labour market return and child quality, from $t+1$ to the final period.

Estimating the Model. The decision of whether or not to have a birth depends upon prior decisions regarding births, as well as the prevailing instantaneous utilities. The likelihood of observing a first birth in a given period t can then be thought of as the intersection of the probability that the individual still remains childless at the end of $t-1$, and the probability that the instantaneous utility of having a birth is greater than the utility of remaining childless. As the error terms $\varepsilon_t^{b=1}$ and $\varepsilon_t^{b=0}$ are assumed to be *i.i.d.*, these two events are independent, and the likelihood will be the product of these two terms.

Define a vector of parameters $\boldsymbol{\theta} = (\gamma, \beta, \sigma_{b=1}, \sigma_{b=0})$. Then we are interested in writing the likelihood function, which for an individual in time t looks like:

$$\begin{aligned} \mathcal{L}(\boldsymbol{\theta}; b_t = 1, U_t^{b=1}, U_t^{b=0}) &= P(b_{t-1} = 0|\boldsymbol{\theta}) \times P(U_t^{b=1} - U_t^{b=0} > 0|\boldsymbol{\theta}) \\ &= \mathcal{L}(\boldsymbol{\theta}; b_{t-1} = 0) \times \mathcal{L}(\boldsymbol{\theta}; U_t^{b=1} - U_t^{b=0} > 0) \end{aligned}$$

writing this as the log-likelihood gives:

$$\ell(\boldsymbol{\theta}; b_t = 1, U_t^{b=1}, U_t^{b=0}) = \ell(\boldsymbol{\theta}; b_{t-1} = 0) + \ell(\boldsymbol{\theta}; U_t^{b=1} - U_t^{b=0} > 0) \quad (3)$$

We can write the likelihood of the second part of this equation by considering the probability that $U_t^{b=1} > U_t^{b=0}$:

$$\begin{aligned} Pr(U_t^{b=1} > U_t^{b=0}) &= Pr\{[\ln(w_{it}^{b=1}) + \gamma q_{it} + \varepsilon_{it}^{b=1}] > [\ln(w_{it}^{b=0}) + \varepsilon_{it}^{b=0}]\} \\ &= Pr[\ln(w_{it}^{b=1}) - \ln(w_{it}^{b=0}) + \gamma q_{it} > (\varepsilon_{it}^{b=1} - \varepsilon_{it}^{b=0})] \qquad (4) \end{aligned}$$

given that each of the ε terms is normally distributed, $\varepsilon_{it}^{b=1} - \varepsilon_{it}^{b=0}$ is also normally distributed, with a mean of zero and a variance of $\sigma_{b=1}^2 + \sigma_{b=0}^2$, which for ease of exposition we will now denote as σ_b^2. We can then simply write the log-likelihood using the well-known formula for a normally distributed variable as:

$$\ell(\boldsymbol{\theta}; U_t^{b=1} - U_t^{b=0} > 0) = \ln\left[\sigma_b^{-1} \cdot \phi\left(\frac{\ln(w_{it}^{b=1}) - \ln(w_{it}^{b=0}) + \gamma q_{it}}{\sigma_b}\right)\right], \qquad (5)$$

where $\phi(\cdot)$ is the normal *pdf*.

The likelihood of the first part of the equation, $\ell(\boldsymbol{\theta}; b_{t-1} = 0)$, can be calculated by using the Bellman equations (1) and (2). This can be calculated analytically using backwards induction, given that the expectation of the value functions is taken over future draws from *i.i.d.* normal variables. We can estimate estimate $\boldsymbol{\theta}$, and hence γ, the parameter which compares the utility from an additional gram of birth weight versus the utility from an additional unit of ln(wage).

Finally then, aggregating over all individuals in each period, we can write the log-likelihood function to maximise as:

$$\ell(\boldsymbol{\theta}; b_t = 1, U_t^{b=1}, U_t^{b=0}) = \prod_{i=1}^{N}\prod_{t=1}^{T} \ell(\boldsymbol{\theta}; b_{it-1} = 0) + \ell(\boldsymbol{\theta}; U_{it}^{b=1} - U_{it}^{b=0} > 0).$$

4.2 Structural estimates

[To be completed]

5 Conclusion

The effects of season of birth on newborn and adult socioeconomic outcomes have been widely documented across disciplines, where a clear and consistent pattern of "good" and "bad" seasons has emerged. This is the first analysis of season of birth as a choice that women may make, and to estimate the value of good season of birth in terms of birth weight and wages.

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Tables

Table 1: Descriptive Statistics

	N	Mean	Std. Dev.	Min.	Max.
Panel A: Mother					
Mother's Age	4863864	30.24	4.06	25	45
Married	4863864	0.84	0.36	0	1
Young (aged 25-39)	4863864	0.97	0.17	0	1
Some College +	3181962	0.87	0.33	0	1
Years of education	3181962	15.33	1.76	4	17
Smoked during Pregnancy	2813344	0.06	0.25	0	1
Used ART (2012-2013 only)	975745	0.02	0.14	0	1
Panel B: Child					
Good season of birth	4863864	0.51	0.50	0	1
Intended good season of birth	4859056	0.52	0.50	0	1
Female	4863864	0.49	0.50	0	1
Twin	4863864	0.03	0.17	0	1
Birthweight (grams)	4849898	3309.42	574.87	500	5000
Low Birth Weight (< 2500 g)	4849898	0.07	0.26	0	1
Weeks of Gestation	4859056	38.85	2.41	17	47
Premature (< 37 weeks)	4859056	0.10	0.31	0	1
APGAR (1-10)	4752668	8.79	0.81	0	10

NOTES: NVSS 2005-2013. Each sample consists of all first-born children born to non-Hispanic white women aged 25-45. Good season refers to birth quarters 2 and 3 (Apr-Jun and Jul-Sept).

Table 2: Percent of Births (Singletons)

	Seasons				Characteristics	
	Bad Season	Good Season	Diff.	Ratio	<37 Weeks	ART
PANEL A: BY AGE						
Young (25-39)	48.43	51.57	3.14	1.06	0.09	0.01
Old (40-45)	50.2	49.8	-0.4	0.99	0.13	0.09
PANEL B: BY EDUCATION						
No College	49.44	50.56	1.12	1.02	0.11	0.00
Some College +	48.34	51.66	3.32	1.07	0.08	0.01
PANEL C: BY AGE AND EDUCATION						
Young No College	49.43	50.57	1.14	1.02	0.11	0.00
Young Some College +	48.28	51.72	3.44	1.07	0.08	0.01
Old No College	49.84	50.16	0.32	1.01	0.17	0.03
Old Some College +	50.24	49.76	-0.4	0.99	0.12	0.10

NOTES: Good season refers to birth quarters 2 and 3 (Apr-Jun and Jul-Sept). Bad season refers to quarters 1 and 4 (Jan-Mar and Oct-Dec). Values reflect the percent of yearly births each season from 2005-2013. 'Young' refers to 25-39 year olds, 'Old' refers to 40-45 year olds.

Table 3: Season of Birth Correlates

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season	(5) Good Season	(6) Good Season	(7) Good Season
Aged 25-39	0.018***	0.018***	0.018***	0.018***	0.020***	0.018***	0.017***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.003]	[0.003]
Some College +			0.011***	0.008***	0.006***	0.006***	0.006***
			[0.001]	[0.001]	[0.002]	[0.002]	[0.002]
Married				0.008***	0.010***	0.011***	0.011***
				[0.001]	[0.001]	[0.001]	[0.001]
Smoked in Pregnancy				-0.008***	-0.008***	-0.008***	-0.008***
				[0.001]	[0.002]	[0.002]	[0.002]
Did not undergo ART						0.029***	0.028***
						[0.005]	[0.005]
Constant	0.499***	0.499***	0.489***	0.486***	0.482***	0.455***	0.565***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.004]	[0.006]	[0.083]
Observations	2708385	2708385	2708385	2708385	891796	891796	891419
Year FE		Y	Y	Y	Y	Y	Y
2012-2013 Only					Y	Y	Y
Gestation FE							Y

Note: Sample consists of singleton first born children to non-Hispanic white women aged 25-45. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 4: Season of Birth Correlates: Very Young (20-24) and ART users

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Expect	(5) Good Expect	(6) Good Expect
Aged 20-24	-0.006***	-0.006***	0.000	-0.005***	-0.005***	0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
ART	-0.032***	-0.032***	-0.034***	-0.033***	-0.033***	-0.035***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Aged 20-24×ART	-0.072**	-0.071**	-0.075**	-0.065*	-0.064*	-0.069**
	[0.033]	[0.033]	[0.033]	[0.033]	[0.033]	[0.033]
Constant	0.515***	0.515***	0.502***	0.517***	0.517***	0.504***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Observations	1318902	1318902	1318902	1318267	1318267	1318267
Year FE		Y	Y		Y	Y
Controls			Y			Y

Note: Sample consists of singleton first born children to non-Hispanic white women aged 20-45 in the years 2012 and 2013. ***p-value<0.01, **p-value<0.05, *p-value<0.01.

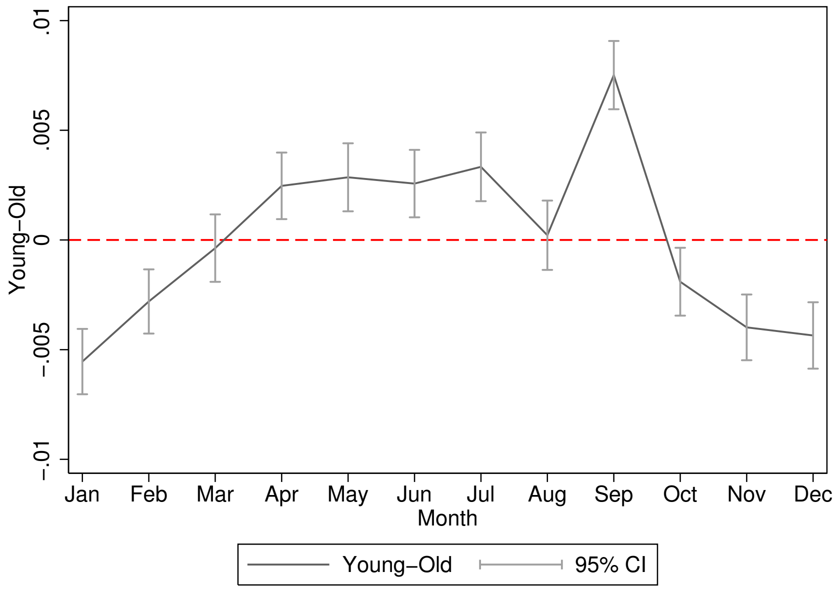
Table 5: Birth Outcomes Correlates

	(1) Birthweight	(2) LBW	(3) VLBW	(4) Gestation	(5) Premature	(6) APGAR
Good Season	8.052***	-0.001***	-0.000***	0.023***	-0.002***	0.002
	[0.659]	[0.000]	[0.000]	[0.003]	[0.000]	[0.001]
Aged 25-39	85.043***	-0.033***	-0.006***	0.450***	-0.042***	0.036***
	[2.237]	[0.001]	[0.000]	[0.009]	[0.001]	[0.003]
Some College +	51.271***	-0.019***	-0.005***	0.166***	-0.019***	0.042***
	[1.113]	[0.001]	[0.000]	[0.005]	[0.001]	[0.002]
Married	32.808***	-0.012***	-0.003***	0.083***	-0.015***	0.022***
	[0.985]	[0.000]	[0.000]	[0.004]	[0.001]	[0.002]
Smoked in Pregnancy	-177.596***	0.048***	0.005***	-0.203***	0.026***	-0.033***
	[1.532]	[0.001]	[0.000]	[0.007]	[0.001]	[0.002]
Constant	3198.041***	0.117***	0.023***	38.184***	0.172***	8.688***
	[2.957]	[0.001]	[0.001]	[0.012]	[0.002]	[0.005]
Observations	2701381	2701381	2701381	2706668	2706668	2693737

Note: Sample consists of singleton first born children to non-Hispanic white women aged 25-45.
***p-value<0.01, **p-value<0.05, *p-value<0.1.

Figures

Figure 1: Younger (25-39) versus older (40-45) women births



Notes to figure: Each point and standard error comes from a regression of birth month x on a binary indicator of being younger (= 1 if 25-39, = 0 if 40-45).

Figure 2: Good Season by State for Younger Women)

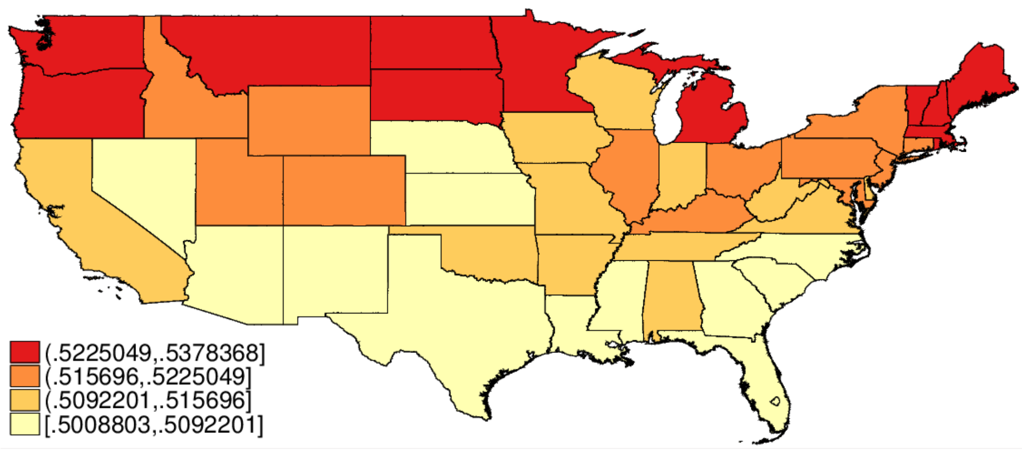


Figure 3: Good Season by State for Older Women

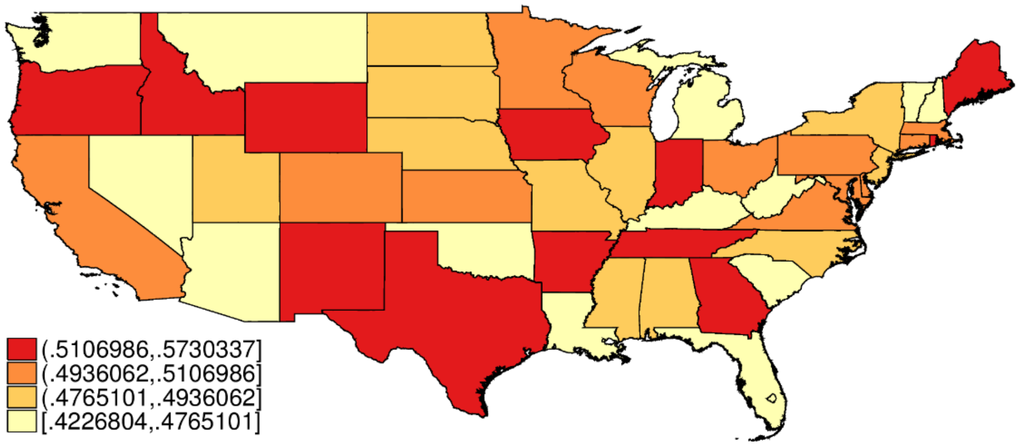
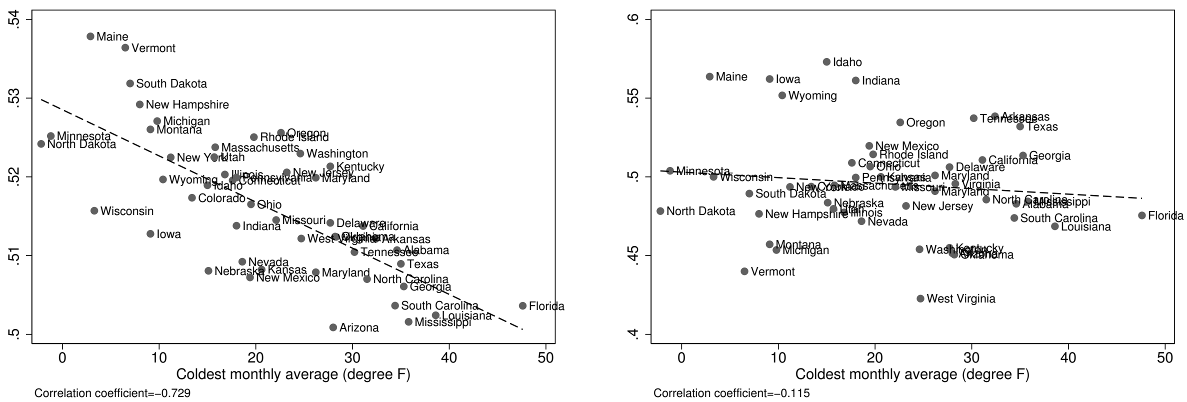


Figure 4: Temperature and Good Season

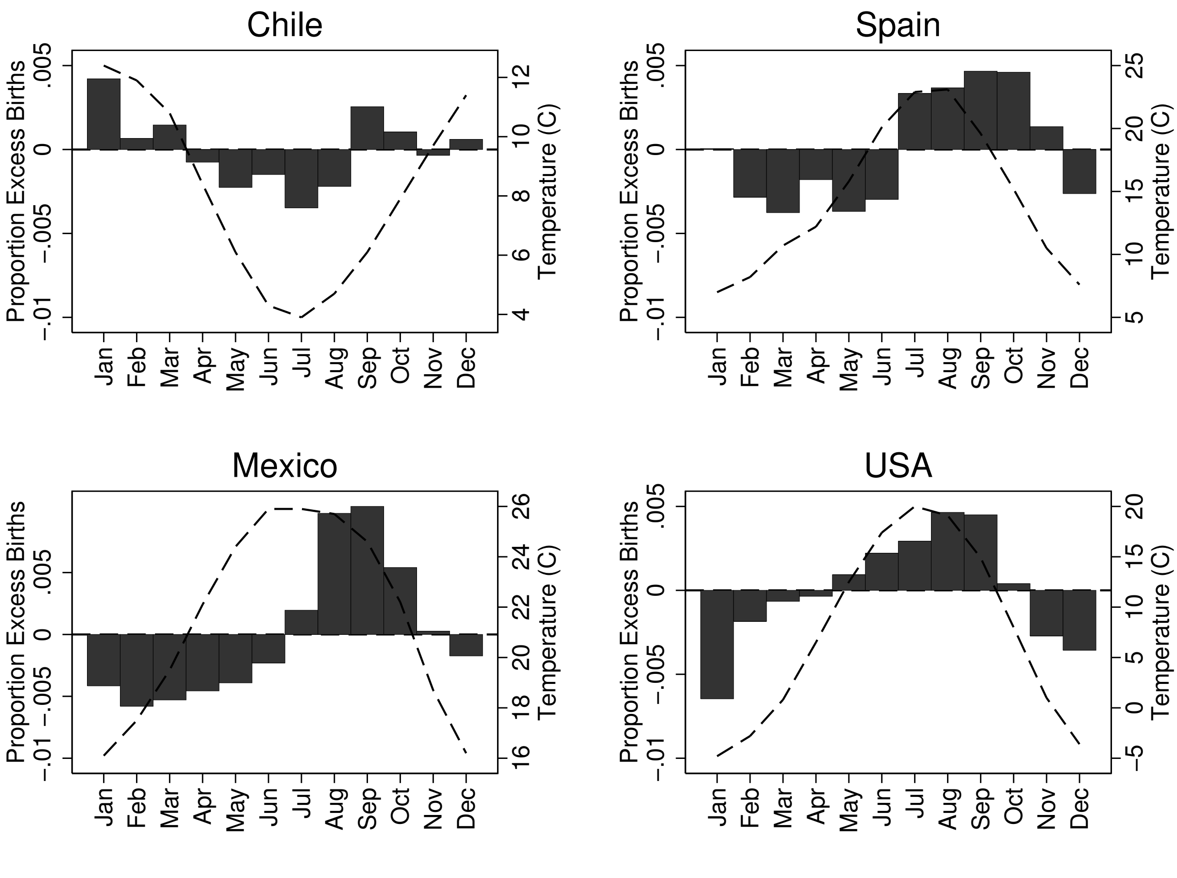


(a) Younger Mothers

(b) Older Mothers

Notes to figure 4: Each point represents a state average of proportion of women giving birth in the good birth season. Dotted line is a fitted regression line. Monthly temperature data is collected from the National Centers for Environmental Information.

Figure 5: Birth per Month and Temperature: Various Countries



Note to figure 5: Each panel is one country. Bars represent the difference between expected (evenly spaced) births and actual births. Dotted line represents average temperature in the whole of the country over the period 1990-2009 from the World Bank Climate Change Portal. Births for US are 2005-2013, for Chile 2000-2012, for Mexico 2000-2005 and for Spain 2013.

Figure 6: Mother's Age at First Birth

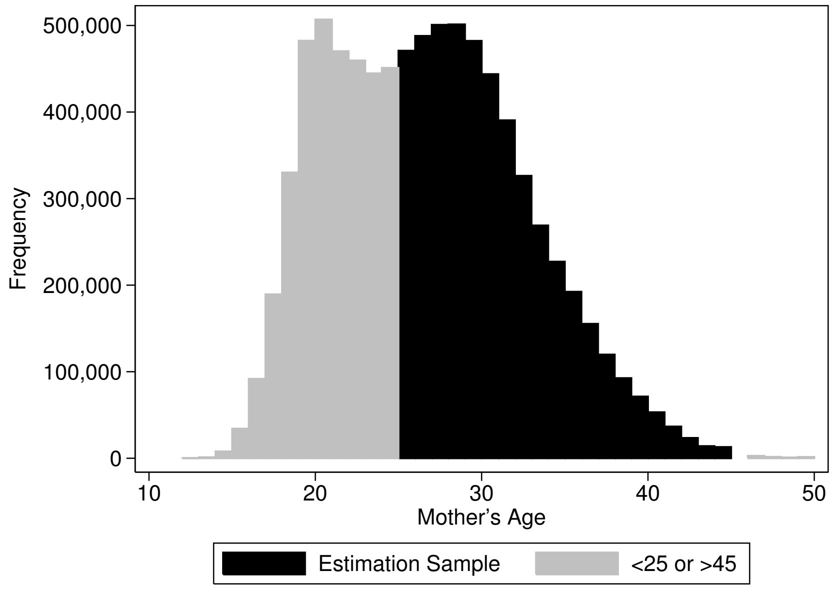


Figure 7: Difference in Births (% Good Season - % Bad Season)

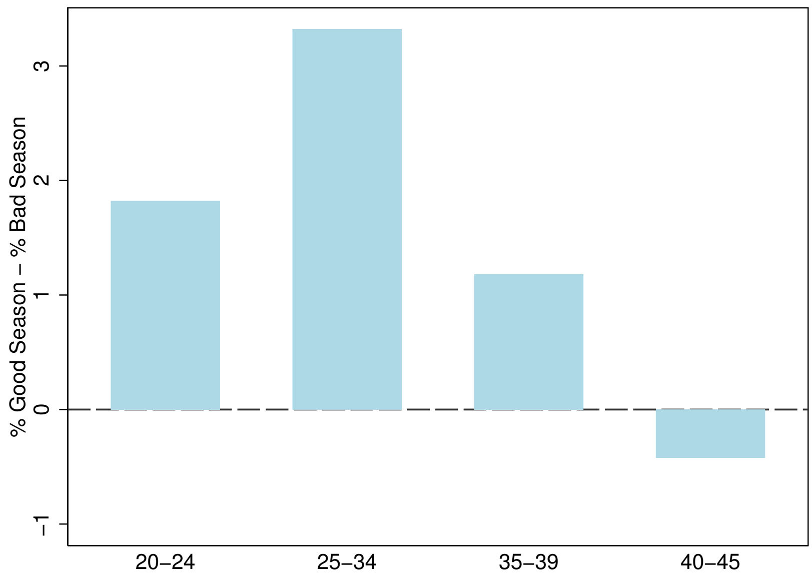
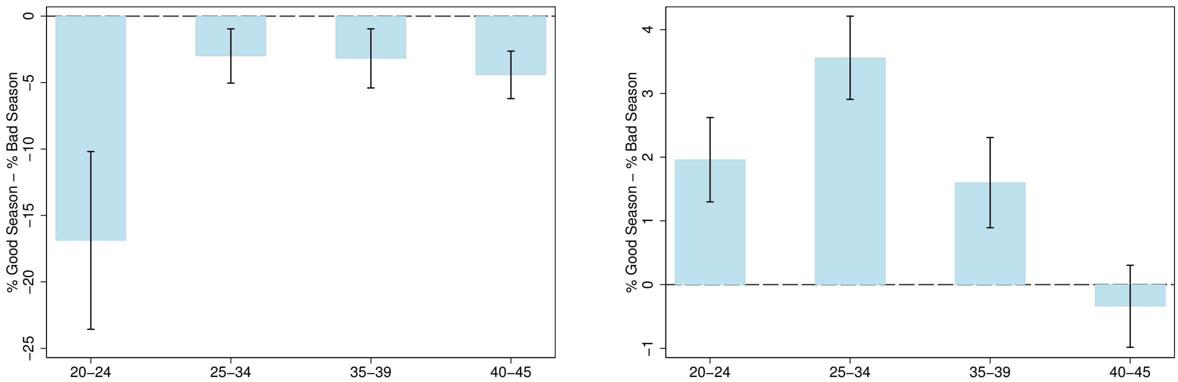


Figure 8: Difference in Births (% Good Season - % Bad Season)



(a) ART Users

(b) Non-ART Users

A Appendix Tables

Table 6: Expected (Intended) Season of Birth Correlates

	(1) Good Expect	(2) Good Expect	(3) Good Expect	(4) Good Expect	(5) Good Expect	(6) Good Expect	(7) Good Expect
Aged 25-39	0.016***	0.017***	0.017***	0.016***	0.019***	0.016***	0.015***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.003]	[0.003]
Some College +			0.011***	0.008***	0.005***	0.006***	0.005***
			[0.001]	[0.001]	[0.002]	[0.002]	[0.002]
Married				0.008***	0.011***	0.011***	0.011***
				[0.001]	[0.001]	[0.001]	[0.001]
Smoked in Pregnancy				-0.009***	-0.008***	-0.008***	-0.008***
				[0.001]	[0.002]	[0.002]	[0.002]
Did not undergo ART						0.027***	0.026***
						[0.005]	[0.005]
Constant	0.501***	0.501***	0.491***	0.489***	0.486***	0.461***	0.452***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.004]	[0.006]	[0.086]
Observations	2706668	2706668	2706668	2706668	891419	891419	891419
Year FE		Y	Y	Y	Y	Y	Y
2012-2013 Only					Y	Y	Y
Gestation FE							Y

Note: Sample consists of singleton first born children to non-Hispanic white women aged 25-45 for whom gestation is recorded. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 7: Season of Birth Correlates (Birth Order = 2)

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season
Aged 25-39	0.021***	0.021***	0.023***	0.023***
	[0.001]	[0.001]	[0.002]	[0.002]
Some College +			0.013***	0.008***
			[0.001]	[0.001]
Married				0.009***
				[0.001]
Smoked in Pregnancy				-0.010***
				[0.001]
Constant	0.504***	0.506***	0.492***	0.490***
	[0.001]	[0.001]	[0.002]	[0.002]
Observations	4180901	4180901	2784809	2442889
Year FE		Y	Y	Y

Note: Sample consists of singleton first born children to non-Hispanic white women aged 25-45. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 8: Season of Birth Correlates (Twin sample)

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season
Aged 25-39	0.010**	0.010**	0.006	0.006
	[0.005]	[0.005]	[0.006]	[0.006]
Some College +			-0.005	-0.001
			[0.005]	[0.006]
Married				-0.010*
				[0.006]
Smoked in Pregnancy				0.010
				[0.009]
Constant	0.493***	0.494***	0.506***	0.513***
	[0.005]	[0.006]	[0.010]	[0.012]
Observations	152415	152415	102544	91158
Year FE		Y	Y	Y

Note: Sample consists of twins born children to non-Hispanic white women aged 25-45. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 9: Season of Birth Correlates (Including Fetal Deaths)

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season
Aged 25-39	0.019***	0.019***	0.018***	0.018***
	[0.001]	[0.001]	[0.002]	[0.002]
Some College +			0.011***	0.008***
			[0.001]	[0.001]
Married				0.008***
				[0.001]
Smoked in Pregnancy				-0.008***
				[0.001]
Constant	0.497***	0.498***	0.488***	0.486***
	[0.001]	[0.002]	[0.002]	[0.003]
Observations	4723699	4723699	3080086	2708798
Year FE		Y	Y	Y

Note: Sample consists of all firsts (live births and fetal deaths) of non-Hispanic white women aged 25-45. Fetal deaths are included if occurring between 25 and 44 weeks of gestation. Education is recorded for fetal deaths only prior to 2008. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 10: Season of Birth Correlates (age as a continuous variable)

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season	(5) Good Season	(6) Good Season
Mother's Age (years)	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Some College +			0.012***	0.009***	0.007***	0.007***
			[0.001]	[0.001]	[0.002]	[0.002]
Married				0.009***	0.011***	0.011***
				[0.001]	[0.001]	[0.001]
Smoked in Pregnancy				-0.009***	-0.008***	-0.008***
				[0.001]	[0.002]	[0.002]
Did not undergo ART						0.027***
						[0.005]
Constant	0.542***	0.542***	0.534***	0.533***	0.538***	0.508***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.004]	[0.007]
Observations	2708385	2708385	2708385	2708385	891796	891796
Year FE		Y	Y	Y	Y	Y

Note: Sample consists of singleton first born children to non-Hispanic white women aged 25-45. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 11: Season of Birth Correlates (age and age squared)

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season	(5) Good Season	(6) Good Season
Mother's Age (years)	0.006***	0.008***	0.009***	0.009***	0.006***	0.005***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]
Mother's Age^2	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Some College +	0.008***	0.012***			0.007***	0.007***
	[0.001]	[0.001]			[0.002]	[0.002]
Married	0.008***				0.011***	0.011***
	[0.001]				[0.001]	[0.001]
Smoked in Pregnancy	-0.008***				-0.008***	-0.008***
	[0.001]				[0.002]	[0.002]
Did not undergo ART						0.026***
						[0.005]
Constant	0.418***	0.401***	0.392***	0.392***	0.432***	0.415***
	[0.015]	[0.015]	[0.015]	[0.015]	[0.027]	[0.027]
Observations	2708385	2708385	2708385	2708385	891796	891796
Year FE		Y	Y	Y	Y	Y

Note: Sample consists of singleton first born children to non-Hispanic white women aged 25-45.
***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 12: Season of Birth Correlates (younger women defined as those aged 25-34)

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season	(5) Good Season	(6) Good Season
Aged 25-34	0.012***	0.012***	0.012***	0.012***	0.013***	0.012***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]
Some College +			0.012***	0.008***	0.007***	0.007***
			[0.001]	[0.001]	[0.002]	[0.002]
Married				0.008***	0.011***	0.011***
				[0.001]	[0.001]	[0.001]
Smoked in Pregnancy				-0.008***	-0.008***	-0.008***
				[0.001]	[0.002]	[0.002]
Did not undergo ART						0.028***
						[0.005]
Constant	0.506***	0.506***	0.496***	0.493***	0.489***	0.463***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.005]
Observations	2708385	2708385	2708385	2708385	891796	891796
Year FE		Y	Y	Y	Y	Y
2012-2013 Only					Y	Y

Note: Sample consists of singleton first born children to non-Hispanic white women aged 25-45. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 13: Birth Outcomes Correlates (Twin sample)

	(1) Birthweight	(2) LBW	(3) VLBW	(4) Gestation	(5) Premature	(6) APGAR
Aged 25-39	-21.836***	0.011*	0.010***	-0.294***	0.014**	-0.095***
	[7.606]	[0.006]	[0.004]	[0.044]	[0.006]	[0.015]
Good Season	3.601	-0.001	0.001	-0.034	-0.001	0.001
	[3.983]	[0.003]	[0.002]	[0.024]	[0.003]	[0.009]
Some College +	64.671***	-0.041***	-0.021***	0.343***	-0.017***	0.132***
	[7.443]	[0.006]	[0.004]	[0.047]	[0.006]	[0.018]
Married	6.797	-0.006	-0.008**	0.010	0.016***	0.021
	[7.045]	[0.006]	[0.003]	[0.043]	[0.006]	[0.016]
Smoked in Pregnancy	-142.752***	0.102***	0.039***	-0.304***	0.040***	-0.107***
	[11.671]	[0.009]	[0.006]	[0.074]	[0.009]	[0.029]
Constant	2286.209***	0.609***	0.112***	34.945***	0.626***	8.429***
	[14.863]	[0.012]	[0.007]	[0.089]	[0.012]	[0.032]
Observations	89960	89960	89960	91072	91072	90395

Note: Sample consists of singleton first born children to non-Hispanic white women aged 25-45.
***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 14: Descriptive Statistics (Spain 2007-2013)

	N	Mean	Std. Dev.	Min.	Max.
Panel A: Mother					
Mother's Age	1239749	32.05	3.87	25	45
Young (aged 25-39)	1239749	0.96	0.19	0	1
Married	1239749	0.64	0.48	0	1
Some College +	1239749	0.53	0.50	0	1
Years of education	1178707	12.59	3.64	0	17
White Collar Job	1195976	0.59	0.49	0	1
Panel B: Child					
Good Season	1239749	0.50	0.50	0	1
Intended good season of birth	1058881	0.50	0.50	0	1
Birthweight	1191623	3201.08	497.41	500	5000
Low Birth Weight (<2500 g)	1191623	0.07	0.25	0	1
Gestation	1058881	39.21	1.81	21	46
Premature (<37 weeks)	1239749	0.06	0.23	0	1
Female	1239749	0.48	0.50	0	1
Cesarean	1239749	0.26	0.44	0	1

NOTES: Sample consists of all singleton first-born children of Spanish mothers. Good season refers to birth quarters 2 and 3 (Apr-Jun and Jul-Sept).

Table 15: Percent of Births (Singletons)

	Bad Season	Good Season	Diff.	Ratio	Premature (< 37 weeks)
PANEL A: BY AGE					
Young (25-39)	49.82	50.18	0.36	1.01	0.06
Old (40-45)	51.38	48.62	-2.7	0.95	0.08
PANEL B: BY EDUCATION					
No College	50.31	49.69	-0.6	0.99	0.06
Some College +	49.51	50.49	0.98	1.02	0.05
PANEL C: BY AGE AND EDUCATION					
Young No College	50.27	49.73	-0.5	0.99	0.06
Young Some College +	49.43	50.57	1.14	1.02	0.05
Old No College	51.31	48.69	-2.6	0.95	0.09
Old Some College +	51.43	48.57	-2.8	0.94	0.07

NOTES: Good season refers to birth quarters 2 and 3 (Apr-Jun and Jul-Sept). Bad season refers to quarters 1 and 4 (Jan-Mar and Oct-Dec). 'Young' refers to 25-39 year olds, 'Old' refers to 40-45 year olds.

Table 16: Season of Birth Correlates (Spain 2007-2013)

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season	(5) Good Season
Young (aged 25-39)	0.015***	0.016***	0.016***	0.017***	0.016***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Some College +			0.007***	0.006***	0.005***
			[0.001]	[0.001]	[0.001]
White Collar Job				0.002**	0.002*
				[0.001]	[0.001]
Married					0.010***
					[0.001]
Constant	0.486***	0.504***	0.500***	0.498***	0.495***
	[0.002]	[0.006]	[0.006]	[0.006]	[0.006]
Observations	1238685	1238685	1238685	1194930	1194930
Province FE		Y	Y	Y	Y

Note: Sample consists of all singleton first born children of Spanish mothers. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

Table 17: Birth Outcomes Correlates (Spain 2007-2013)

	(1) Birthweight	(2) LBW	(3) VLBW	(4) Gestation	(5) Premature	(6) Cesarean
Good Season	5.066***	-0.001***	0.000	0.020***	-0.000	-0.000
	[0.921]	[0.000]	[0.000]	[0.004]	[0.000]	[0.001]
Young (aged 25-39)	44.810***	-0.027***	-0.006***	0.261***	-0.023***	-0.167***
	[2.647]	[0.001]	[0.001]	[0.011]	[0.001]	[0.002]
Some College +	25.432***	-0.011***	-0.001***	0.059***	-0.007***	-0.005***
	[1.087]	[0.001]	[0.000]	[0.004]	[0.000]	[0.001]
White Collar Job	11.828***	-0.006***	-0.000**	0.009**	-0.005***	-0.001
	[1.110]	[0.001]	[0.000]	[0.004]	[0.001]	[0.001]
Married	18.914***	-0.006***	-0.001***	-0.045***	-0.000	0.003***
	[0.989]	[0.001]	[0.000]	[0.004]	[0.000]	[0.001]
Constant	3132.146***	0.099***	0.013***	38.993***	0.081***	0.300***
	[6.040]	[0.003]	[0.001]	[0.022]	[0.003]	[0.005]
Observations	1157129	1157129	1157129	1028549	1194930	1194930

Sample consists of all first born children of Spanish mothers. Gestation weeks and premature are recorded separately in birth records: premature (binary) for all, and gestation (continuous) only for some. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

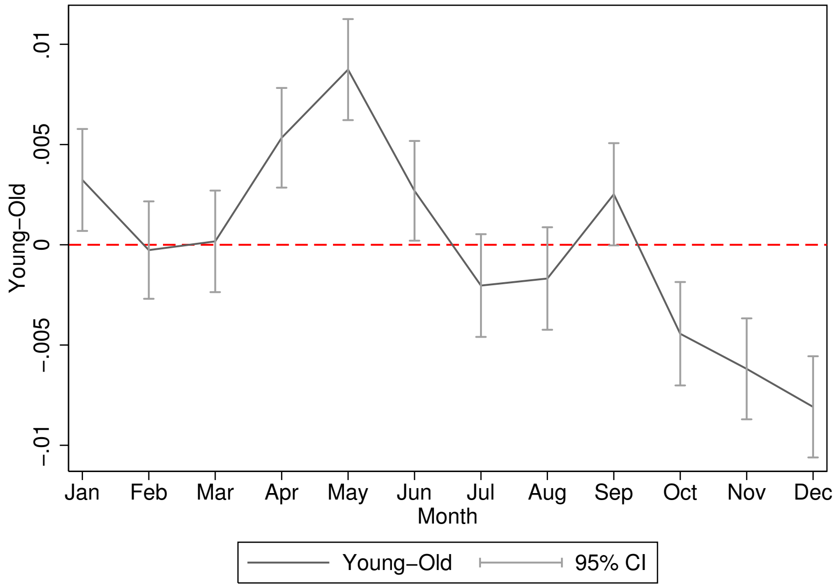
Table 18: Season of Birth Correlates and Labor Market Status (Spain 2007-2013)

	(1) Good Season	(2) Good Season	(3) Good Season	(4) Good Season	(5) Good Season
Young (aged 25-39)	0.015***	0.016***	0.016***	0.017***	0.016***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Some College +			0.007***	0.006***	0.005***
			[0.001]	[0.001]	[0.001]
In Labour Market				0.009***	0.009***
				[0.001]	[0.001]
Married					0.010***
					[0.001]
Constant	0.486***	0.504***	0.500***	0.492***	0.488***
	[0.002]	[0.006]	[0.006]	[0.006]	[0.006]
Observations	1238685	1238685	1238685	1194930	1194930
Province FE		Y	Y	Y	Y

Sample consists of all singleton first born children of Spanish mothers. ***p-value<0.01, **p-value<0.05, *p-value<0.1.

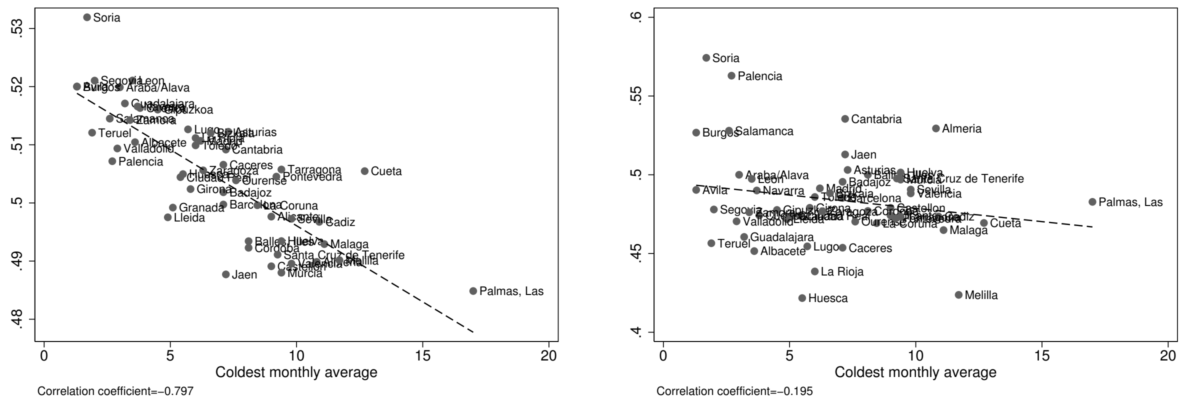
B Appendix Figures

Figure 9: Younger versus older women births (Spain)



NOTES TO FIGURE: Each point and standard error comes from a regression of birth month x on a binary indicator of being young (25-39).

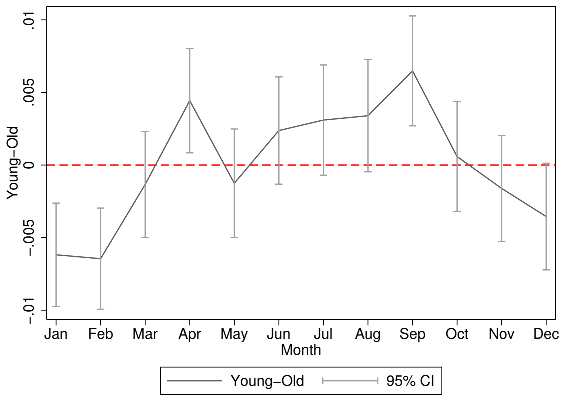
Figure 10: Temperature and Good Quarter (Spain)



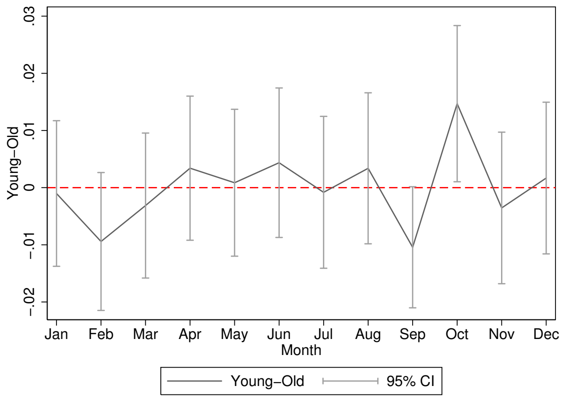
(a) Young Mothers (b) Old Mothers

NOTES TO FIGURE: See notes to figure 4a. Monthly temperature data is collected from the Spanish State Meteorology Agency (AEMET).

Figure 11: Younger versus older women births (USA)



(a) No ART Usage



(b) ART Usage

NOTES TO FIGURE: Each point and standard error comes from a regression of birth month x on a binary indicator of being young (25-39).

C Data Appendix

C.1 US Birth Data

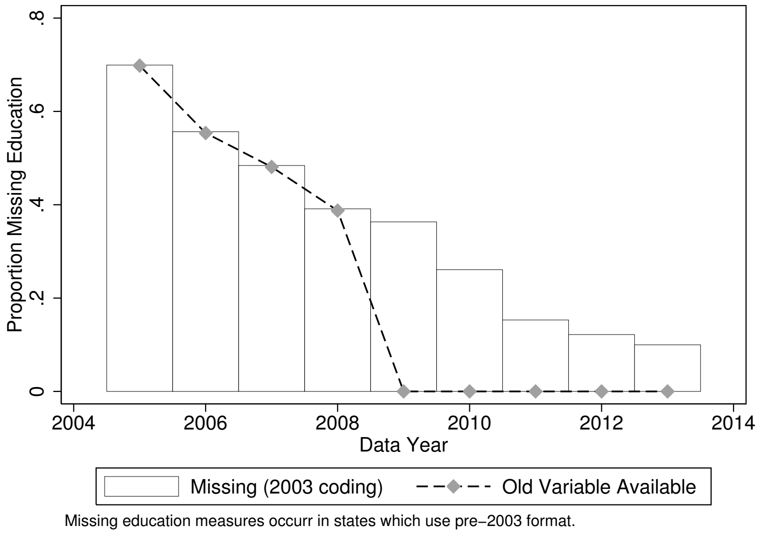
A brief description of US birth certificate data is provided in section 2.1 of the paper. As discussed, the format of US birth certificates has undergone two important revisions: The first in 1989 and the second in 2003. The date of adoption of these revisions varies by state. By 2013, 41 states or territories had adopted the revised (2003) format, while the reaminder still follow the 1989 format.[9]

In all cases where variable coding differs between the revised and unrevised certificates (principally education for mother and father), we use the revised 2003 coding of the variables. The reason we do this is because after 2008, variables which are exclusive to 1989 certificates are no longer reported. Figure 12 illustrates this pattern. The dotted line represents the proportion of observations for maternal education which are reported in the 1989 format,

[9]The full birth certificate for each revision is reproduced as figures 1 and 2 in Menacker and Martin (2005). Over time the adoption of the 2003 certificate was as follows: 2005: 12 (31%), 2006: 19 (49%), 2007: 22 (53%), 2008: 27 (65%), 2009: 28 (66%), 2010: 33 (76%), 2011: 36 (83%), 2012: 38 (86%), and 2013: 41 (90%). In each case the first number refers to the number of states, while the parenthesis indicates the percent of births in revised states.

while the bars represent the proportion *missing* in the 2003 format. From 2005-2008, all missing 2003 revision variables are recorded in the 1989 format. However, from 2009 onwards only the 2003 revision of education is reported, meaning that those states who still use the 1989 standard certificate do not have publicly released education data.

Figure 12: Missing Education Data by Time



C.2 Spanish Data

Birth certificate records from Spain are released by the National Institute of Statistics (INE) with coverage from 1979 to 2013 inclusive. These consist of the universe of births registered annually in Spain. Our principal estimation sample consists of all first born children who survived one day, born to Spanish mothers. We use births from the period 2007 to 2013, given that prior to 2007, education was not recorded on birth certificates. This results in a sample of 1,239,749 live births, of which 1,238,685 were singletons.

Like birth certificate data in the US, Spanish certificates provide mother and child characteristics, including education and labour market status of the mother (and father where present), mother's age at time of birth, marital status, and child APGAR, gestation, birth weight, prematurity, and so forth (INE, 2013). The Spanish records include publicly released data on geographical location of birth, at both the provincial and municipal level (similar to US states and counties respectively).

Descriptive statistics for Spanish births are provided in table 14. In the same age group, the average age and proportion of young mothers is similar to data from USA (32 years and 96% respectively), however a lower proportion report being married (64%), or having at least some post secondary education (53%). Spanish newborns are slightly lighter on average than their USA-born counterparts (3,200g), however are also less likely to be born prematurely, or classified as having low birth weight.

Spanish climate data at the level of the province is calculated from data released by the State Meteorlogical Agency (AEMET). These data record the temperature at principal state meteorological stations, from which we calculate monthly average, minima and maxima.