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Girls and boys: economic crisis, fertility, and birth outcomes

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Girls and Boys:
Economic Crisis, Fertility, and Birth Outcomes

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Abstract

We investigate the impact of an economic downturn on natality and birthweight for newborns when parents prefer sons. We examine South Korea, unexpectedly hit by the Asian financial crisis in 1997. For identification, we exploit regional- and time- variation in the crisis, focusing on women who were already pregnant when the downturn began. We find that the number of girls would have been 2 percent higher absent the crisis and that birth outcomes for girls were no better than those for boys, findings that differ from the Trivers-Willard Hypothesis. This relative disadvantage of girls is more severe among newborns who have at least two older siblings.

JEL Classification: H0; I1; J1
Keywords: Fertility, Birth Outcomes, Economic crisis, Sex Ratio, Trivers-Willard Hypothesis, Scarring

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1.Introduction

Economists have long been interested in studying how economic incentives affect households' fertility decisions and infant health. For example, researchers around the world report systematic changes in fertility in response to unemployment (e.g., Adsera, 2005, for 13 EU countries; Dehejia and Lleras-Muney, 2004, for the US), income and government transfers (e.g., Gonzales, 2013 for Spain; Lovenheim and Mumford, 2013, for US), and wealth shocks and economic uncertainty (e.g., Dettling and Kearney, 2014 for the US; Chevalier and Marie, 2015, for Germany). Furthermore, the literature reports that economic conditions in utero can impact health at birth (e.g., Bozzoli and Quintana-Domeque, 2014, for Argentina; Lindo, 2011 for the US; Currie, 2011 for an overview of various studies).

Our paper contributes to this rich literature by examining the interaction between *parental choices* and *involuntary biological forces* in shaping fertility and health outcomes at birth in response to an economic downturn experienced *in utero* in a setting where parents have a preference for sons.[1] In such an environment, adverse economic conditions can affect fertility and birth outcomes through the following two sets of factors. On the one hand, parents may change their investments in the well-being of a child *in utero* depending on the gender of the child. For example, parents may maintain nutritional intake if the child is of their preferred gender but may not do so otherwise, which could lead to differential health outcomes depending on gender. In extreme cases, such gender-specific changes in parental investments may result in a relative increase in miscarriages of children who are not of the preferred gender, leading to a change in sex ratio at birth and a possible change in health at birth by gender. Furthermore, if abortion is available, parents may respond to an economic downturn by disproportionally having an abortion when expecting children who are not of their preferred gender, a mechanism leading to a change in sex ratio at birth. On the other hand, biological factors outside of parental control can affect children *in utero*

[1] Two strands of studies in the literature examine the role of the business cycle, more specifically the role of economic downturns, on fertility and health at birth. One strand studies the fertility response and health at birth by focusing on children who were *in utero* when the business cycle changed. The other strand examines the fertility response in terms of changed conception rate and health at birth. In our paper, for identification purposes as we explain in detail below, we focus on understanding the role of a severe and exogenous economic downturn on fertility and health at birth by focusing on children who were already *in utero* when the crisis started.

differently by gender. Theories of biological selection suggest that males are more fragile than females *in utero* (Trivers and Willard, 1973; Krackow, 2002), which, in turn, suggests an increase in the fraction of newborn girls as a consequence of an economic downturn, although the theories provide no unanimous prediction of health at birth. The interaction between these two sets of factors leads to ambiguous predictions regarding the impact of adverse economic conditions on sex ratios and health at birth for boys and girls, implying that the net effect of an economic downturn on fertility and birth outcomes is an empirical question, which we examine in the remainder of this paper.

We exploit the 1997 financial crisis that unexpectedly affected South Korea and caused severe economic difficulties. We examine how the interaction between biological forces and parental choices may have shaped gender composition and health at birth as a consequence of this economic downturn. To the best of our knowledge, examining the interaction between these two types of forces in a setting with a son preference is new to the literature. For example, none of the studies on developed countries mentioned above examine the role of business cycles in an environment with a gender preference. Although a strand of the literature in development economics examines the gender-specific impact of economic conditions on fertility and birth outcomes (e.g., Chakraborty, 2015; Qian, 2008), it does not examine the interaction between parental preferences and biological factors. Our focus on a developed country such as Korea allows us to accurately measure the response of fertility and health-at-birth to the crisis because Korea has a well-developed civil registration system. In principle, our research question could be examined in other countries that experienced a dramatic change in economic conditions and that are characterized by a son preference. For instance, several developing countries, such as India, China, Pakistan, and Vietnam, are known for a strong son preference and skewed sex ratios. However, the civil registration systems in developing countries reportedly fail to record many infants in a timely fashion (or at all), which would make it difficult to precisely measure the impact of severe downturns on fertility and health at birth (World Bank/WHO, 2014).[2]

[2] According to a recent report (World Bank/WHO, 2014) almost 230 million children under the age of five are not registered in vital statistics records. Of these, 85 million are estimated to live in Sub-Saharan Africa and 135 million in Asia and the Pacific.

Furthermore, because South Korea is a high-income country, our findings are helpful in understanding how the impact of a severe economic downturn may affect gender composition and health at birth in developing countries with a preference for sons once such countries become more developed.

The crisis in South Korea provides us with a clean identification strategy to measure the causal impact of the economic crisis on fertility and birth outcomes of children *in utero* when the crisis started. The economic shock was very severe and largely unforeseen (International Monetary Fund, 2003), because, in the thirty years prior to the crisis, South Korea had strong economic growth, high savings rates, and a balanced budget in the public sector. However, the crisis reduced GDP per capita by 30 percent, and unemployment rates rose by a factor of 3. The crisis was not only unexpected and severe, but its severity differed over time and across regions. We use such time and regional variation for identification. Our identification strategy is related to the strategy used by the literature on economic cycles and health that has used geographic variation in the severity of the business cycle as a quasi-experiment:[3] we measure the severity of the crisis with the surge in unemployment rates relative to their long-term values for each region. For each newborn in our sample, we calculate the average of this unexpected rise in unemployment rates during the 9 months before birth and use it as a proxy for the economic difficulties a newborn was unexpectedly exposed to while *in utero*. Using this time and regional variation, we identify the impact of the crisis on the fraction of newborn girls. Our empirical models allow for possible heterogeneous impacts based on number of older siblings (i.e., parity of a newborn), sub-period, and parents' socioeconomic status. We provide the empirical evidence supporting the plausibility of our identification strategy and find supporting evidence for it.

Regarding the sample for our empirical analysis, we use birth records from January 1998 to August 1998, data containing information on births of children who were already *in utero* when the economic crisis

[3] The most famous study to use geographic variation in the severity of the business cycle as a quasi-experiment to study health outcomes (specifically mortality) was Ruhm (2000). Since then, a large body of literature has used geographic variation in the business cycle to look at several health outcomes in various countries. Although we also use geographic variation in the severity of the crisis as a quasi-experiment, our region-specific measure of the severity of the shock is unique to our setting and, as explained in the main text, takes into account that we focus on pregnant women as well as the unique Korean setting of lack of downturns for a very long time before the crisis.

affected South Korea. We select such a sample because, for our identification, it is crucial to distinguish unexpected shocks from expected ones. Because prior to the 1997 crisis South Korea had shown stable economic conditions, it is reasonable to assume that people made their decisions – including decisions regarding whether to have a child – based on those stable economic trends. By studying only children who were already conceived before the crisis, we can create a measure of the unexpected shock faced by parents as the difference between the long-term trends and the actual economic measures during the crisis.[4]

We find that between January and August 1998, the economic crisis reduced the number of girls by 2 percent. This substantial reduction is driven by the decline in the number of girls among newborns who have two or more older siblings, and this pattern is more pronounced among those born between May and August 1998. This reduction in girls' natality can be explained by the effect of sex-selective abortion outweighing the effect due to biological forces.[5] Specifically, in South Korea, the desire to have a son drives parents to have multiple children, implying that mothers who already have two children are likely to have a stronger son preference than those who have one child or no children. Furthermore, the health risk or monetary cost of abortion is small if it is performed at an early stage of pregnancy, which can explain why we find a stronger impact of the crisis on gender composition at birth among newborns between May and August 1998 relative to those born between January and April. However, the impact due to parental responses does not always outweigh the impact of biological factors. For example, when we examine newborns with one older sibling, the crisis increased the fraction of newborn girls by 1 percentage point during the first four months of 1998, a finding consistent with the impact of biological forces outweighing

[4] In contrast, we have little information regarding the basis on which people may have made their fertility decisions once the crisis started and economic measures became volatile. For example, unemployment rates started to surge and GDP per capita plummeted in the first quarter of 1998 but started to recover in the second quarter. Given the sudden change in economic circumstances, people may have formed their expectations of future economic conditions using different rules, such as a Bayesian updating rule, last-period condition (myopic rule), or other behavioral methods. Without a strong assumption about individuals' beliefs, for babies conceived after the onset of the crisis, researchers cannot distinguish unexpected economic shocks from expected economic conditions, which is crucial for identification.

[5] See Chung and Das Gupta (2007) and Section 2.3 for details regarding the son preference in South Korea. In another paper, we examine the impact of the Great Recession on gender composition at birth for Asian populations in the United States (see Lee and Orsini, 2017). Compared to non-Hispanic Whites, we find that the share of boys among Chinese Americans increased during the Recession. However, we do not find the same pattern for Korean Americans.

the impact due to parental responses. Our findings suggest that even in a country as developed as Korea, a severe economic shock may trigger sizable effects on outcomes at birth due to biological factors, even for those affected by the crisis at a relatively advanced stage of pregnancy. We further investigate the impact of the crisis on birthweight and find that, even conditional on being born, girls' birthweight is not higher than boys' birthweight. Our results also suggest that designing proper fertility incentives that incorporate changes in economic booms and busts may be worth considering for countries with a son preference.

2. Institutional Background

2.1 The 1997 Financial Crisis in South Korea

The Asian financial crisis unexpectedly affected South Korea in December 1997 and brought about a sharp economic downturn until the economy stabilized at the end of 1999. Before the onset of the crisis, South Korea had been one of the world's fastest growing economies, with an average annual growth between 7 and 9 percent, a balanced government budget, and modest annual inflation rates. Based on these macroeconomic indicators, the International Monetary Fund's (IMF) pre-crisis surveillance concluded that Korea was unlikely to become a victim of the financial crisis that had started affecting Southeast Asia in the summer of 1997 (e.g., International Monetary Fund, 2003).

However, the crisis eventually spread to South Korea as well, and commentators suggest that the main cause of the Korean crisis was a liquidity shortage in the corporate sector. The liquidity problems caused bankruptcies of major firms, and the financial markets – stock prices and the value of the Korean currency – plummeted as a result. After fierce policy debates, on November 21, 1997, the Korean government decided to request financial aid from international organizations; the request was granted on December 3, 1997 (see Table O.1 in Online Appendix). The impact of the financial crisis on the Korean economy was enormous: firms had difficulty securing funds, explaining the soaring interest rates at the end of 1997. Unemployment rates sharply increased at the beginning of 1998 and peaked in early 1999.[6]

[6] Such an increase in the unemployment rates was partially due to conditions imposed by international lenders, who asked the Korean government to facilitate exit from the market of insolvent or inefficient firms. This "restructuring" was extensively implemented in mid-1998 and 1999. At the end of 1999 the government repurchased all urgent loans from the IMF, and stopped withdrawing stand-by loans from the IMF by December 1999. In June 2000 the Korean

Figure 1 shows monthly unemployment rates and interest rates in South Korea since 1990. Unemployment rates show some seasonality but are stable around 3 percent before the onset of the crisis, and rise significantly afterwards. Corporate bond interest rates skyrocketed at the end of 1997. These time trends are consistent with the widely held view that no one could have predicted the crisis until the value of Korean currency plummeted in late 1997 (Demetriades and Fattouh, 1999, International Monetary Fund, 2003). See additional information in Online Appendix B.

2.2 Perception of the Crisis in South Korea

At the onset of the crisis, most people in South Korea viewed the worsening economic conditions at the end of 1997 as a serious and potentially long-lasting threat to their country. The bailout conditions imposed by international creditors required severe reduction in public spending, liquidation of marginal banks and large-scale firms, and facilitation of workers' layoffs. As well documented in local media, South Koreans perceived the crisis as an event difficult to overcome and with severe long-term consequences, comparable to the loss of sovereignty to Japan in 1910, which brought severe hardships to many Koreans until the country gained independence in 1945. The view of the crisis as a long-term shock is well represented by a civil movement that started at the time of the crisis. This movement, called the Grassroots Movement, encouraged people to donate their gold and gold jewelry to help the government buy out the foreign debts to remove the bailout conditions.[7] See Figure B.1 in the Online Appendix showing the long lines of people waiting for their turn to donate gold. The total value of gold collected in the first quarter of 1998 was over 220 million US dollars, equal in value to 6.8 percent of total export during the same period, exceeding the value of automobile exports.[8] These episodes suggest that, at the beginning of the crisis, many were likely to view it as a permanent shock. Even if some did not perceive it

government had a final policy consultation with the IMF as a part of a stand-by arrangement, and it finally managed to clear all outstanding IMF credits in August 2001.

[7] The Grassroots Movement was initiated by a Protestant pastor, Kim Jee-Gil, on December 3, 1997, and soon spread across the entire country.

[8] Numerous news media reported on the Korean volunteer movement. Examples can be found at the following websites: http://news.heraldcorp.com/view.php?ud=20130503000336&md=20130510102830_BL(in Korean) http://news.bbc.co.uk/2/hi/world/analysis/47496.stm (in English)

as a permanent shock, many were likely to experience credit constraints, because the financial crisis dried up liquidity in the Korean financial market and consumer lending was rare, especially without proper collateral.[9]

2.3 Son Preference and Sex-Selective Abortion in Practice

The roots of the son preference in Korea date back to the Choson Dynasty, which lasted from 1392 to 1910. The Choson Dynasty was established based on the societal views of neo-Confucianism, which supported a kinship system with the main characteristic of promoting loyalty to the household, the lineage, and the dynasty. The Choson Dynasty adopted a rigid patrilineal system in which the male head of a household had unchallenged authority. Only sons could carry the family lineage, and thus family members exerted pressure on their kin to bear sons. In more recent times, the rules of patrilineal society were embedded in the Korean Civil Code in 1958, which specified that the eldest son holds the family headship and that inheritance follows the male children. Over time, various legal changes were introduced to improve gender equality. However, the revision process is still ongoing. For example, the law that only a man can represent a household had been maintained until the beginning of 2008.

Given Korea's widely held son preference, it is not surprising that sex ratios at birth started to become unbalanced when prenatal sex-screening became available in 1984. South Korea provides national health insurance to its residents, and prenatal care is widely available to pregnant women. As part of such care, women have access to ultrasound tests to determine the sex of the unborn child (Park et al. 2008). Even though the law strictly restricts abortions to cases of threats to the mother's life and rape within 26 weeks of pregnancy, abortion is widely performed. For example, a quarter of all pregnancies are reportedly terminated by illegal abortions (Choi et al., 2010), and approximately 40 percent of married women have had at least one abortion (Korea Ministry of Health and Welfare, 2005).

[9] Although South Korean households showed a high savings rate before the crisis (15.6 percent of disposable income in 1997 was saved), the liquidity constraints were severe. A few major banks and many credit unions were foreclosed because they failed to renew their debts. At that time, there was no formal insurance program protecting the households' savings. Liquidity injected by the government was prioritized to renew corporate debts.

Abortion is costly in monetary terms and can harm maternal health as well. Furthermore, both these costs of abortion are higher if abortion is performed at a later stage of pregnancy. Couples need to pay for an abortion out of pocket, and our online search suggests that the cost ranges from 300 to 6,000 US dollars, depending on the gestation period.[10] Additionally, abortion can cause death, medical complications including uterine perforation, and emotional stress. For example, the mortality rate due to abortion is 0.6 per 100,000 operations if the operation is conducted within the first two months of gestation; the rate doubles every 2 additional weeks of gestation (Korea Ministry of Health and Welfare, 2005).[11] Despite the wide use of sex-selective abortion since the spread of ultrasound screening, South Korea had shown improvement in girls' natality relative to boys before the 1997 crisis started.[12] Sen (1992) reports that the natural sex ratio at birth is around 105 boys per 100 girls, a number that implies that, without sex-selective abortion, girls should account for around 48.8 percent of newborns. When the crisis affected South Korea, the improvement in girls' natality started reversing. In 1998, girls were only 47.6 percent of newborns, and, among newborns with two older siblings, the fraction of newborn girls decreased by 2 percentage points, from 42.8 percent in 1997. As time passed, girls' disadvantage in natality slowly decreased, reaching its pre-crisis level in 2003, and continued to decrease in the following years, so that in 2014 girls were 48.7 percent of newborns.

3. Conceptual Framework

We view the impact of the economic crisis on fertility and health at birth as the outcome of the interaction of two channels. One channel includes factors that parents can change to affect their unborn child such as abortion, changes in consumption and exercise, and the use of medical services. The other channel

[10] We could not find any estimate of monetary costs in existing studies or government documents, which may not be surprising because abortions are mostly used for illegal purposes. The average monthly earnings per household were around 4,000 US dollars in 2014, suggesting that the monetary cost of abortion can be sizable. We also find that the monetary cost can be higher for unmarried women/teenagers because some clinics charge more in exchange for exempting patients from parents' or partner's approval.

[11] See more information in Coleman (2010).

[12] For example, girls accounted for 48 percent of newborns in 1981, but after the ultrasound screening technology was adopted in 1984, the fraction of newborn girls dropped, reaching 46.4 percent in 1993. However, this share increased back to 48.0 in 1997.

includes factors that parents cannot directly control. For example, adverse circumstances may elevate maternal stress levels, shown to be important determinants of the health of children *in utero*.

3.1 Factors under Parental Control

This section builds upon the conceptual framework in Dehejia and Lleras-Muney (2004), who examine the impact of unexpected income shocks on fertility rates and health of newborns. Their framework carefully illustrates that unexpected permanent income shocks or temporary shocks under credit constraints have ambiguous impacts on fertility and health outcomes because such shocks generate two counteracting responses. On the one hand, a decline in income may induce people to desire fewer children and could even make it difficult to invest in the health of a newborn. On the other hand, such shocks may not only decrease mothers' opportunity costs of having a child but can also reduce consumption of goods that could be harmful to a child (e.g., drinking and smoking).

We introduce a son preference into that framework by assuming that parents consider the net benefit of having a girl to be smaller than the net benefit of having a boy.[13] If children are normal goods, then the economic crisis may reduce parents' desired number of children. If so, given the lower net benefit of having a daughter compared to having a son, parents will be more likely to decide to undergo an abortion when expecting girls than boys. Therefore, all else being equal, the likelihood of undergoing an abortion when expecting a girl will be higher among parents who have a stronger son preference, and this, in turn, suggests that sex-selective abortion may appear among newborns of higher parity. This higher propensity to use sex selective abortion for higher parity pregnancies can be understood by remembering that the desire for sons in Korea drove the likelihood of having more than one child. Indeed, Larsen et al. (1998) report that among mothers who already have at least two children, the likelihood of having another child is at least 35 percentage points higher if the youngest child is a girl. Their finding implies that, in our

[13] We are uncertain what factors make the net benefit of having a child vary by the child's gender. It may be due to parents' pure preference or a reflection of the gender difference in monetary benefits that children of different genders bring to their parents. For example, the net cost of raising a daughter can be higher than the cost of raising a son when, because of cultural and legislative norms, parents rely more on a son than a daughter when they become old and require help from their offspring.

sample, pregnant women who have a larger number of existing children are likely to have strong son preference, and thus are expected to show strong sex-selective abortion in response to the crisis. Therefore, we expect a stronger response among newborns of higher parity.[14]

The cost of abortion is another factor to examine in trying to understand parental decisions, because abortion – regardless of the gender of the unborn child – will be more likely for those parents who face a lower cost. As discussed in Section 2.3, both the monetary and health costs of abortion are higher the more advanced the pregnancy is at the onset of the crisis. Furthermore, the opportunity cost of using money for abortion may vary by a pregnant woman's socioeconomic status as well as the number of her existing children. For example, if a pregnant woman is credit constrained, she is less likely to be able to have an abortion compared to her counterpart with some savings. Relatedly, if a pregnant woman has multiple children to feed with little means and she is credit constrained, she may use the money to support her existing children, instead of using it for an abortion. In reality, the relationship between abortion and parents' socioeconomic status is ambiguous because a mother with more savings is more likely to be educated and face a higher opportunity cost of having a child. For these reasons, we will examine possible heterogeneous effects of the crisis based on how far along in the pregnancy women are, and we will consider maternal education as a proxy for parents' socioeconomic status.

The economic crisis may affect health outcomes at birth through multiple channels. For example, it is possible that parents may selectively use abortion when children *in utero* are unhealthy to avoid medical expenses for those children. If this possibility is true, then the crisis will induce more abortions of unhealthy fetuses, leading to healthier newborns. Besides this possible selective abortion, there are several channels through which the crisis may affect newborn health, and the net impact of these channels is ambiguous. Adverse economic shocks may reduce consumption of health-damaging goods (e.g. alcohol or cigarettes), leading to an improvement in health at birth. However, the crisis may also reduce consumption of health-improving goods such as a nutritious diet, which, in turn, can adversely impact

[14] In our empirical analysis, we cannot examine the heterogeneous impact of the crisis based on the gender of older siblings because our dataset does not include the sex composition of older siblings (Section 4 describes our dataset).

measures of health at birth. In principle, the responses described above can be heterogeneous depending on the gender and parity of the child as well as a family's socioeconomic status.

3.2 Factors outside Parental Control

Several factors outside direct parental control can affect fertility and the health of newborns. For example, uncertainty and economic difficulties due to a crisis may increase maternal stress levels, and a child who is exposed to high levels of stress *in utero* is more likely to suffer poor health. Such an impact on health may be different for male and female fetuses, an insight coming from a long tradition in theoretical biology. For example, both Trivers and Willard (1973) and Krackow (2002) hypothesize that female fetuses dominate their male counterparts in terms of survivability. In fact, both studies suggest that if a fetus's health is below the minimum health level for survival, biological forces will terminate the pregnancy, so that the mother can have another chance to get pregnant with a healthy child. Thus, when they are exposed to adverse environments *in utero*, more males than females will be naturally aborted, increasing the fraction of newborn girls.

However, the two studies propose different biological mechanisms generating opposite predictions in terms of health outcomes of newborns. According to Trivers and Willard (1973), adverse environments raise the minimum health threshold while the distribution of fetuses in terms of survivability remains the same. As males are, on average, weaker than their female counterparts, they are more likely to be aborted due to the raising of the minimum threshold for survival. This mechanism is commonly referred to as *culling*. In contrast, Krackow (2002) suggests that adverse environments do not change the minimum health level for survival, but the entire distribution of survivability shifts to the left (i.e., fetuses have weaker health). Even if the extent to which the distribution shifts is the same across genders, more male fetuses will be aborted because they are, on average, less healthy than females. This mechanism is called *scarring.* For a detailed explanation, see Catalano and Bruckner (2006).

In principle, culling and scarring can be simultaneously present, leading to clear predictions regarding changes in the sex composition at birth (i.e. an increase in the fraction of girls) and ambiguous

predictions on health outcomes as a consequence of the financial crisis.[15] We conjecture that, everything else being equal, these biological factors may vary according to the number of children a mother already has: the more children she already has, the greater the stress the same intensity of the crisis may inflict on her, because, for example, she needs to meet the needs of both her existing children and her unborn child.[16]

3.3 Empirical Predictions

To sum up, our conceptual framework suggests that the fraction of newborn girls should increase if the effects of the crisis due to factors outside parental control dominate the effects due to parental choices. However, if the latter dominates, the crisis may decrease the fraction of newborn girls, especially among those who have a larger number of older siblings and whose mothers were at an early stage of pregnancy when the crisis started.

4. Data

4.1 Data Source and Outcomes of Interest

For the purpose of our study, it would be ideal to have a representative dataset that includes births, abortions, and parental behavior during pregnancy such as consumption patterns, smoking, drinking, and prenatal care. Such a dataset would allow us not only to estimate the impact of the crisis on overall fertility but also to assess the importance of each mechanism behind our results, such as parental response in terms of abortion, changes in consumption during pregnancy, and the biological factors hypothesized by the Trivers-Willard and scarring hypotheses. Unfortunately, such a dataset does not exist in South Korea. The lack of a representative dataset on abortion is not surprising given that abortion is illegal as a

[15] Various studies present empirical evidence of changes in the sex composition of newborns when mothers face adverse conditions while pregnant. To mention just a few examples, the literature has considered terrorist attacks (Catalano et al., 2006), increased alcohol consumption (Nilsson, 2016), anxiety (Subbaraman et al., 2010), and pollution (Sanders and Stoecker, 2015).

[16] Buckles and Kolka (2014) show that in the US mothers pay less attention to their unborn children if they already have children to take care of. For example, mothers are 7 percent less likely to take prenatal vitamins in a fourth or higher-order birth pregnancy than in a first pregnancy and are 11 percent less likely to receive early prenatal care. If this finding applies to our setting, it implies that a child born of higher parity (i.e. a child who has older siblings) can be particularly vulnerable to external shocks while *in utero*.

means to control fertility. Also, for the period covered by our study – 1997 and 1998 – there is no representative micro-level dataset that can inform us about parental behavior regarding consumption and prenatal care visits.

The available dataset closest to the ideal one is an administrative dataset that includes detailed information on births but lacks information on abortions or prenatal behavior. Part of the information reported on birth certificates is published in the annual birth record issued by the Korean Statistical Office, and such data is our primary data source. Micro-level data from birth certificates contain information on the sex of newborns, their birth weight, and birth parity, as well as parental characteristics including age, education, marital status, and the location of residence. Due to the data limitation, we can estimate the overall effect of the crisis on fertility using birth records, but we cannot separately measure the impact of each factor (e.g., parental behaviors using abortions or other health behavior).

When conducting fertility analysis, our primary outcome variable is the dummy variable indicating whether a newborn is female. We focus on this outcome because it highlights the differential impact on natality by gender and makes use of the detailed child-level information in our data. As a separate analysis, we examine the number of births by aggregating birth records in cells defined by region and month (and some parental information). This additional analysis informs us about the impact of the crisis on the total number of births of boys and girls.

4.2 Sample, Measure of Economic Shocks, and Summary Statistics

We restrict our analysis to children *in utero* at the onset of the crisis, namely those born between January and August 1998, in order to cleanly identify the impact of the crisis. For our identification, it is crucial to distinguish unexpected economic difficulties caused by the crisis from expected economic conditions. This is because before the 1997 crisis, the South Korean economy had continuous economic growth with stable economic indicators. For instance, unemployment rates were around 2 to 3 percent. Therefore, it may be reasonable to assume that individuals make their decisions based on the long-term trend of those indicators and any deviation from the long-term trend is likely to be viewed as a "surprise". However, when the crisis started, the economic indicators such as unemployment rates, interest and exchange rates,

widely fluctuated. It is therefore difficult for researchers to model how individuals updated their expectations during the crisis. For example, some individuals may use a myopic updating rule by setting their expectations of economic conditions equal to the conditions in the previous period; others may use Bayesian-style updating rules; others may not update their expectations at all. Therefore, without a strong assumption about individuals' beliefs, researchers cannot distinguish unexpected economic shocks from expected economic conditions, which is crucial for identification.

For the individuals in our sample, we create a measure of long-term unemployment rates to proxy for the economic conditions that a couple expects during pregnancy. We regard any deviation of the actual unemployment rates during the crisis, compared to the long-term trend, as an unexpected shock due to the crisis. Specifically, for each region by month, we calculate the average of unemployment rates from 1989 to 1996. Because the unemployment rates show seasonality but are stable at around 2 to 3 percent, this calculated average is considered an expected long-term unemployment rate.[17] With this in mind, for a newborn born in a given month of 1998, we calculate the simple average of the 9-month long-term unemployment rates before birth and regard such a measure as the unemployment rate parents expected when they planned to have a baby.[18] We denote this rate by "preUR" in the rest of this manuscript. Next, we calculate the average of actual unemployment rates over the same period and take the difference between the actual and expected unemployment rate. We denote that difference by a variable called "IntensityCrisis," which captures the region- and time-varying intensity of the unexpected shock

[17] When we calculate the long-term trend, we did not use 1997 because the mothers in our sample conceived in 1997 and thus the unemployment rates in 1997 will be used for "realized" unemployment rates. Finally, we use 1989 as the starting year because it was the earliest year for which we can get regional unemployment rates. Our results are robust when we use a shorter time span to calculate the long-term unemployment rates. See details in Section 6.5.

[18] It is worth noting the rationale behind choosing a "9-month" window in calculating the expected and unexpected unemployment rates (URs). As the gestation information (measured in weeks) for a newborn is available in our dataset, we could have calculated the URs while the newborn was *in utero*. However, our measure is basically equivalent to this alternative measure, as the South Korean statistics office only offers quarterly UR per locality. With this information, we calculate monthly URs using the linear interpolation method (see Appendix 1). Therefore, even if we use information on gestation to impute unemployment rates, such an alternative measure is extremely close to the measure of the monthly URs we use here for babies born after gestation around 40 weeks. Indeed, in our sample, 98 percent of newborns were born between 36 and 42 weeks. However, we do not use gestation in the main analysis as gestation is only estimated in birth records and may contain misreporting (See Section 6.5).

generated by the crisis (for details see Appendix 1). In our analysis, we exclude births from a region called Ulsan, because Ulsan lacks historical regional unemployment rates.

Table 1 reports summary statistics from birth certificates and from our measures of unemployment created from statistics at the regional level provided by the Bank of Korea. In column 1 of Panel A of Table 1 we provide the average of the two measures for the period we study weighted by the number of births at the local level. The weighted average of preUR is equal to 2.468% and the weighted average of the variable IntensityCrisis is equal to 1.888%. That is, the unemployment rate during the 9 months before birth rose unexpectedly by 1.888 percentage points on average. Table 1 also shows that newborn girls are 48.6 percent of first-born children (Parity 1), a figure comparable to the figure under balanced sex ratios. However, only 41 percent of newborns with at least two older siblings (children born of Parity 3 or higher) are girls, suggesting that sex-selective abortion is especially likely for girls with at least two older siblings. It is worth noticing that in our data almost all births are to married mothers, not a surprising fact given the large social stigma associated with non-marital childbearing in South Korea. Finally, statistics on birth weight in Table 1 show that girls tend to be lighter than boys.

5. Empirical Framework and Identification Strategy

5.1 Empirical Framework

We examine the impact of the crisis on the fraction of newborns girls by estimating the following regression model:

$$Girl_{i,j,t} = \alpha\, IntensityCrisis_{j,t} + \beta preUR_{j,t} + \theta_j + \mu_t + \varepsilon_{i,j,t} \qquad (1)$$

where $Girl_{i,j,t}$ is a dummy equal to 1 if the newborn child *i* is girl, born in region *j* (15 regions) in month *t*. As discussed in Section 4.1, $IntensityCrisis_{j,t}$ and $preUR_{j,t}$ capture, respectively, the unexpected economic hardship due to the crisis and the expected long-term economic condition. Parameters θ_j and μ_t, are region- and time-specific fixed effects, respectively.[19] The random shock $\varepsilon_{i,j,t}$ is allowed to be

[19] We have also estimated Equation 1 without the variable $preUR_{j,t}$ and our results remain the same. Our models do not include parental characteristics as control variables because parents' responses to the crisis may differ by their characteristics. For instance, if we include a mother's age in equation (1), its coefficient will capture both the

correlated with the shock for another observation as long as the two are from the same region. To do so, we cluster the standard errors at the regional level.[20]

The parameters of interest are α in equation (1), which measures the causal impact of the economic crisis through the variable $IntensityCrisis_{j,t}$ if this variable is not correlated with the error term $\varepsilon_{i,j,t}$. Because the economic crisis in 1997 was a surprise to South Koreans, perhaps the only possible source of endogeneity is migration in response to the crisis. We find suggestive evidence that such a concern is not likely to affect our results, which we will discuss in detail in the subsequent section.

5.2 Plausibility of the Identification Strategy

Our models rely on the time- and regional- variations in the unexpected surge of unemployment rate ("IntensityCrisis" in equation (1)) to identify the causal effect of the crisis on our outcomes of interest. For causal inference, we need to verify that the variable $IntensityCrisis_{j,t}$ is uncorrelated with the error term $\varepsilon_{i,j,t}$. As the 1997 crisis was unexpected and we focus on a short time window right after the onset of the crisis, we think the correlation between the intensity of the crisis and the error term is unlikely. Nonetheless, we use two approaches to empirically test the plausibility of our identification strategy.

First, we examine the extent to which people may migrate to another location in response to the crisis. This concern arises because we measure the intensity of the economic difficulties based only on the location where mothers gave birth but not based on the location(s) mothers and their partners resided in during pregnancy since the crisis started. It is worth pointing out that migrations could lead us to either underestimate or overestimate the true causal impact of the crisis. For example, suppose that pregnant women remain in their current residence at the onset of the crisis but that, to support their family, their partners migrate to another region that is suffering less from the crisis. Then, our estimated coefficients will underestimate the true impacts due to attenuation bias. Alternatively, suppose that women who are

mother's age effect and the differential impact of the crisis by maternal age. We avoid this complication by omitting parental characteristics in our baseline analyses, although our estimates are qualitatively and qualitatively very similar when we include parental characteristics. See the Online Appendix (Table O.2).

[20] We also used wild bootstrapping of the t-statistics as a robustness check, and our results remain valid.

reluctant to have an abortion are more likely to move to a region less affected by the crisis than their region of residence, trying to find better economic conditions for the benefit of their children. In this case, our estimated coefficients would exaggerate the true impact of the crisis. To assess whether selective migration happened in the period under study, we examine the extent to which people moved across regions in a given month and test whether such migration is systematically correlated with our measure of the unexpected economic shocks (i.e., "IntensityCrisis"). Specifically, we estimate the following regression model:

$$Netoutflow_{j,t} = \alpha\, IntensityCrisis_{j,t} + \theta_j + \mu_t + \varepsilon_{j,t}, \qquad (2)$$

where $Netoutflow_{j,t}$ measures the extent to which people moved from location *j* at time *t*. Consistent with our baseline models, our unit of time is a month and it ranges from January to August 1998. The variable $Netoutflow_{j,t}$ is the number of out-migrants subtracted from the number of immigrants per 1,000 residents in location *j* at time *t.* Note that the number of residents is based on the Korea's 1995 Population Census, as the total number of residents is available only every 5 years. Table 2 reports the results. In column (1), we estimate equation (2) using all migrations. In columns (2) and (3), we narrow our analysis by focusing on individuals between 20 and 49 years of age, who are likely to be married and may consider having a child. In our analysis, we cannot focus on married individuals or pregnant women because the administrative dataset we use to calculate migration does not include such information. Table 2.1 shows that the estimated coefficients of the intensity of crisis are all insignificant at conventional levels.

Second, we examine a more complicated scenario. Suppose that, before the crisis, people sorted geographically based on some unobservable characteristics, and that the unobservables may be correlated with the intensity of the crisis. If this scenario is true, then our estimates would be biased, because they would capture both the true effect of the crisis and the effect of the unobservables. Two pieces of evidence suggest that such a scenario is not likely to occur in our setting. The first piece of evidence shows that a region's relative intensity of the crisis varies greatly by month. That is, the crisis affected some regions

more adversely than others in one month, and it affected different regions more adversely in another month. Please see more details in the Online Appendix (Figure B.3). As a result, the correlation between the intensity of the crisis in January 1998 and the intensity of the crisis in August 1998 is low.[21] Because of this large variation in the intensity of the crisis even within a location, it is difficult for us to imagine any unobservable characteristic that systematically sorts individuals into regions hit more severely (or weakly) by the economic crisis when the crisis did not even occur.

The second piece of evidence is based on a falsification test. Specifically, if the unobservables are correlated with the intensity of the crisis, then our measure of the intensity of the crisis should be correlated with pre-crisis fertility outcomes. To test this possibility, we select the period between January and August 1997 (a period of the same length as the period we consider in the main analysis, but antecedent to the crisis)[22] and regress the dummy variable indicating whether a newborn is female on the long-term unemployment trend ("long-term" trend), the deviation of the actual unemployment rate relative to the long-term trend ("deviation-actual")[23], the intensity of the crisis ("deviation-future: intensity of the crisis")[24], and other fixed effects described in equation (1). If our identification strategy is valid, then the coefficient of the variable "intensity of the crisis" will not be systematically correlated with the pre-crisis outcomes. Column (1) of Table 2.2 shows our results based on the pooled sample across all parities, while columns (2) to (4) are based on each parity separately. Except for Parity 1 (column 2), we find no significant relationship between the future intensity of the crisis and the pre-crisis fertility outcomes. Although the coefficient for Parity 1 is positive and significant at the 5 percent level, that

[21] The Spearman rank correlation is 0.59 and correlation coefficient is 0.58. Note that there are two regions, called Kyunggi and Incheon, that recorded the largest intensity of the crisis throughout our sample period. If we remove these two regions and calculate the correlation, the Spearman rank correlation drops to 0.36 and correlation coefficient is only 0.22. Our main results described in Section 5.3 and 6 are robust even if we exclude these two regions from our sample.
[22] We focus on 1997 because microdata are available only from 1997.
[23] The variable "deviation actual" is calculated in a way that is, all in all, the same way we use to calculate the variable "intensity of the crisis," but obviously it uses the values for year 1997 instead of using the values for year 1998.
[24] The variable intensity of the crisis is the same variable we use in the main regressions, and it is calculated as explained in Appendix 1.

relationship is not robust to model specifications.[25] Furthermore, as the next section will describe, our main findings focus on higher parities and exhibit the opposite negative relationship between the intensity of the crisis and the female share of newborns.

5.3 Baseline Results

Panel A in Table 3 reports our baseline results. As we conjectured in Section 2, we find that the crisis had a stronger impact on births of higher parity. Specifically, we do not find that the crisis was significantly related to a change in the fraction of newborn girls when considering first-born children or children with another sibling (columns 2 and 3, Panel A, Table 3). However, among those who have two or more elder siblings (Parity 3+, column 4), the unexpected economic shock significantly reduced the fraction of newborn girls: a one percentage point increase in the unexpected unemployment rates during the 9 months before birth reduces the fraction of girls by 2.6 percentage points.

To calculate the overall impact of the crisis, we multiply this point estimate by the simple average of the variable "IntensityCrisis" across months and regions (1.751 percent) and find that the economic crisis reduced the fraction of girls with at least two older siblings by 4.55 percentage points during the first 8 months of 1998. With the point estimate, we calculate the number of missing girls as a consequence of the crisis. Holding the number of boys at Parity 3 or higher to be the same as in the data (that is 24,006 in total), our calculation suggests that, without the crisis, there would have been 3,399 more girls among those at Parity 3 or higher.[26] This figure implies that, absent the crisis, the total number of births of girls would have been 2 percent larger than the actual number. It also implies that if we limit our focus to only Parity 3 or higher, the number of girls would have been 20 percent larger.

We can interpret the findings on sex ratio by parity as follows: as Larsen et al. (1998) reported, parents do not sex select their first-born children in South Korea. Therefore, *not finding* that the crisis

[25] For example, when we use a more flexible functional form allowing for the interactions between maternal education and the rest of control variables, the coefficient of "devUR: future" becomes small and insignificant at conventional levels (i.e., 0.007(s.e.0.007) for college educated mothers; 0.008 (s.e.0.006) for high school graduate mothers; and 0.011(s.e.0.021) for mothers without high school degree.

[26] Please see Appendix 2 for a detailed explanation.

affected the fraction of newborn girls of Parity 1 suggests that the biological factors we discussed in our conceptual framework are mild at best for women expecting their first child. In Section 3.2, we conjectured that the impact of biological factors may become stronger the higher the parity of the child, because the same intensity of the crisis may place greater financial and emotional stress on mothers who need to take care of existing children in addition to a child *in utero*. At the same time, parents' willingness to have sex-selective abortion may become greater at higher parity as well. For example, as Larsen et al. (1998) reported, desire to have a son drives parents who already have a child to decide to have another child. Considering the fact that the modal number of children in Korea is two, families expecting their second child may use sex-selective abortion but not too often compared to parents expecting their third child, for example. However, families expecting their third child or a child of higher parity are much more likely to be a selected group who chose to have a third child (or a child of higher parity) *because* they are likely to be pregnant because they wanted a boy. Therefore, even if we may expect that the biological factors may be stronger at higher parity, we may find that the parental behavioral mechanism operating via sex selection could be stronger. Our findings for children of Parity 2 for the entire period January-August 1998 overall suggest that the biological factors and sex-selective parental behaviors counterbalance each other for newborns with one sibling. We will look more in depth at these findings when looking at heterogeneous effects by sub-period in the following sections. However, for Parity 3 or higher, we find a negative impact of the crisis on the fraction of newborn girls, implying that sex-selective parental behaviors outweigh biological factors.

6 Discussions

6.1 Heterogeneous Effects by Stage of Pregnancy

As abortion is more costly when performed at an advanced stage of pregnancy, we expect parents to be more likely to use abortion when women are at an early stage of pregnancy. Following this idea, we divide the first 8 months of 1998 into two equally-long periods: January to April, and May to August. Assuming 9 months of gestation, babies born before May would already have been *in utero* at least 4 months. To see whether the response to the crisis varies by sub-period, we modify equation 1 by replacing

"IntensityCrisis" with the two variables: "IntensityCrisis x Jan.-April" and "IntensityCrisis x May-Aug." Variable "IntensityCrisis x Jan.-April" is "IntensityCrisis" for those who were born between January and April 1998 and zero otherwise. Likewise, "IntensityCrisis x Jan.-April" is defined. If our conjecture is correct, then we should find that the estimate for "IntensityCrisis x Jan.-April" is smaller in absolute value than that of "IntensityCrisis x May-Aug."

Panel B of Table 3 reports the results regarding possible heterogeneous effects based on timing of birth. As shown in column (2), we do not find any significant impact on the fraction of newborn girls of Parity 1, a finding similar to our baseline result. In contrast, as reported in column (3), our results show an increase in the fraction of girls born with Parity 2 between January and April. The unexpected surge in unemployment rates increases the fraction of newborn girls by 0.9 percentage points in the first four months of 1998, while it shows no impact for the period from May to August. For Parity 3, we find a reduction in the fraction of newborn girls in both sub-periods and the estimated impact for the second sub-period is twice as large as that for the first period and statistically significant at conventional levels.

6.2 Maternal Education

We examine possible heterogeneous impacts depending on mother's educational attainment: college graduates, high school graduates, and those without a high school degree. It is possible that a mother's response to an economic downturn may vary by her monetary or non-monetary resources and this could generate heterogeneous impacts of the crisis by educational attainment.[27] Panel C of Table 3 reports the results and full regression results are presented in the Online Appendix (Tables O.3-5).

In general, our findings from the baseline analyses are also found across all groups of maternal educational attainments. For example, across all three maternal educational groups, the crisis decreased the fraction of newborn girls of Parity 3 or higher, and the impact is larger for the second period

[27] For example, given the positive correlation between education and health, more educated mothers have a better underlying level of health compared to less educated mothers, and their health may better shelter highly educated mothers from the negative impact of the crisis. Furthermore, educated mothers may have a different opportunity cost of having a child compared to lower educated mothers. In the context of the U.S., Dehejia and Lleras-Muney (2004) report that an unexpected rise of unemployment rates changes mothers' fertility behaviors depending on educational attainment.

(May to August 1998). The estimated coefficient of the variable "IntensityCrisis" for the second period is equal to -0.031 for college graduate mothers, equal to -0.017 for high school graduate mothers, and equal to -0.045 for mothers without high school degree. Each of these estimated coefficients is not statistically different from the other two. One may imagine that college educated mothers may respond less to the crisis than less educated mothers because they have more resources to mitigate the shock, and in light of this consideration, our finding may seem puzzling. We suspect that the reason behind our findings may be selection into fertility. To explain this, consider that giving birth to a third child or more is rare among college graduate mothers, but it is not so rare for less educated mothers.[28] Therefore, it is possible that college educated mothers who get pregnant with their third child are especially eager to have a son compared to their less educated counterparts.[29]

6.3 Analysis with Aggregated Data: Number of Births

In this section, we aggregate our data up to the cell level, defining a cell by month, region of birth, and gender, and we examine the impact of the financial crisis on the number of births. The motivation behind this analysis is twofold. First, we seek to examine the possibility that the crisis may affect the natality of boys, which cannot be detected by our baseline analysis. Second, due to difference in functional form assumptions, we can examine the robustness of our baseline results when we calculate the number of missing girls. Specifically, we estimate the following model:

$$\ln(Births_{g,j,t}) = \alpha IntensityCrisis_{j,t} + \alpha' IntensityCrisis_{j,t} \times girl_{j,t}$$

[28] For example, in our sample, the fraction of newborns of Parity 3 or higher is only 6 percent among college graduate mothers, 10 percent among high school graduate mothers, and 26 percent among mothers without a high school degree.

[29] Among newborns with Parity 3 or higher, we find that the likelihood of having a girl is the lowest among mothers with a college degree (41%), followed by mothers with a high school degree (42%) and then by mothers without a high school degree (44%). The estimates of the coefficients of the variable measuring expected unemployment rates ("preUR") in Table 4 differ by maternal education. In fact, a high level of expected unemployment rates has a negative impact on the fraction of newborn girls when mothers have no high school degree (Panel C, -0.323), while the value of the coefficient of the variable preUR is comparable for births to college graduate mothers and to mothers with only a high school degree (-0.057 vs -0.067). See Tables O.3 to 0.5 in the Online Appendix. Perhaps this difference can be ascribed to the high level of education of Koreans. In fact, it is widely known that Koreans place a high value on educational attainment and have an exceptionally high level of education, so those without even a high school degree have a distinct disadvantage in society, which could make less educated individuals especially vulnerable to economic conditions.

$$+\beta preUR_{j,t} + \beta' preUR_{j,t} \times girl_{j,t} + \lambda girl_{j,t} + \theta_{g,t} + \mu_{g,t} + \varepsilon_{g,j,t}. \qquad (6)$$

That is, we regress the natural logarithm of the number of births of gender *g* (boys vs. girls), in region *j* at time *t* on the control variables in equation (1), but we allow for the possibility that coefficients may differ by gender (i.e., we interact the girl dummy with all control variables). The regression is weighted by the number of observations in each cell and standard errors are clustered at the regional level.

Table 4 (Panel A) reports the results. Consistent with our earlier finding, we do not find any systematic relationship between the crisis and fertility for both boys and girls of Parity 1 or 2. For Parity 3 or higher, we find that the intensity of the crisis has a positive impact on the number of male births but a negative impact on the number of female births (that is larger in absolute value than the impact on boys), and this gender gap is significant. In fact, a one percentage point increase in the unexpected unemployment rates increases the number of male births by 3.7 percent (pvalue: 0.09), while it decreases the number of female births by 6.5 percent (pvalue: 0.12). The estimated coefficient of the interaction term "IntensityCrisis x Girl" is -0.102 (pvalue: 0.02), suggesting that, relative to male births, a one percentage point increase in unexpected unemployment decreases the number of female births of Parity 3 or higher by 10.2 percent. This point estimate implies that, for the case of Parity 3 or higher, the crisis reduces the number of female births relative to the number of male births by 18 percent, a result remarkably similar to our baseline result (20 percent, see Section 5.3).

6.4 Birth weight

When studying the health outcomes of newborns, we examine two outcomes: average birth weight and whether a newborn weighs less than 2,500 grams.[30] As shown in panels B and C of Table 4, we find no statistically significant relationship between the intensity of the crisis and birth weight outcomes. The only exception is for the average birth weight among boys with one older sibling. These findings suggest that the crisis negatively affects the natality of girls with two or more older siblings, but conditional on being born, the girls do not get compensated in terms of birth weight, relative to their male peers. This finding suggests

[30] Although we are aware of limitations of using birthweight, we nonetheless examine birthweight because there is no well agreed upon measure superior to birthweight (see Almond and Currie, 2011).

that the scarring mechanism (Krackow, 2002) dominates the culling mechanism (Trivers and Willard, 1973). For a more detailed analysis of birthweight outcomes, see the Online Appendix (Section A, Tables O.7-10)

6.5 Alternative Specifications

We examine the sensitivity of our results to the definition of "unexpected" economic shock. First, instead of using the 9-month span from the month of birth, we use the information on gestation and calculate the expected and unexpected unemployment rates during gestation. Panel D of Table 4 shows that the crisis reduced the fraction of girls among newborns with Parity 3, a result quantitatively comparable to our baseline results.[31] Next, instead of using the period between 1989 and 1996, we use a shorter time span, 1992 to 1996, and construct the two variables, preUR and IntensityCrisis. See Table O.6 in the Online Appendix for the estimation results when we use this alternative definition. The results are remarkably comparable to our baseline results.

6.6 Robustness to Multiple Testing Adjustments

The most conservative multiple-hypothesis-testing method is Bonferroni's, which requires the researcher to increase the p-values of estimates by multiplying them by the number of tests (i.e., number of coefficients). We conduct the following heuristic analysis in the spirit of the Bonferroni method. Consider Panel A in Table 3. We can consider the three regression results (Parity 1 to Parity 3+: columns 2 to 4) in an MHT setting. In such a setting, we need to test whether any of the three coefficients (IntensityCrisis for Parity 1, Parity2 and Parity 3+) are statistically different from zero. Our main finding is that the coefficient of IntensityCrisis for Parity3+ is -0.026, statistically different from zero. As the corresponding p-value is 0.015, the product of multiplying it by 3 is still less than 5%. Similarly, if we take the same approach for Panel B in Table 3, we have 6 coefficients of interest (IntensityCrissXJan-April, IntensityCrisis-May-Aug. x Pairty1 to Parity 3+). Our main finding is the estimate for Parity3+

[31] For the main regressions, to facilitate comparison with studies from other countries, we did not use the information on gestation. Information on gestation is often estimated, not accurately reported. See, for example, for US data, the following paper: https://www.ncbi.nlm.nih.gov/pubmed/17803618

(IntensityCrisis x May-Aug). The p-value of the coefficient is 0.003. If we multiply it by the number of coefficients (i.e., 6), the resulting product is still far below 5%.

7. Conclusion

We have used the deep financial crisis affecting the South Korean economy at the end of the 1990s to investigate the extent to which economic hardship affects fertility and the birth weight of newborns. We find that the crisis increased the disadvantage in natality of girls compared to boys: approximately 2 percent of girls were never born in South Korea as a consequence of the crisis, and this reduction took place among those who had at least two older siblings. We attribute the cause of this negative impact on girls' natality to parental economic decisions when parents prefer sons. The effects of these parental decisions outweigh biological selection mechanisms that predict an advantage for girls in terms of survivability. Furthermore, conditional on being born, the health at birth of girls is worse than the health of boys, especially among those who were born between May and August 1998 and those who had at least two older siblings and were born to less educated mothers.

This paper raises follow-up research agendas that may prove fruitful for both scholars and policy makers. For countries that have a son preference, the South Korean experience can be valuable when designing policies. In fact, despite its son preference, South Korea had been making progress in balancing sex ratios at birth since the early 1990s. However, this improvement was overturned during the economic turmoil. It is worth noticing that high levels of household savings and long-term steady growth prior to the crisis did not prevent a surge in the number of missing girls as a consequence of the crisis. Therefore, one promising avenue of research is to investigate whether other countries – especially those with a son preference – engage in increased sex-selective fertility behavior as a consequence of economic downturns. In fact, statistics show that the fraction of newborn girls sharply decreased in Armenia, Azerbaijan, and Georgia when these countries suffered economic downturns in the 1990s (see Duthé et at., 2012; Das Gupta, 2015). Relatedly, China, which is known for a strong son preference, recently has shown several economic signs of slower growth. If our findings apply to the Chinese setting, then an economic slowdown may

exacerbate sex selection. Our results suggest that designing proper fertility incentives that incorporate changes in economic booms and busts may be worth considering for countries with a son preference.

Our findings may provide important policy implications even for countries that do not show a son preference. In fact, several studies find that parents spend more time and resources on sons than daughters (e.g., Lundberg et al., 2007). If our findings apply to those countries, parents may reduce investments more for girls than boys under adverse economic conditions such as the recent Great Recession in the US. It is therefore worth examining parental investment in response to economic business cycles, depending on their children's gender.

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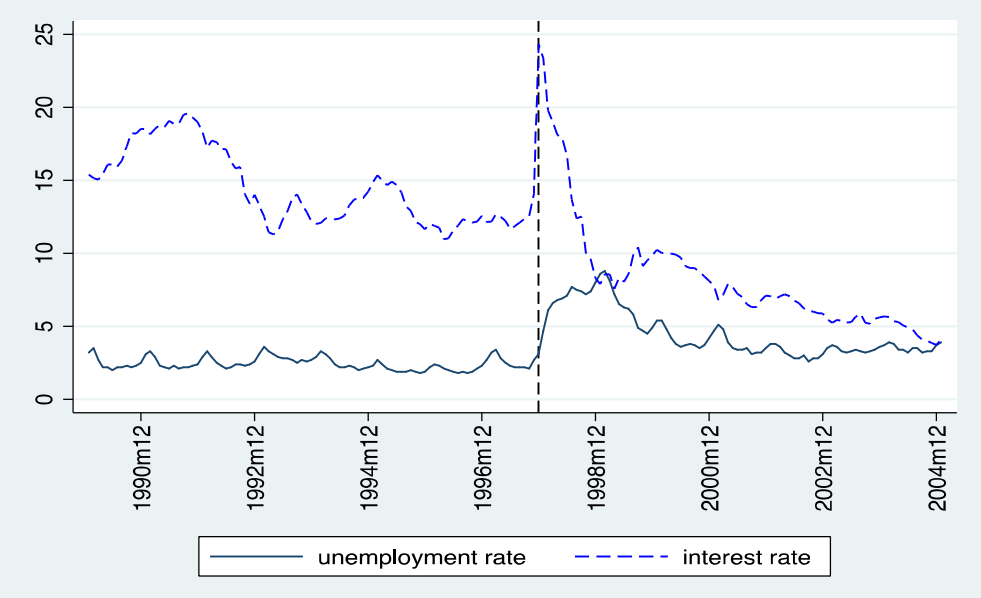
Figure 1. Trend of Unemployment and Interest Rates in South Korea



Note: The vertical line indicates December 1997. Interest rate is calculated based on the 3-year corporate bonds rated as AA-. Data is from the Bank of Korea (https://ecos.bok.or.kr/). The solid vertical line indicates December 1997, when the Korean government started to receive the rescue loans from international creditors, including the IMF/WB.

Table 1. Summary Statistics

	All	Jan.-April	May-Aug.
	(1)	(2)	(3)
A. Economic indicators			
IntensityCrisis (%)	1.888	0.090	2.927
Pre UR (%)	2.468	2.432	2.509
B. Parental Background			
% out of wedlock birth	0.42	0.40	0.46
Mother: age	28.02	27.98	28.06
college grad (%)	32.14	31.81	32.52
less than high school (%)	5.54	5.52	5.57
Father: age	31.02	30.98	31.06
college grad (%)	45.10	45.20	44.98
less than high school (%)	6.54	6.52	6.56
C. Fertility/Birth weight			
No. of newborns	414,279	222,086	192,193
% of girls among newborns			
- All births	47.65	47.72	47.57
- Parity 1	48.60	48.52	48.69
- Parity 2	48.13	48.32	47.90
- Parity 3 or higher	40.99	41.02	40.95
% low birth weight			
- All	4.90	4.70	5.14
- Boys	4.28	4.05	4.54
- Girls	5.59	5.42	5.79
Average Birth weight (grams)			
- All	3,271	3,280	3,260
- Boys	3,320	3,329	3,309
- Girls	3,216	3,225	3,206

Note: Economic indicators in Panel A are based on statistics provided by the Bank of Korea and are weighted by the number of births at the regional level (a total of 15). Panel B and C are based on birth records provided by the Korean Statistical office. "Low birth weight" is a dummy equal to 1 if a newborn weighs strictly less than 2,500 grams. Refer to Appendix 1. for the calculation of the variables preUR and IntensityCrisis.

Table 2. Plausibility of the Identification Strategy

Table 2.1. Testing Endogenous Migration

	All	Men: age 20 – 49	Women: age 20 – 49
	(1)	(2)	(3)
IntensityCrisis	0.194	0.388	0.394
	(0.215)	(0.220)	(0.231)
preUR	-1.687	-2.362	-1.079
	(3.021)	(2.985)	(3.604)
Mean dept. var.	-0.178	-0.209	0.033
R-sq	0.65	0.71	0.68

Note: OLS regressions. Month and Location fixed effects are included. The unit of observations is region by month and the number of observations is 120. The outcome is the number of "net" migrants per 1,000 residents. Note that the number of residents is calculated based on the Korea's 1995 Population Census. Standard errors are clustered at the regional level, and are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Refer to Appendix 1. for the calculation of the variables preUR and IntensityCrisis.

Table 2.2. Falsification Test: Fraction of Females before the Crisis

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Unemployment Rates				
- Long-term trend	-0.022	-0.035	0.012	-0.064
	(0.027)	(0.034)	(0.041)	(0.085)
- Deviation: actual	0.006	0.005	-0.000	0.041***
	(0.006)	(0.005)	(0.011)	(0.015)
- **Deviation: future**(IntensityCrisis)	0.003	0.008**	-0.000	0.003
	(0.002)	(0.003)	(0.005)	(0.006)
Mean dep. Var.	0.479	0.487	0.484	0.422
N	431,315	205,055	185,765	40,495
R-sq	0.479	0.487	0.484	0.424

Note: The outcome variable is 1 if a newborn is a girl, and its average is reported in rows titled "Mean dep. var." We include region fixed effects (a total of 15) and month of birth fixed effects (January to August 1997). Standard errors are in parentheses and are clustered at the regional level. * significant at 10%; ** significant at 5%; *** significant at 1%. Refer to Appendix 1. for the calculation of the variables IntensityCrisis and preUR. As reported in the main text, the significance of the estimate "Deviation: future" in column (2) is not robust to model specification. Please refer to Section 5.2 and the relevant footnote therein.

Table 3. Fraction of Girls Among Newborns

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. Baseline				
IntensityCrisis	-0.003	-0.003	0.002	-0.026***
	(0.003)	(0.004)	(0.004)	(0.009)
preUR	-0.075**	-0.079	-0.089*	0.006
	(0.034)	(0.049)	(0.051)	(0.057)
Mean dep. var.	0.476	0.486	0.481	0.409
N	414,279	197,464	176,133	40,682
R-sq	0.477	0.486	0.481	0.412
Panel B. Timing				
IntensityCrisis x Jan.-April	0.000	-0.005	0.009**	-0.012
	(0.003)	(0.004)	(0.004)	(0.008)
IntensityCrisis x May-Aug.	-0.002	-0.003	0.003	-0.024***
	(0.003)	(0.004)	(0.003)	(0.006)
Mean dep. var: Jan-April	0.477	0.485	0.483	0.410
May-Aug	0.476	0.487	0.479	0.409
N	414,279	197,464	176,133	40,682
R-sq	0.477	0.486	0.481	0.413
Panel C. Maternal Edu.				
College grad: IC*Jan-April.	-0.002	-0.003	0.002	-0.025
	(0.005)	(0.008)	(0.007)	(0.015)
IC*May-Aug.	-0.002	0.006	-0.008	-0.031**
	(0.005)	(0.008)	(0.006)	(0.013)
HS Grad: IC*Jan-April.	0.003	-0.006	0.014**	-0.003
	(0.004)	(0.005)	(0.007)	(0.010)
IC*May-Aug.	-0.001	-0.007	0.008	-0.017*
	(0.004)	(0.005)	(0.006)	(0.009)
Less HS: IC*Jan-April.	-0.014	-0.006	-0.008	-0.029
	(0.016)	(0.020)	(0.020)	(0.024)
IC*May-Aug.	-0.014	-0.013	0.005	-0.045**
	(0.011)	(0.011)	(0.014)	(0.020)

Note: The outcome variable is 1 if a newborn is a girl, and its average is reported in rows titled "Mean dep. var." We include constant, preUR, region fixed effects (a total of 15), and month of birth fixed effects (January to August 1998). Standard errors are in parentheses and are clustered at the regional level. * significant at 10%; ** significant at 5%; *** significant at 1%. Refer to Appendix 1. for the calculation of the variables IntensityCrisis and preUR.

Table 4. Additional Analyses

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. Log. no. newborns				
IntensityCrisis	-0.001	0.005	-0.015	0.037*
	(0.006)	(0.010)	(0.015)	(0.021)
IntensityCrisis x Girl	-0.011	-0.012	0.007	-0.102**
	(0.012)	(0.015)	(0.016)	(0.040)
Girl	0.869*	0.882	1.143	-0.219
	(0.451)	(0.635)	(0.653)	(0.760)
Mean dep. var	7.78	7.08	6.93	5.37
R-sq	1.00	1.00	1.00	0.99
Panel B. Birth weight				
IntensityCrisis	4.703	2.211	10.928**	-12.449
	(5.053)	(6.126)	(4.948)	(14.431)
IntensityCrisis x Girl	-4.535	-0.858	-8.020	-4.365
	(4.419)	(8.366)	(8.488)	(26.844)
Girl	-193.405	-302.685	-140.941	132.502
	(180.386)	(190.127)	(304.075)	(570.284)
Mean dep. var.	3,270	3,261	3,271	3,313
R-sq	0.982	0.982	0.982	0.978
Panel C. Incidence of low birth weight				
IntensityCrisis	-0.000	-0.002	-0.000	0.003
	(0.001)	(0.002)	(0.001)	(0.005)
IntensityCrisis x Girl	0.003	0.005	0.002	0.000
	(0.003)	(0.004)	(0.003)	(0.017)
Girl	0.079	0.060	0.194	-0.191
	(0.088)	(0.164)	(0.145)	(0.314)
Mean dep. var.	0.049	0.047	0.047	0.061
R-sq	0.50	0.48	0.50	0.65
Panel D. Gestation				
IntensityCrisis	0.000	-0.000	0.005*	-0.027***
	(0.002)	(0.003)	(0.003)	(0.005)
Mean dep. var.	0.476	0.486	0.481	0.409
R-sq	0.477	0.486	0.481	0.412

Note: The unit of observations is sex x birth month x region (total of 240). We include region and month of birth fixed effects, interacted with the female dummy. Standard errors are in parentheses and are clustered at the regional level. * significant at 10%; ** significant at 5%; *** significant at 1%. Refer to Appendix 1. for the calculation of the variables IntensityCrisis and preUR.

Appendix 1. Calculation of the variable measuring the intensity of the crisis in the 9 months before birth

We calculate our month by region measures of expected and unexpected unemployment rates ($preUR_{j,t}$ and $IntensityCrisis_{j,t}$) in two steps. First, we construct *quarter* by region measures of expected and unexpected unemployment rates. This is because, in our sample period, the Korean Statistical Office provides regional unemployment data on a quarterly basis. We take the regional quarterly unemployment rates from 1989 to 1996 and calculate the simple average given a region and quarter. We regard the simple average as the long-term unemployment rates or expected unemployment rate:

$$preUR_{q,j} = \frac{1}{6}\sum_{l=198}^{1996} un_{q,j,l} \qquad q = 1, 2, 3, 4 \qquad \text{(a)}$$

$$l = 1989\text{-}1996$$

where $preUR_{q,j}$ is the quarterly long-term unemployment rate in quarter q in region j and $un_{q,j,l}$ is the regional unemployment rate in quarter q in region j in year l. We then take the statistics from 1997 to 1998 and calculate the difference between the two rates, yielding an unemployment rate $IntensityCrisis_{q,j,k}$ in quarter q in region j in year k. That is,

$$IntensityCrisis_{q,j,k} = ActualUR_{q,j,k} - preUR_{q,j} \qquad q = 1, 2, 3, 4 \qquad \text{(b)}$$

$$k = 1997, 1998$$

where $ActualUR_{q,j,k}$ is the actual unemployment rate in quarter q in region j in year k.[32]

Second, we convert these quarterly measures to monthly ones to match our birth records. That is, for every baby in the micro-level birth records, we use his/her month and year of birth to identify the period of the 1 to 9 months before birth. Then we select the 3 or 4 quarters that overlap with this 9-month period for each newborn and weight the unemployment variables accordingly to compute $preUR_{j,t}$ and $IntensityCrisis_{j,t}$ where subscript j stands for region and t stands for month of birth. For example, consider a baby born in Seoul in January 1998. The 9 months before birth are April to December 1997. For her, the long-term unemployment rate in the 9 months before birth ($preUR_{j,t}$ in equation (a)) is:

$$\frac{3}{9}preUR_{2,seoul} + \frac{3}{9}preUR_{3,seoul} + \frac{3}{9}preUR_{4,seoul},$$

and her unexpected unemployment rate (IntensityCrisis in equation (b)) is:

$$\frac{3}{9}\text{IntensityCrisis}_{2,seoul,1997} + \frac{3}{9}IntensityCrisis_{3,seoul,1997} + \frac{3}{9}IntensityCrisis_{4,seoul,1997}.$$

It is worth noting that we could use alternative methods, such as HP filters, to construct the long-term trend of unemployment rates, instead of a simple average. We chose the simple average because, as

[32] Variable t includes 1997, because babies born in the first months of 1998 were conceived in 1997.

shown in Figure 1, unemployment rates remained stable before the onset of the crisis in Korea. Also, the current method is straightforward, leaving us little discretion to construct the long-term trends than alternatives.

Appendix 2. Fraction of Girls and Missing Girls

Following Oster (2005), we compute the number of net missing girls as follows:[33] The number of net missing girls from type c newborns can be written as

$$Missing_c = \left(\frac{SR_{crisis,c}}{SR_{nocrisis,c}} - 1\right) N_{girls,c},$$

where $SR_{crisis,c}$ is the observed sex ratio for type c newborns after crisis, $SR_{nocrisis,c}$ is the hypothetical sex ratio without crisis, and $N_{girls,c}$ is the actual number of girls born after the crisis whose type is c. The total number of missing girls will be the summation of $Missing_c$ over types. Note that this formula calculates the number of missing girls, holding the number of boys constant.

Note that the sex ratio is defined by number of boys over number of girls; that is, a function of the fraction of girls as follows:

$$SR_{crisis,c} = \frac{1}{Fractiongirls_{crisis,c}} - 1,\ SR_{nocrisis,c} = \frac{1}{Fractiongirls_{nocrisis,c}} - 1$$

and $Fractiongirls_{nocrisis,c}$ can be predicted by the regression results in micro-data. That is, we replace the variable that indicates post-crisis with 0 and then predict the fraction of girls among type c newborns.

Consider newborns of Parity 3 or higher. From the data, we know $Fractiongirls_{crisis,c}$ is 0.4099, and $N_{girls,c}$ is 16,676. Our baseline estimate predicts that, without the crisis, the fraction of girls should have been 0.4554(=0.4099 + 0.0455). Therefore, $SR_{crisis,c}$ and $SR_{nocrisis,c}$ are 1.4396 and 1.1959, respectively. Therefore, the number of missing girls with at least two older siblings (Parity 3 or higher) is 3,399. This magnitude is 20 percent of the actual number of girls at Parity 3 or higher, or 2 percent of the actual number of all girls.

[33] Oster, Emily (2005). "Hepatitis B and the Case of the Missing Women," *Journal of Political Economy,* 113(6), 1163-1216.

Online Appendix

Girls and Boys: Economic Crisis, Fertility, and Birth Outcomes

by Soohyung Lee and Chiara Orsini

This PDF file includes

A. Further Analysis on Birth Weight

A.1 Baseline Results

Panel C and D of Table 4 in the main text show that except for Parity 2 in Table 4 Panel C (column 3), both average birth weight and incidence of low birth weight responded little to the intensity of crisis. The insignificant impact of the crisis on birth weight differs from findings by Bozzoli and Quintana-Domeque (2014), who examine the economic crisis in Argentina from 2000 to 2005 and report a significant reduction in birth weight among newborns. We suspect that this difference could be explained by several factors: South Korea is more developed than Argentina and has universal health care coverage, and almost all births are to married mothers, making families better able to care for their unborn children compared to families in other countries with a higher fraction of out of wedlock births.[34]

A.2 Heterogeneous Effects By Timing of Births

Next, consider our results on birth weight when looking at the two sub-periods Jan-April and May-August (Table O.7). As described in Section 3 in the main text, we expect that health at birth will be better, especially for boys, if the culling mechanism is present. We find precisely this for Parity 2 for births between January and April, the period in which we find a relative increase in the fraction of newborn girls due to the crisis. A one percentage point increase in unexpected unemployment rates raises birth weight by 20 grams for boys born in the first four months and 12 grams for the latter period. The increase in birth weight for girls is negligible (i.e., 3 to 5 grams in total). We do not find that an unexpected negative economic shock affects average birth weight of other newborns.

Regarding the incidence of low birth weight, we a find reduction in the likelihood of low birth weight among boys: an increase of one percentage point in the unexpected unemployment rate decreases the likelihood that boys are born with low birth weight by 0.4 percentage points during January to April in 1998 (column 1, Table O.8). The estimated impact is comparable across parities (columns 2 to 4),

[34] To get an idea of the high ratio of births to married mothers in South Korea, consider that in the US in 1998 only 67.18 percent of births were to married mothers. This calculation is based on the US vital statics natality file in 1998. Additional references on stress and birth outcomes include: Black, Devereux, and Salvanes, 2016; Quintana-Domeque and Rodenas-Serrano, forthcoming; Persson and Rossin- Slater, forthcoming.

although the point estimate for newborns of Parity 3 or higher is insignificant at conventional levels. In contrast, the point estimates for girls are either close to zero or positive, although all of them are insignificant.

In summary, the unexpected crisis reduced the fraction of newborn girls of Parity 3 or higher, and this impact was larger among newborns whose mothers were at an earlier stage of pregnancy at the onset of the crisis. Regarding birth weight and the incidence of low birth weight, we find improvement among a subset of boys, but not among girls. These results suggest that the crisis had a more negative impact on girls in terms of natality (the only exception being for Parity 2 for the period between January and April, where the biological mechanism prevails) and birth outcomes. These patterns are heterogeneous by socioeconomic status, findings that we will discuss in the next subsection.

A.3 Subgroup Analysis by Maternal Education

We find no systematic impact on average birthweight for first-born children across all maternal education groups (Table O.9, column 2). Results on average birthweight are less homogeneous across education groups when considering other parities. Average birthweight increases for boys born to college educated or high school graduate mothers (Table O.9, column 3, Panel A and B), and this positive impact is larger in the first period (January to April) than in the second period (May to August). Average birthweight of second-born children of mothers without a high school degree is not affected. Specifically, for second-born children of college graduate mothers, a one percentage point increase in the unexpected unemployment rates raises average birth weight of boys by 18.3 grams for the first period and 12.1 grams for the second period; the difference in these two estimates is not statistically significant at conventional levels. Meanwhile, there is little change for girls (only a 7-gram decrease: 18.23-20.3, Table O.9, Panel A, column 3). These findings suggest that gender-biased behavior of college educated mothers may not be large enough to alter sex ratio at birth but is sufficient to widen the gender gap in average birth weight.

Looking at second-born children of a high-school graduate mother (Panel B, column (3) of Table O.9), we find a similar pattern but a larger increase in average birth weight of boys during the first period. That is, a one percentage point unexpected increase in unemployment rates raises boys' average birth

weight by 23.8 grams during the first period and 13.6 grams during the second period; the difference between these two estimates is statistically significant at the 1 percent level. Because for second-born children we find that there is an increase in the fraction of newborn girls in the period between January and April 1998, the increase in average birthweight during this period can be explained by the *culling* mechanism, a mechanism that predicts an increase in the fraction of newborn girls and an improvement in health at birth, especially for boys (see Section 3.2).

Looking at the results for Parity 3, we find a negative impact of the crisis on girls' average birth weight for the least educated mothers in our sample (Panel C, column 4, of Table O.9). A one percentage point unexpected increase in unemployment rates reduces girls' average birth weight by 107 grams (-96.777-10.525) in the first period and by 16.9 grams in the second period; these two estimates are statistically different at the 1 percent level. Not only do we find evidence of sex-selective abortion for these children; we also find that the girls who survived weigh less than boys. In contrast, among children born to college graduate mothers or high school graduate mothers, we find that the crisis did not reduce the birth weight of girls of Parity 3 or higher.

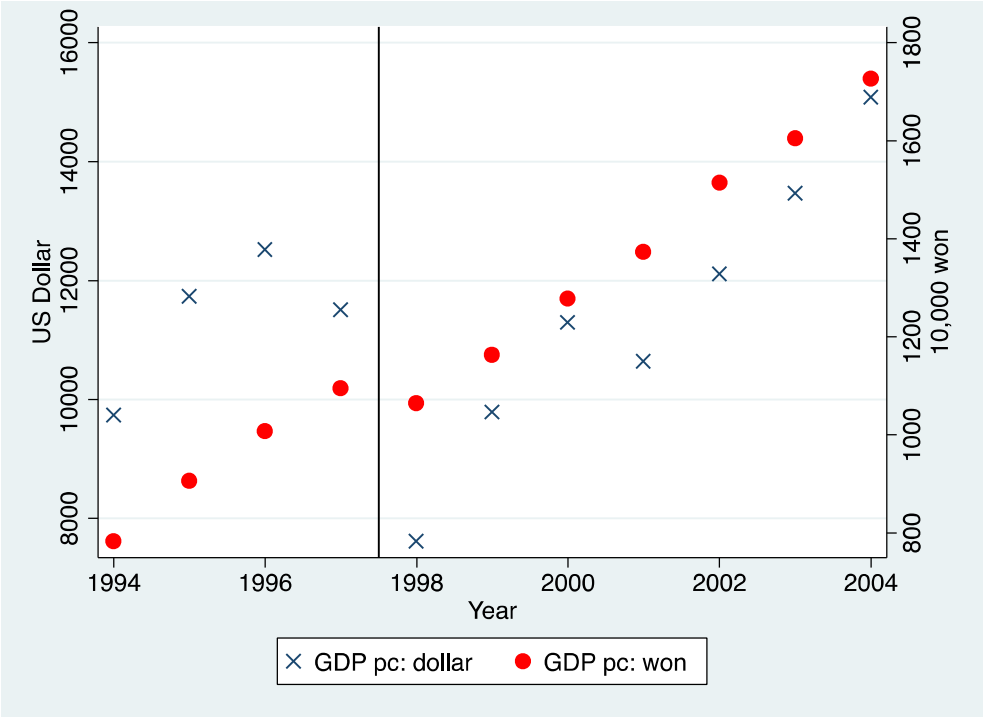
Table O.10 reports the results on the impact of the crisis on the fraction of children born with low birth weight. Children born to high school graduate mothers (Panel B) are the most responsive to the crisis. Between January and April 1998, a one percentage point increase in the variable Intensity Crisis decreases the likelihood of being born with low birth weight by approximately 0.8 percentage points for boys, but it has an opposite and smaller impact on girls (-0.008 + 0.012). This pattern holds across all parities, although we lose significance at Parity 3 or higher. The positive impact on boys becomes much smaller in the second sub-period (-0.008 vs -0.002). Finally, it is worth noting that for children born to mothers without a high school degree, we find an increase in the fraction of first-born children born with low birth weight only in the period between January and April.

B. Additional Figures

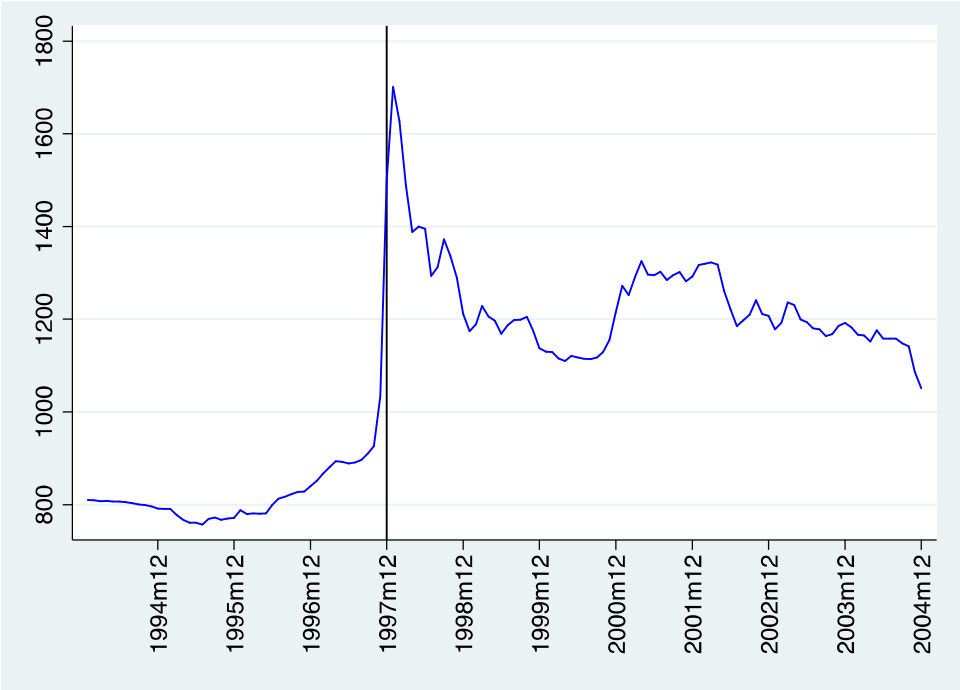
Figure B.1 Grassroots Movement to Repay Foreign Debts

Note: The photos above show people lined up to donate their gold jewelry so that South Korea could export it and repay the foreign debts that triggered the 1997 crisis.

Figure B.2 1997 Financial Crisis

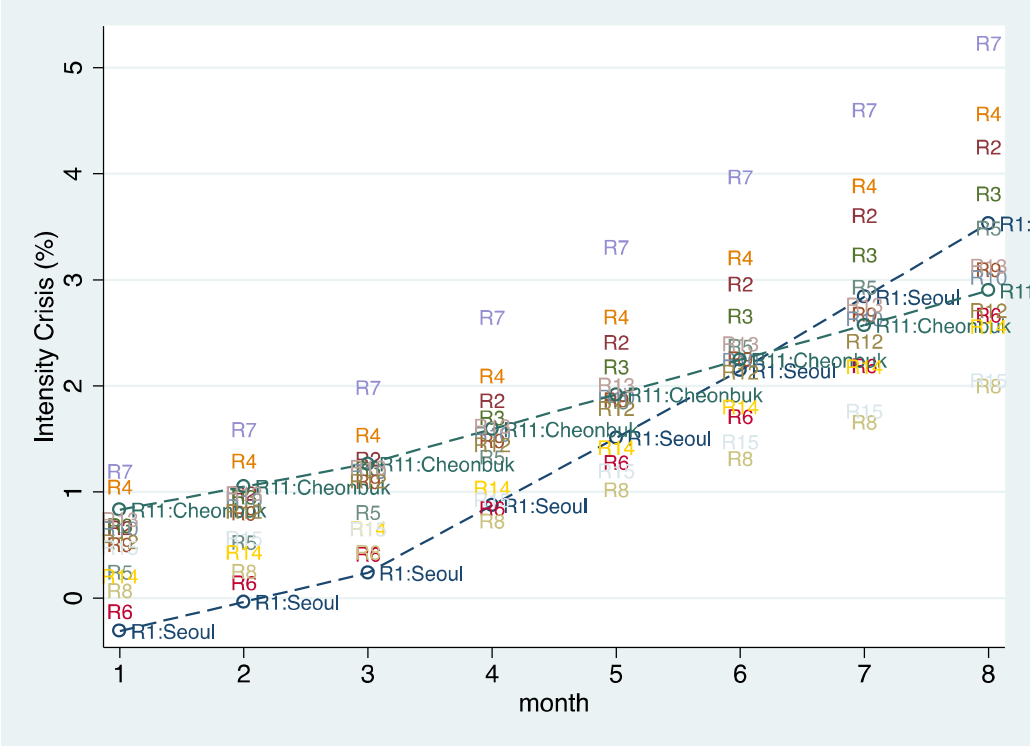


Panel A: GDP per capita



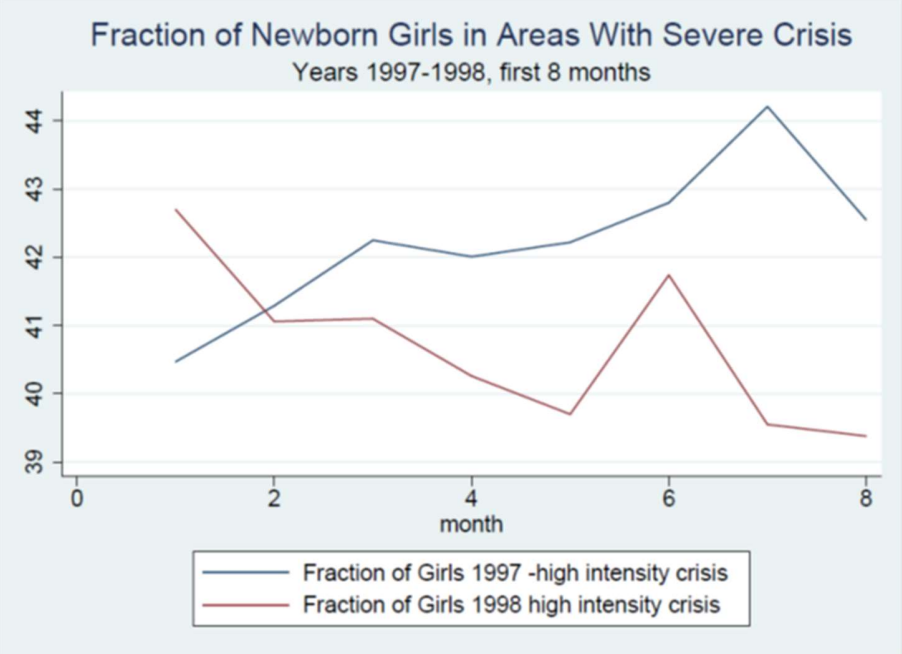
Panel B: Exchange Rate (Korean won per 1 US dollar)

Figure B.3 Variations in Intensity of The Crisis

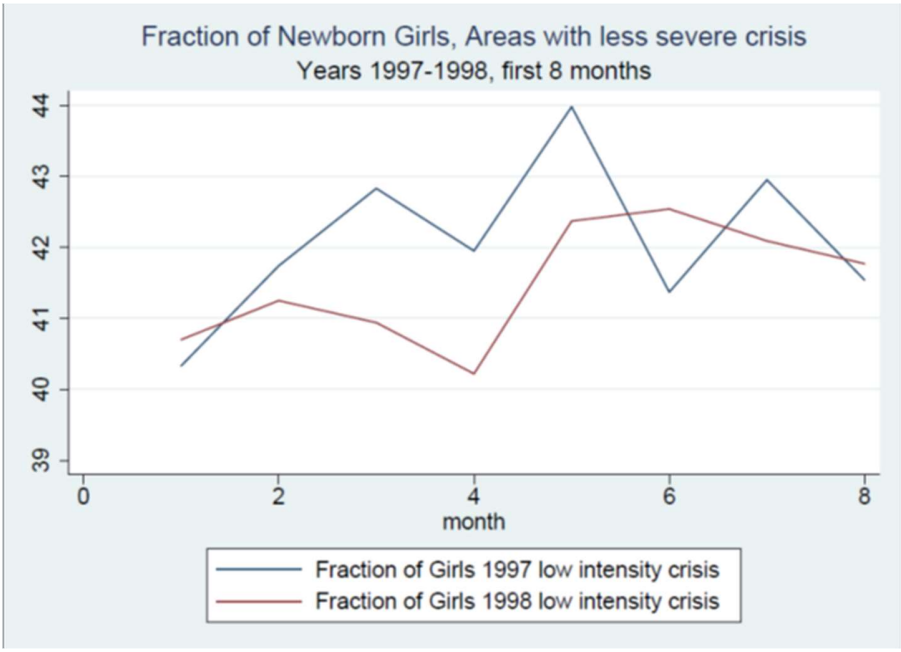


Note: This figure plots the intensity of the crisis of the 15 different regions in South Korea from January to August 1998. For a given month, the intensity of the crisis in a region is displayed as one of "R1" to "R15." R1 refers to Seoul metropolitan area; R2 to Pusan metropolitan area; R3 to Daegu metropolitan area; R4 to Incheon metropolitan area; R5 to Gwangju metropolitan area; R6 to Daejeon metropolitan area; R7 to Gyeonggi province; R8 to Gangwon province; R9 to Chungbuk province; R10 to Chungnam province; R11 to Cheonbuk province; R12 to Cheonnam province; R13 to Gyeongbuk province; R14 to Gyeongnam province; and R15 to Jeju province. The two dashed lines show the evolution of the intensity of the crisis for Seoul (R1) and Cheonbuk (R11).

Figure B.4 Fraction of Newborn Girls



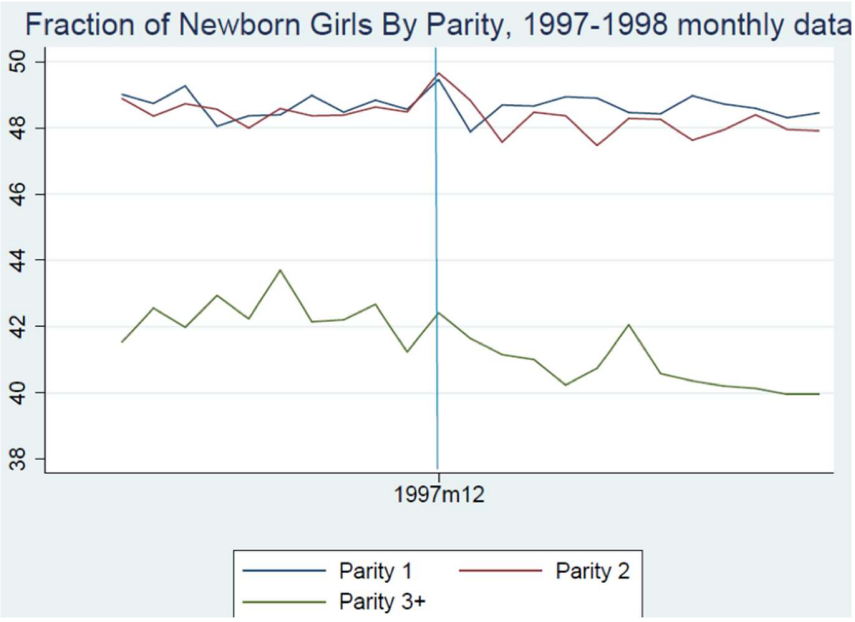
Panel A: Regions with Severe Crisis



Panel B: Regions with Less Severe Crisis

Note: The areas that are relatively more affected by the crisis in 1998 have been identified by dividing regions in 2 groups for each of the sub-periods January-April and May-August: one group of regions with the variable IntensityUR above the median value for that sub-period and the other below the median. The subdivision of periods and regions so calculated for 1998 has been kept the same also in 1997

Figure B.4 Fraction of Newborn Girls (cont'd)



Panel C: Overall Trend

Note: The above figure displays the fraction of newborn girls by parity for each month from January 1997 to December 1998.

C. Additional Tables

Table O.1 Chronology of Korea's Financial Crisis

	Date	Note
1997	Nov. 21	Korea requested the IMF bailout loans
	Dec. 3	Korea and the IMF reached an agreement on a financial aid package totaling $58.35 billion that included loans worth $21 billion from the IMF ($7.5 billion Supplemental Reserve Facility [SRF], and $13.5 billion stand-by loan), $10 billion from the World Bank, $4 billion from the Asian Development Bank (ADB), and $23.35 billion from the Group of Seven (G-7) and other countries.
	Dec. 18	Presidential election: Kim Dae-Jung elected
	Dec. 21	Moody's downgraded Korea's long-term sovereign bond from "investment grade" to "non-investment grade"
	Dec. 22	"Emergency Economic Committee" launched
	Dec. 23	S&P downgraded the Korea's long-term sovereign bond from "investment grade" to "non-investment grade"
	Dec. 23	The World Bank approved $3 billion emergency loan
	Dec. 24	Korea won an early payment of $10 billion in loans from the IMF and G-7 to forestall a default on its short-term loan debts. In return, South Korea agreed to expedite financial reforms and open its domestic financial markets
	Dec. 25	The IMF and lender nations moved to finance $10 billion in loans to South Korea
	Dec. 30	The IMF $2 billion early input
	Dec. 29	Congress passed the package of 13 financial reform bills
1998	Feb. 14	Congress passed 10 economics bills on corporate and labor reforms
	Feb. 18	Kim Dae-Jung inaugurated as 15th president
	Mar. 27	Korea received $2 billion from the IBRD
	Apr. 3	Korea issued $4 billion government dollar-based bond
	Jun. 18,29	Korea announced the list of 55 firms for market-exits and restructuring plans for the financial sector
	Dec. 18,30	Korea repaid $2.8 billion SRF loans from the IMF in advance
1999	Jan. 25	S&P upgraded Korea's long-term sovereign bond from non-investment grade to investment grade.
	Feb. 12	Moody's upgraded Korea's long-term sovereign bond from non-investment grade to investment grade.
	Sep. 18	Korea made advance repayment of all SRF loans from the IMF
	Dec. 24	Korea stopped using new stand-by loans from the IMF
2000	Aug. 23	Korea and the IMF announce completion of policy consultation as a part of stand-by arrangement that expires on December 3, 2000.
	Sep. 20	Korea announces plans for the early repayment of stand-by loans
2001	Aug. 23	Korea repaid all outstanding credit from the IMF

Note: See Chopra et al. (2002), Choi (1999), and http://www.imf.org/

Table O.2 Controlling for Parental Characteristics

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. 1 if a newborn=girl				
IntensityCrisis	-0.003	-0.003	0.002	-0.026***
	(0.003)	(0.004)	(0.004)	(0.009)
preUR	-0.074**	-0.079	-0.088*	0.004
	(0.034)	(0.049)	(0.051)	(0.056)
Panel B. Birth Weight				
IntensityCrisis	4.701	2.684	10.934**	-12.022
	(5.087)	(6.189)	(5.096)	(14.294)
IntensityCrisis x Girl	-4.526	-1.072	-7.833	-4.642
	(4.440)	(8.370)	(8.618)	(26.765)
preUR	-12.355	-51.125	17.679	59.287
	(53.044)	(45.571)	(78.308)	(110.989)
preUR x Girl	24.396	59.989	6.569	-77.087
	(56.926)	(60.726)	(96.706)	(177.080)
Girl	-184.367	-293.721	-131.272	114.860
	(179.992)	(191.632)	(305.105)	(564.097)
Panel C. 1 if low birth weight				
IntensityCrisis	-0.001	-0.002	-0.000	0.003
	(0.001)	(0.002)	(0.001)	(0.005)
IntensityCrisis x Girl	(0.028)	(0.052)	(0.046)	(0.100)
	0.003	0.005	0.002	0.000
preUR	-0.005	0.000	0.005	-0.050
	(0.012)	(0.023)	(0.032)	(0.067)
preUR x Girl	-0.019	-0.015	-0.054	0.068
	(0.028)	(0.052)	(0.046)	(0.100)
Girl	0.076	0.059	0.189	-0.184
	(0.088)	(0.166)	(0.146)	(0.313)

Note: We include region and month of birth fixed effects in Panel A and in Panels B and C, we include region and month of birth fixed effects, interacted with the female dummy. Standard errors are in parentheses and are clustered at the regional level. * significant at 10%; ** significant at 5%; *** significant at 1%. Please refer to Appendix 2 for the calculation of the variables IntensityCrisis and preUR.

Table O.3 College Graduate Mothers

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. 1 if a newborn=girl				
IntensityCrisis	-0.002	0.006	-0.009	-0.032**
	(0.005)	(0.010)	(0.008)	(0.013)
preUR	-0.057	-0.107*	0.008	0.008
	(0.051)	(0.060)	(0.068)	(0.090)
Panel B. Birth Weight				
IntensityCrisis	3.973	1.397	11.469	-19.806
	(4.471)	(5.917)	(8.976)	(20.791)
IntensityCrisis x Girl	-13.812*	-9.839	-13.605	-51.828
	(7.953)	(11.015)	(12.779)	(34.956)
preUR	-2.449	-99.025	160.431*	-123.102
	(73.743)	(63.290)	(89.428)	(447.790)
preUR x Girl	-16.622	42.567	-111.654	18.735
	(89.630)	(73.430)	(108.022)	(712.048)
Girl	-50.345	-223.994	236.928	-200.499
	(286.108)	(233.178)	(340.851)	(2,270.35)
Panel C. 1 if low birth weight				
IntensityCrisis	0.001	0.002	-0.001	-0.006
	(0.001)	(0.004)	(0.004)	(0.012)
IntensityCrisis x Girl	0.007	0.008	0.002	0.024
	(0.005)	(0.007)	(0.006)	(0.016)
preUR	-0.040	-0.031	-0.094***	0.151
	(0.032)	(0.041)	(0.034)	(0.149)
preUR x Girl	-0.018	0.018	-0.018	-0.338
	(0.059)	(0.070)	(0.076)	(0.284)
Girl	0.069	-0.054	0.077	1.106
	(0.188)	(0.224)	(0.239)	(0.901)

Note: See Note in Table O.2

Table O.4 High School Graduate Mothers

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. 1 if a newborn=girl				
IntensityCrisis	-0.002	-0.007	0.007	-0.020
	(0.004)	(0.005)	(0.006)	(0.012)
preUR	-0.063**	-0.043	-0.124**	0.095
	(0.032)	(0.061)	(0.054)	(0.085)
Panel B. Birth Weight				
IntensityCrisis	3.329	1.290	11.518*	-19.531
	(6.780)	(7.618)	(6.892)	(24.745)
IntensityCrisis x Girl	1.657	5.833	-6.600	17.021
	(7.504)	(9.814)	(11.260)	(36.753)
preUR	-23.770	-18.486	-48.715	99.138
	(54.329)	(55.328)	(79.778)	(94.270)
preUR x Girl	52.762	64.347	98.591	-235.822*
	(54.340)	(67.789)	(100.118)	(125.421)
Girl	-280.738	-316.191	-428.417	641.720
	(170.738)	(213.116)	(317.631)	(399.254)
Panel C. 1 if low birth weight				
IntensityCrisis	-0.001	-0.004*	-0.000	0.008
	(0.003)	(0.002)	(0.003)	(0.010)
IntensityCrisis x Girl	0.002	0.004	0.003	-0.011
	(0.004)	(0.004)	(0.004)	(0.024)
preUR	0.027	0.031	0.057	-0.097
	(0.027)	(0.030)	(0.041)	(0.067)
preUR x Girl	-0.040	-0.052	-0.095*	0.218**
	(0.028)	(0.050)	(0.050)	(0.087)
Girl	0.142	0.179	0.323**	-0.679**
	(0.088)	(0.158)	(0.160)	(0.274)

Note: See Note in Table O.2

Table O.5 Mothers without High School degree

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. 1 if a newborn=girl				
IntensityCrisis	-0.014	-0.014	0.007	-0.048**
	(0.011)	(0.012)	(0.013)	(0.024)
preUR	-0.322***	-0.273	-0.306	-0.413**
	(0.107)	(0.188)	(0.187)	(0.169)
Panel B. Birth Weight				
IntensityCrisis	19.454	21.494	-2.707	30.646
	(23.030)	(25.854)	(31.421)	(36.857)
IntensityCrisis x Girl	-21.591	-31.157	0.902	-31.841
	(33.668)	(44.736)	(43.498)	(30.557)
preUR	36.404	-74.180	17.438	191.055
	(132.135)	(234.177)	(276.768)	(344.656)
preUR x Girl	-70.162	197.035	-482.985	387.905
	(236.762)	(415.933)	(374.528)	(489.356)
Girl	125.374	-735.480	1,452.337	-1,341.469
	(749.663)	(1,321.834)	(1,182.523)	(1,574.477)
Panel C. 1 if low birth weight				
IntensityCrisis	-0.003	-0.002	-0.002	-0.002
	(0.008)	(0.010)	(0.013)	(0.013)
IntensityCrisis x Girl	0.005	0.003	0.004	0.005
	(0.011)	(0.014)	(0.012)	(0.024)
preUR	-0.152**	-0.159	-0.053	-0.225
	(0.072)	(0.159)	(0.133)	(0.153)
preUR x Girl	0.219**	0.224	0.246	0.085
	(0.101)	(0.229)	(0.165)	(0.183)
Girl	-0.679**	-0.697	-0.776	-0.226
	(0.325)	(0.735)	(0.524)	(0.574)

Note: See Note in Table O.2

Table O.6 Alternative Definition of Economic Conditions

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. 1 if a newborn=girl				
IntensityCrisis	-0.003	-0.004	0.001	-0.025***
	(0.003)	(0.004)	(0.004)	(0.008)
preUR	-0.056*	-0.079*	-0.056	0.052
	(0.033)	(0.045)	(0.044)	(0.070)
Panel B. Birth Weight				
IntensityCrisis	4.725	1.798	11.023**	-11.052
	(4.918)	(6.051)	(5.061)	(13.189)
IntensityCrisis x Girl	-4.724	-0.444	-8.666	-5.524
	(4.261)	(8.600)	(8.706)	(26.254)
preUR	7.147	-31.356	18.160	147.822
	(55.926)	(52.275)	(74.929)	(124.615)
preUR x Girl	-17.923	34.246	-50.853	-127.560
	(56.244)	(61.124)	(91.988)	(225.023)
Girl	-55.684	-199.195	34.302	247.869
	(158.771)	(174.351)	(262.379)	(642.645)
Panel C. 1 if low birth weight				
IntensityCrisis	-0.000	-0.002	0.000	0.003
	(0.001)	(0.002)	(0.001)	(0.005)
IntensityCrisis x Girl	0.003	0.005	0.002	0.001
	(0.003)	(0.004)	(0.004)	(0.015)
preUR	0.002	-0.011	0.033	-0.051
	(0.014)	(0.023)	(0.031)	(0.071)
preUR x Girl	-0.003	0.002	-0.042	0.102
	(0.031)	(0.048)	(0.044)	(0.116)
Girl	0.023	0.002	0.140	-0.266
	(0.088)	(0.137)	(0.128)	(0.327)

Note: We include region and month of birth fixed effects in Panel A, and in Panels B and C, we include region and month of birth fixed effects, interacted with the female dummy. Standard errors are in parentheses and are clustered at the regional level. * significant at 10%; ** significant at 5%; *** significant at 1%. Refer to Appendix 2 for the calculation of the variables IntensityCrisis and preUR.

Table O.7 Average Birth Weight, Sub-period Analysis

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
No of obs.	414,279	197,464	176,133	40,682
IntensityCrisis				
x Jan.-April	8.613*	-1.054	20.287***	2.420
	(5.147)	(7.162)	(4.427)	(16.494)
x May-Aug.	5.210	1.847	12.288***	-10.038
	(4.437)	(6.479)	(3.778)	(12.447)
x Jan-April x Girl	-3.930	9.906	-15.371*	-24.142
	(5.410)	(10.261)	(8.580)	(34.359)
x May-Aug. x Girl	-4.458	0.332	-9.078	-7.519
	(4.586)	(8.880)	(8.204)	(24.489)
preUR	-17.092	-49.230	8.809	31.973
	(51.080)	(45.079)	(73.666)	(107.586)
preUR x Girl	26.387	55.067	14.978	-52.010
	(56.568)	(55.358)	(97.617)	(179.873)
Girl	-192.282	-277.189	-160.989	48.710
	(179.312)	(173.945)	(309.466)	(573.805)
Mean dep. var: Jan.-April	3,280	3,268	3,282	3,323
May-Aug.	3,260	3,253	3,258	3,303
R-sq	0.982	0.982	0.982	0.978

Note: The outcome variable is the birth weight of newborns (measured by grams). We include region and month of birth fixed effects, interacted with the female dummy. Standard errors are in parentheses and are clustered at the regional level. * significant at 10%; ** significant at 5%; *** significant at 1%. Refer to Appendix 1. for the calculation of the variables IntensityCrisis and preUR.

Table O.8 Fraction of Babies Born With Low Birth Weight, Sub-period Analysis

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
No of obs.	414,279	197,464	176,133	40,682
IntensityCrisis				
x Jan.-April	-0.004***	-0.004**	-0.003*	-0.004
	(0.001)	(0.002)	(0.002)	(0.006)
x May-Aug.	-0.001	-0.002	-0.001	0.002
	(0.001)	(0.002)	(0.002)	(0.004)
x Jan.-April x Girl	0.005*	0.003	0.006	0.013
	(0.003)	(0.005)	(0.004)	(0.019)
x May-Aug. x Girl	0.003	0.005	0.003	0.002
	(0.002)	(0.004)	(0.003)	(0.014)
preUR	-0.001	0.003	0.009	-0.036
	(0.010)	(0.025)	(0.029)	(0.065)
preUR x Girl	-0.022	-0.015	-0.058	0.051
	(0.029)	(0.049)	(0.046)	(0.104)
Girl	0.084	0.056	0.203	-0.138
	(0.093)	(0.157)	(0.145)	(0.328)
Mean dep. var: Jan-April	0.047	0.045	0.045	0.061
May-Aug.	0.051	0.048	0.052	0.062
R-sq	0.050	0.048	0.050	0.065

Note: The outcome variable is the indicator of whether a newborn weighs less than 2,500 grams (i.e., low birth weight). See note in Table 4 in the main text for additional controls.

Table O.9 Subgroup Analysis: Average Birth Weight

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. Mom: College grad				
IntensityCrisis				
x Jan.-April	2.884	-8.494	18.239**	2.262
	(6.441)	(8.513)	(8.596)	(22.640)
x May-Aug.	3.903	0.972	12.070*	-17.540
	(4.840)	(7.046)	(7.297)	(19.183)
x Jan-April x Girl	-8.908	8.561	-25.253**	-59.038
	(8.850)	(13.372)	(11.099)	(41.512)
x May-Aug. x Girl	-13.476*	-9.050	-14.709	-52.648
	(8.165)	(11.418)	(11.892)	(34.640)
Panel B. Mom: HS grad				
IntensityCrisis				
x Jan.-April	11.931*	3.612	23.805***	3.426
	(6.489)	(9.665)	(5.981)	(22.316)
x May-Aug.	4.715	1.633	13.641**	-15.338
	(5.351)	(7.554)	(5.468)	(20.461)
x Jan-April x Girl	-1.840	9.664	-15.955	6.909
	(6.968)	(12.404)	(10.338)	(46.675)
x May-Aug. x Girl	1.091	6.394	-8.208	15.035
	(6.700)	(10.295)	(10.157)	(36.500)
Panel C. Mom: Less HS				
IntensityCrisis				
x Jan.-April	-1.429	-2.695	-14.147	-10.525
	(14.762)	(25.276)	(36.544)	(31.641)
x May-Aug.	16.377	17.863	-4.205	23.692
	(17.116)	(23.916)	(29.184)	(28.380)
x Jan-April x Girl	1.692	12.466	39.650	-96.777**
	(23.466)	(38.947)	(38.085)	(47.223)
x May-Aug. x Girl	-18.221	-25.016	5.494	-39.931
	(26.989)	(37.115)	(33.117)	(33.420)

Note: See note in Table 4 in the main text.

Table O.10 Subgroup Analysis: Fraction of Babies Born With Low Birth Weight

	All	Parity 1	Parity 2	Parity 3+
	(1)	(2)	(3)	(4)
Panel A. Mom: College grad				
IntensityCrisis				
x Jan.-April	0.002	0.001	0.003	-0.002
	(0.002)	(0.004)	(0.004)	(0.013)
x May-Aug.	0.001	0.002	-0.000	-0.005
	(0.002)	(0.004)	(0.004)	(0.012)
x Jan-April x Girl	0.001	0.002	-0.001	0.010
	(0.006)	(0.007)	(0.006)	(0.020)
x May-Aug. x Girl	0.006	0.008	0.002	0.023*
	(0.005)	(0.007)	(0.006)	(0.014)
Panel B. Mom: HS grad				
IntensityCrisis				
x Jan.-April	-0.008***	-0.010***	-0.008***	-0.007
	(0.002)	(0.004)	(0.002)	(0.009)
x May-Aug.	-0.002*	-0.005***	-0.002	0.005
	(0.001)	(0.002)	(0.002)	(0.007)
x Jan-April x Girl	0.007***	0.005	0.012**	0.004
	(0.003)	(0.004)	(0.006)	(0.030)
x May-Aug. x Girl	0.002	0.004	0.004	-0.008
	(0.003)	(0.004)	(0.004)	(0.022)
Panel C. Mom: Less HS				
IntensityCrisis				
x Jan.-April	0.007	0.031*	-0.004	0.004
	(0.008)	(0.018)	(0.015)	(0.014)
x May-Aug.	-0.001	0.003	-0.002	-0.001
	(0.007)	(0.011)	(0.013)	(0.011)
x Jan-April x Girl	0.011	-0.014	0.004	0.051
	(0.014)	(0.026)	(0.013)	(0.033)
x May-Aug. x Girl	0.006	0.000	0.004	0.011
	(0.011)	(0.016)	(0.012)	(0.022)

Note: See Note in Table 4 in the main text.

Additional References

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