Risk Aversion and Son Preference: Experimental Evidence from Chinese Twin Parents*

Soo Hong Chew[1] Junjian Yi[1] Junsen Zhang[2] Songfa Zhong[1]

March 2015

* This research project was supported by grants from the Research Grants Council of Hong Kong (Project No. CUHK4358/01H) and from the Hong Kong University of Science and Technology (Project No. AOE-MG/H-03/06).
[1] Department of Economics, National University of Singapore
[2] Department of Economics, Chinese University of Hong Kong

Risk Aversion and Son Preference:

Experimental Evidence from Chinese Twin Parents

Abstract

Sons are better insurance than daughters for parents in patriarchal societies. We first use a source-dependence expected utility model to investigate the relationship between son preference and risk attitude. The model shows that more risk-averse parents have a stronger preference for sons than for daughters prior to the birth of their children and that parents exhibit greater risk taking after giving birth to a son than to a daughter. We then conduct an incentivized choice experiment to assess parental risk attitude in a sample of Chinese twin parents to identify these two effects. The twins tend to have greater similarity in risk attitude before the birth of their child because of shared genetic and environmental factors. Therefore, a within-twin-pair fixed-effects (FE) estimate delivers a lower bound on the effect of the presence of sons on parental risk attitude. We find that having sons significantly decreases parental risk aversion. We compare FE and the ordinary least squares estimates and find that parents with greater risk aversion before the birth of their children are more likely to have sons through sex-selection behavior than parents with lesser risk aversion. The results contribute to the understanding the persistent gender imbalance in China and other Asian countries.

JEL classification: C93, D01, D80, J13

Keywords: risk aversion, son preference, twins, experimental economics

1. Introduction

Son preference has been rooted in human history for millennia. Son preference continues to prevail in most modern societies, especially in Asia, despite modernization and rapid economic growth.[1] With the increasing availability of modern gender selection technologies, the deeply rooted son preference has continued to cause gender imbalance with serious social and economic implications (Das Gupta, 2005; Ebenstein, 2010, 2011; Li, Yi, and Zhang, 2011; Wei and Zhang, 2011).[2] Unsurprisingly, son preference has been a subject of extensive studies by researchers and policy makers worldwide, particularly in developing countries (see Das Gupta, Ebenstein, and Sharygin, 2013, for a review).

The causes of son preference have been investigated from various perspectives. Two approaches have been proposed to model son preference in the economic literature (Leung, 1991; Davis and Zhang, 1995). One approach extends utility function by enabling parents to directly derive a higher utility from having sons than daughters. This approach is also used to capture the influence of factors related to religion and culture, for example, the Confucian saying, "Of three forms of unfilial conduct, having no descendants (sons) is the worst." Only sons can play a role in ancestor worship and continue the family line as patriarchs. Another approach modifies the budget constraint instead of the utility function. This approach accounts for the observation that economic returns are higher when rearing sons than daughters in traditional agrarian economies (Rosenzweig and Schultz, 1982). For example, Das Gapta et al. (2003) suggest that the support to old parents from adult sons contributes to the persistence in son preference in China, India, and Korea, even in urban areas. The son preference induced by the first factor is called "pure" son preference in some cases. Our paper uses the term "son preference" interchangeably with the demand for male children and does not distinguish the different forms of son preference.

---

[1] Almond and Edlund (2008) and Almond, Edlund, and Milligan (2013) find that sex ratio is biased toward males even among second-generation Asian migrants to Canada.

[2] The gender imbalance toward males has been regarded as a manifestation of the severe gender discrimination against females (Sen, 1992). Das Gupta, Ebenstein, and Sharygin (2012) report that the male biased sex ratio has posited serious challenges to the old-age pension system in China.

Children serve as a source of insurance for old age in traditional societies in which environmental and social risks are pervasive (Chu, Xie, Yu, 2011). For example, Cain (1981) shows a positive relationship between environmental risk and fertility in rural populations in India and Bangladesh. Sons are expected to shoulder more of the responsibility of caring for their parents aside from having higher agricultural productivity than daughters. This notion has given rise to the Chinese proverb of "raising sons to insure against old age." However, no formal economic modeling and rigorous empirical analysis have been presented in the literature on the sense of security in the presence of risk to the demand for sons.

We apply the source preference approach in decision theory (Fox and Tversky, 1995; Chew and Sagi, 2008; Abdellaoui, Baillon, Placido, and Wakker, 2010) and derive a simple utility-based model to link risk aversion and son preference. First, parents who are "endowed" with greater risk aversion may have a stronger need for security when risk is presented,[3] and a higher need for security leads to a greater revealed preference for sons by engaging more in gender selection. Second, parents with sons, *ceteris paribus*, feel more secure and consequently are less risk averse.

Subsequently, we empirically test the theoretical predictions of our utility-based model. The endowed risk attitude, which is unobservable, and the demand for sons are potentially correlated. Therefore, the ordinary least squares (OLS) estimate is generally biased in estimating the effect of having sons or the gender composition of children on parental risk attitude. We develop a novel identification strategy to address this omitted-variable bias. Specifically, we use a twin dataset with both the gender composition of children and the experimentally assessed risk attitude in conjunction with a within-twin-pair fixed-effects (FE) estimator.[4] When the endowed risk attitude is assumed to be more similar between twin siblings, the FE estimates provide a lower

[3] The "endowed" risk attitude may include the real genetic endowment of risk attitude and all the other factors affecting parental risk attitude before the births of children.

[4] A number of recent studies show that experimentally elicited risk preference predicts real-life economic outcomes and provide supports for the external validity of experimentally elicited risk preference (e.g., Sutter, Kocher, Rützler, and Trautmann, 2013; Noussair, Trautmann, and van de Kuilen, 2014; Dimmock, Kouwenberg, and Wakker, 2015; Baillon, Bleichrodt, Huang and Potter van Loon, 2005).

bound on the effect of the presence of sons on parental risk attitude. Furthermore, the sign of the behavioral effect of endowed risk aversion on the demand for sons can be identified by comparing the FE and OLS estimates. As a result, our twin-based design can be used to empirically analyze not only the effect of endowed risk attitude on parental demand for sons but also the effect of the gender composition of children on parental risk attitude.

The empirical results are consistent with our theoretical predictions. The within-twin-pair FE estimates indicate that the presence of sons significantly decreases the revealed risk aversion of parents. These findings are robust when we control for parental educational attainment and family income. Moreover, we compare the FE and OLS estimates and find that parents with more endowed risk aversion are more likely to have sons than those with less endowed risk aversion. We further discuss the robustness of our findings in various scenarios.

Our research contributes to the literature of family economics. Davies and Zhang (1995) seem to be the first to distinguish modeling son preference in budget constraint and utility function. They also discuss the empirical content when son preference is embodied either in utility function or budget constraint. Our paper may be the first to analyze son presence in the presence of risk with a utility-based model. We explore son preference and parental risk attitude theoretically and offer experimental and empirical basis for testing the implications of the model. The results help us to understand the persistent gender imbalance in China and other Asian countries.

Development economics is another research area on which our paper can shed light. Credit markets in developing countries are generally far from perfect (Rosenzweig, 1988a, 1988b, 1993; Townsend, 1994). Therefore, families in these countries usually rely on their (extended) family for risk pooling. For instance, Rosenzweig (1988a) provides an example of the insurance incentive in arranging the marriage of a daughter. Ebenstein and Leung (2010) find that the old-age pension program in rural China mitigates the gender imbalance in areas where the program is more available. Our paper directly provides experimental evidence to establish the relation between the parental risk attitude and the demand for sons, in which the presence of sons can be regarded as insurance. This evidence also explains the persistence of son preference in Asian societies in which the availability of insurance and old-age pension systems remains low.

The rest of the paper is organized as follows. Section 2 proposes a simple model linking parental risk attitude and son preference and discusses the econometric identification strategy. Section 3 describes the data. Section 4 presents the estimation results. Section 5 concludes.

2. Theoretical Modeling and Empirical Identification

We begin with a simple model relating son preference to parental risk attitude, followed by an exposition of the identification strategy.

2.1. *Modeling Son Preference and Risk Attitude*

Consider a setting where the agent has initial wealth *w* and faces an investment decision between a sure and risky asset. For convenience, we assume that the sure asset has a zero rate of return and that the risky asset has a random return of *x* distributed through a cumulative distribution function *F(x)*. Let α be the dollar amount invested in the risky asset and $w - \alpha$ be the amount invested in the sure asset given budget constraint *w*. The expected utility of this situation is given by the following:

$$EU = \int u(w + \alpha x)\, dF(x). \tag{1}$$

Suppose *u* is increasing and twice differentiable. The decision maker engages in a positive level of investment, i. e., $\alpha > 0$, if and only if the risky asset has a positive expected return *x*.

Sons provide major support and security to their ageing parents in traditional patriarchal societies. When evaluating the situations in terms of the effect of their children, parents with sons have a stronger sense of security and are thus more risk seeking than those without sons. We apply a source-dependent expected utility model to capture this intuition (see Chew and Sagi, 2008; Abdellaoui et al., 2010). The model enables the agent to have distinct risk attitudes with different sources of risks. Specifically, the individual can have distinct utility functions, that is, u_S with sons and u_D with daughters. If the Arrow–Pratt measure for u_D is uniformly lower than that for u_S, the agent is more risk averse with daughter-related risks than with son-related risks.

Next, we consider how individual difference in the endowed risk attitude may affect son preference or the demand for sons. Each individual can have distinct utility functions for sons and daughters. Therefore, the risk aversion between two individuals cannot be compared in a straightforward manner. For simplicity, we assume that the attitude toward risks with sons is identical for each individual, whereas the attitude toward risks with daughters is diverse. Consequently, individuals who are more averse to risks with daughters tend to favor risks with sons more than those who are less averse to risks with daughters. Put differently, when the agent is differentially more averse to risk with daughters, he/she exhibits a stronger son preference and is more likely to have sons securing themselves by practicing gender selection.

2.2. *Empirical Identification*

The gender composition of children can be selective in China because it can be affected by unobservable factors, such as the heterogeneity in the endowed risk aversion across individuals.[5] These factors may simultaneously affect the choice of agents in eliciting risk aversion. Therefore, the OLS estimate suffers from omitted-variable bias and fails to identify the causal effect of the gender composition of children on the attitude of parents toward risk. We demonstrate that the twin design helps us perform the identification in this subsection to address this concern. At the same time, the direction of the behavioral effect of endowed risk attitude on the demand for sons can be inferred from the comparison between the OLS and FE estimates.

We specify the following linear structural equation in a stochastic form relating the risk attitude (y_{ji}) of the j^{th} ($j = 1, 2$) twin in pair i to the gender composition

[5] Sex ratio at birth is traditionally biased toward males in China. Prior to introducing ultrasound B machines in the 1980s in China, infanticide is one of the main methods to exercise gender selection. With the widespread of ultrasound B machines after the 1980s, gender selective abortion has become a common method for gender selection in China. See Sharping (2002) and Li, Yi, and Zhang (2011) for a detailed discussion on the causes and methods of gender selection in China.

of her children (S_{ji}):

$$y_{ji} = \alpha + \beta S_{ji} + X_{ji}\delta + \gamma\vartheta_{ji} + \varepsilon_{ji} \,. \tag{2}$$

Conceptually, the risk attitude of the subject is affected by the gender composition of her children (S), her characteristics (X), and endowed risk aversion (ϑ). X is an assumed observable vector, such as family income and parental education. The endowed risk attitude (ϑ) includes the genetic endowment of risk attitude and all other factors affecting parental risk attitude before the birth of children. The subject knows her own ϑ when making decisions in a risk environment, but ϑ is unobservable to the researchers. ε is a disturbance term that includes the measurement errors of the risk attitude of subjects. We assume that ε is $i.i.d$.

Empirically, we conduct an incentivized choice experiment to assess the degree of the risk aversion of the subject (y_{ji}), where a higher value of y_{ji} means more risk aversion. We further construct three variables to measure the gender composition of children: (i) a dummy indicating whether at least a son exists, (ii) a dummy indicating whether the first child is a son, and (iii) the ratio of the number of sons to that of children.

$\beta = \partial y / \partial S$ in Equation (2) measures the causal effect of the gender composition of the children on parental risk aversion. Conditional on the endowed risk aversion of ϑ, although not directly observable, we assume that the gender composition of children is orthogonal to the error terms in Equation (2). Our theoretical model indicates that sons provide old-age support and security to their parents in countries where son preference is prevalent. Therefore, β is expected to be negative. However, the estimation of the above equations is unidentifiable because of the non-observability of ϑ and the behavioral relationship between the endowed risk aversion and the demand for sons specified as follows:

$$S_{ji} = \phi + \xi\vartheta_{ji} + Z_{ji}\varphi + \nu_{ji} \,, \tag{3}$$

where Z is a vector of variables affecting the parental gender selection behavior. Based on our theoretical model, Equation (3) states that the gender composition of children is a choice variable affected by the endowed risk aversion and other covariates. $\xi = \partial S / \partial \vartheta$ in Equation (3) measures the casual effect of the endowed risk aversion on the demand for sons. Our theoretical model predicts that ξ is positive.

If the endowed risk aversion of ϑ is observable, Equations (2) and (3) then form a recursive structure, and both β and ξ can be easily identified. However, the endowed risk aversion is usually unobservable. Therefore, the OLS estimate of β in Equation (2) is generally biased if the individual heterogeneity of ϑ is ignored by regressing equations, such as the following:

$$y_{ji} = \alpha^{OLS} + \beta^{OLS} S_{ji} + X_{ji}\delta^{OLS} + \varepsilon_{ji}^{OLS} \tag{4}$$

and[6]

$$\begin{aligned} p\lim \hat{\beta}^{OLS} &= \beta + \gamma \xi^{-1} \\ &= \beta + \gamma \frac{\sigma_{\vartheta s}}{\sigma_S{}^2}. \end{aligned} \tag{5}$$

Therefore, $\hat{\beta}^{OLS}$ is a biased estimate of β.

The instrumental variable (IV) estimator is generally applied to identify β in Equation (2). Hypothetically, if a variable, which is included in Z (Equation (3)) but excluded from X (Equation (2)), is found, it can be used as an IV to identify β. The IV should be correlated with parental demand for sons but uncorrelated with the risk attitude of parents. Empirically, this IV is difficult, if not impossible, to find.

Our twin-based data in which parents are twins can help us perform the identification. Therefore, we first take the within-twin-pair difference of Equation (2):

$$\Delta y_{ji} = \beta^{FE} \Delta S_{ji} + \Delta X_{ji}\delta^{FE} + \gamma^{FE} \Delta \vartheta_{ji} + \Delta \varepsilon_{ji}. \tag{6}$$

The within-twin-pair FE estimate is as follows:

$$p\lim \hat{\beta}^{FE} = \beta + \gamma \frac{\sigma_{\Delta\vartheta\Delta s}}{\sigma_{\Delta s}{}^2}. \tag{7}$$

---

[6] We ignore the covariates of X_{ji} below to simplify our discussion.

The literature on twin method usually assumes that both twin siblings share identical endowments ($\vartheta_1 = \vartheta_2$); in this case, $\sigma_{\Delta\vartheta\Delta s} = 0$. The within-twin-pair FE estimate is unbiased so that $p\lim \hat{\beta}^{FE} = \beta$.

However, the assumption that twin siblings share identical endowments is admittedly strong. Conceptually, ϑ in Equation (2) measures not only the genetic endowment of risk aversion but also the prenatal factors influencing parental risk attitude. The genetic endowments are not necessarily identical even between MZ twins. Furthermore, sibling-specific shocks to risk attitude, which may affect parental gender selection decision if they occur prior to the births of their children, may exist. Therefore, within-twin-pair FE estimation cannot completely eliminate bias resulting from unobservable heterogeneity in the endowed risk attitude.

This paper develops a weak assumption to tighten the lower bound of β and to identify the signs of both β and ξ.

Identification Assumption. The endogenous variation of the gender composition of children induced by the endowed risk aversion within twin pairs is smaller than that across twin pairs, that is, $|\sigma_{\Delta\vartheta\Delta s}|/\sigma_{\Delta s}^2 < |\sigma_{\vartheta s}|/\sigma_s^2$.

This identification assumption is unlikely to be violated. To see this, we check the magnitude of the four terms, namely, $\sigma_{\Delta\vartheta\Delta s}$, $\sigma_{\vartheta s}$, $\sigma_{\Delta s}^2$, and σ_s^2. The latter two terms, $\sigma_{\Delta s}^2$ and σ_s^2, are observable, whereas the other terms, $\sigma_{\Delta\vartheta\Delta s}$ and $\sigma_{\vartheta s}$, are unobservable. We first examine the two observable terms. Based on our estimation sample described below, σ_s^2 equals 0.49, 0.50, and 0.46 in terms of the three variables used to measure the gender composition of children, namely, having at least one son, the first child being a son, and the fraction of sons out of all children, respectively. By contrast, $\sigma_{\Delta s}^2$ equals 0.72, 0.81, and 0.73 in terms of the same three variables, respectively. Therefore, $\sigma_{\Delta s}{}^2 > \sigma_s{}^2$.

We then examine the two unobservable terms, namely, $\sigma_{\Delta\vartheta\Delta s}$ and $\sigma_{\vartheta s}$. We note that

$$\begin{aligned}\sigma_{\Delta\vartheta\Delta s} &= \sigma(\vartheta_1 - \vartheta_2, S_1 - S_2) \\ &= \sigma(\vartheta_1, S_1) + \sigma(\vartheta_2, S_2) - \sigma(\vartheta_1, S_2) - \sigma(\vartheta_2, S_1).\end{aligned}$$

If we assume that ϑ and S are drawn from same distributions for twin siblings, then $\sigma(\vartheta_1, S_1) = \sigma(\vartheta_2, S_2) = \sigma(\vartheta, S)$ and $\sigma(\vartheta_1, S_2) = \sigma(\vartheta_2, S_1)$. The endowed risk attitude is correlated with twin siblings because of the shared genetic endowments and family background. We use ρ to denote the correlation coefficient between ϑ_1 and ϑ_2. Therefore, $|\sigma_{\Delta\vartheta\Delta s}| < |\sigma_{\vartheta s}|$ if and only if $\rho > 0.5$. In the extreme case that $\rho = 1$, we have $\sigma_{\Delta\vartheta\Delta s} = 0$. $|\sigma_{\Delta\vartheta\Delta s}|$ is always less than $|\sigma_{\vartheta s}|$. The identification assumption is automatically satisfied. Furthermore, the within-twin-pair FE estimates are unbiased for fully identical twins.

We cannot directly observe the endowed risk attitudes of twin siblings, that is, ϑ_1 and ϑ_2. Zhong et al. (2009) show a similar risk attitude in twins. In particular, the latter reports that the correlation in risk attitude between identical Chinese twins is 0.57. Generally, the correlation in endowed risk attitudes should be higher than the correlation in the risk attitude measured in adulthood between identical twins because the latter contains accumulated shocks to the risk attitude of an individual over a lifecycle. Therefore, ρ should be larger than 0.5, and $|\sigma_{\Delta\vartheta\Delta s}| < |\sigma_{\vartheta s}|$.

In summary, with respect to the inequality $|\sigma_{\Delta\vartheta\Delta s}| / \sigma_{\Delta s}{}^2 < |\sigma_{\vartheta s}| / \sigma_s{}^2$ in the identification assumption, the denominator on the left-hand side is large, and the numerator on the left-hand side is small. The identification assumption, $|\sigma_{\Delta\vartheta\Delta s}| / \sigma_{\Delta s}{}^2 < |\sigma_{\vartheta s}| / \sigma_s{}^2$, is unlikely to be violated.

We derive the following proposition based on this identification assumption:

Proposition. Under the identification assumption, the FE estimate can tighten either the lower or the upper bound of β and identify the signs of both β and ξ. Specifically, when $\hat{\beta}^{OLS} > \hat{\beta}^{FE}$ and $\hat{\beta}^{FE} < 0$, we conclude that (1) $\beta < 0$, (2) $\xi > 0$, and (3) $\hat{\beta}^{FE}$ is a less biased estimate of β than $\hat{\beta}^{OLS}$ by providing a lower bound of the negative effect of the gender composition of children on parental risk aversion.[7]

The proof is presented in Appendix II. Therefore, we can identify the signs of the structural parameters of both β and ξ that give us causal interpretations.

3. Data Description

The datasets used in this study come from two sources. One source is based on the Chinese Adult Twins Survey (CATS) in 2002, and the other is derived from an incentivized experiment conducted on a subsample of the twins from CATS in 2008. This section describes the CATS, experiments, and summary statistics.

3.1. *The Chinese Adult Twins Survey*

The socioeconomic variables in our analysis are derived from CATS.[8] The survey was conducted by the Urban Survey Unit of the National Bureau of Statistics (NBS) in June 2002 and July 2002 in the urban areas of five cities in China, namely, Chengdu, Chongqin, Harbin, Hefei, and Wuhan. CATS is supported by the Research Grants Council of Hong Kong. It covers a wide range of demographic, social, and economic information and is based on existing twin questionnaires from the United States and other sources. The questionnaire was designed by one of the authors of this paper and Chinese experts at the NBS. Adult twins aged between 18 and 65 were identified by the local statistical bureaus. The questionnaires were completed through face-to-face personal interviews. One author closely monitored both the input and the process of

[7] Other cases can be analyzed in a similar way. The case analyzed in the proposition corresponds to the empirical results presented in our paper.
[8] Li, Rosenzweig, and Zhang (2010) use data from CATS and provide a detailed description of this data set.

conducting the survey so the survey was carefully conducted. CATS is the first socio-economic survey on twins in China and perhaps Asia. The summary statistics of the socioeconomic variables shown in Table 1 are discussed below.

3.2. *Experimental Elicitation of Risk Attitude*

The measure of risk aversion is derived from an incentivized experiment in 2008 on a subsample of twins from CATS. The experiments were financially supported by a grant from the Hong Kong University of Science and Technology. We conducted the experiments only in Hefei and Wuhan, the capital cities of Anhui and Hubei Provinces, respectively. Our sample was composed of 48 pairs (96 individuals) of monozygotic (identical) twins with children.

Chew et al. (2012) discuss the procedure and instructions of our experiment in detail. One approach in this literature is through a simple experimental elicitation known as the multiple price list design (Holt and Laury, 2002), in which subjects make an ordered array of binary choices. We used a simplified version of this procedure in the present study to assess the risk attitudes of the subjects, as we were concerned with the ease of understanding of the non-student subjects based on some pre-tests. Subjects chose an even-chance lottery of receiving ¥40 and receiving zero, or receiving a guaranteed ¥20.[9] The subjects were incentivized for their choice in this comparison.[10] As revealed by their decisions, the valuation of subjects of the gamble can be categorized as risk aversion if certainty is chosen and risk seeking if lottery is chosen. Appendix I shows the experimental instructions.

3.3. *Summary Statistics of Variables*

The summary statistics of the variables are reported in Table 1. As shown in the table, 43% of the subjects chose the certain amount of ¥20 over the gamble. The sex ratio of children is 52%, which is biased toward sons, although only 49% of the first-born

[9] The exchange rate in 2008 is US \$1≈ ¥6.8.

[10] In these two cities, the minimum wage per hour for a full-time employee is ¥6.5, and the average wage per hour is ¥9.5 (NBS, 2009). The expected gain from this simple game is ¥20, which is much higher than their alternative hourly wages. This finding suggests that the participants have a nonnegligible incentive to make decisions in the experiment.

children are boys. Moreover, 60% of the families have at least one son. After combining the three measures of the gender composition of children, we find that gender selection behavior tends to be focused on high birth parities. We use a relatively old adult twins sample with a mean age of 52. The children were born before the one-child policy; thus, the issue of using fertility drugs on the occurrence of the twins is not a concern. Most children of these adult twins were born before the one-child policy was implemented in 1979. Therefore, most of these adult twins have more than one child. Only one-third of our subjects are males. Their educational attainments are categorized into three levels, namely, middle school or below (omitted baseline group), high school, and technical school and college.[11] The mean annual family income in our sample is ¥19,800.

4. Estimation Results

This section reports and discusses our estimation results. We first present the basic results of the OLS and the FE estimates. We subsequently conduct a robustness analysis by including educational attainment and family income. Finally, we examine the possible biases in the FE estimates.

4.1. *Basic Results*

The dependent variable is the experimentally measured parental risk aversion subsequent to having children. The independent variable is the gender composition of their children for which we have three measures, namely, (1) having at least one son, (2) the first child being a son, and (3) the ratio of sons to all children. These measures give rise to three regression specifications.

Table 2 reports the OLS and the FE estimates of the effects of the gender composition of children on the parental risk aversion. We report bootstrapped standard errors throughout the paper, given the small size of our sample. Our regression results remain robust when we use a permutation method to correct for potential bias with

[11] As only four individuals finished technical school education, we categorize technical school and college into one group.

standard errors arising from the small sample (Heckman et al., 2010). Columns (1) to (3) of Table 2 present the OLS estimates. We find that the estimated coefficients of these three variables are consistently negative but statistically insignificant. The estimated coefficients of both age and age-squared variables are statistically significant, as shown in Columns (1) and (3). Age exhibits a U-shaped relationship, with risk aversion initially decreasing and then increasing with age. Males are more risk seeking than females, although the estimates are statistically insignificant in all three specifications.

Columns (4) to (6) of Table 2 are parallel to Columns (1) to (3) of the FE estimator. All three estimates of the effects of the gender composition of children are statistically significant at the 5% level despite the relatively small sample size, and they are consistent across the three columns. Furthermore, the R-squares in the last row indicate that the gender composition of children can explain a significant proportion of the variation in parental risk attitude. We compare the three estimates and find that having at least one son has the largest negative effect on parental risk aversion. The differences between the FE and the OLS estimates are statistically significant. For example, given the null hypothesis that the FE estimate equals the OLS estimate with respect to having at least one son, the Wald cross-equation test statistic is significant at the 10% level.

Guided by the proposition in Section 2, we can identify the signs of the structural parameters of both β and ξ by comparing the FE estimates (Columns (4) to (6)) with the OLS estimates (Columns (1) to (3)). Both the FE and OLS estimates are negative, but the FE estimates are more negative. Therefore, we first conclude that β is negative; that is, having sons significantly decreases the degree of parental risk aversion. Second, we conclude that ξ is positive; that is, the endowed risk aversion increases the demand for sons. These two findings are consistent with our theoretical predictions. Finally, the FE estimates are less biased than the OLS estimates by providing a lower bound of the negative effect of the gender composition of children on parental risk aversion.

4.2. *Robustness Check*

4.2.1. *Omitted Variables*

The results reported in Table 2 may be driven by omitted variables because we do not control for the other variables in Columns (4) to (6) in this table. We include additional control variables measuring educational attainment and family income to check for the robustness of our estimation results with respect to omitted variables. Table 3 reports the estimation results. Columns (1) to (3) control for only educational level, and Columns (4) to (6) control for both educational level and family income. The results indicate that the presence of sons significantly decreases the degree of parental risk aversion conditional on educational attainments and family income. Comparing with the estimates in Columns (4)–(6) in Table 2, the magnitudes of the estimates reported in Table 3 experience marginal changes. This finding reveals that the effect of the gender composition of children on parental risk attitude is not mainly driven by either their educational attainment or family income.[12]

4.2.2. *Measurement Errors*

The within-sibling FE estimator, especially the within-twin-pair one, has been used to identify causal relationships in labor economics for a long time, following the study of economic return to education by Behrman and Taubman (1976). Griliches (1979) first provides a rigorous treatment of the sibling models and data in econometric research. This method has received criticisms in the literature. For a recent discussion on this issue, readers are referred to the special issue on the twin-based estimator of *Economics of Education Review* (Behrman and Rosenzweig, 1999).

One of the major concerns with the within-twin-pair FE estimator is the possible effect of measurement errors with respect to whether the FE estimator is more fragile than the OLS estimator (Griliches, 1979). Nevertheless, we believe that measurement errors are not an issue in our analysis unlike in other studies, such as on estimating the return to schooling. First, the quality of CATS data is high.[13] Second, parents are less

---

[12] Admittedly, we are unable to control for all potential twin individual-specific characteristics, such as IQ in the regression equations. However, our regression results may be robust to the inclusion of these characteristics. For example, the difference in IQ is small between identical twin siblings. Moreover, we do not know whether IQ affects parental gender selection as a prior.

[13] See the work of Li et al. (2012) for a detailed description of the quality of CATS data. For example,

likely to misreport the number and gender of their children than schooling years. Finally, the magnitude of FE estimates is consistently larger than that of OLS estimates in terms of absolute values. Therefore, the attenuation bias induced by measurement errors may not be applicable to our study.

4.2.3. *Linear Specification*

A final potential pitfall of the within-twin-pair FE estimator is the additivity assumption. This estimator assumes that the effect of endowed risk aversion, which is unobservable in the choice of agents in the risk elicitation task, is additive with respect to the effects of other covariates. If the effects of endowed risk aversion interact with other covariates in Equation (2), the regression equation will be incorrectly specified. Evdokimov (2012) develops the identification and estimation of nonparametric panel data models to deal with individual-specific effects that are not additively separable from the structural equation. However, this method does not apply well to our sample given its small size. Instead, we regard Equation (2) as a linear approximation in case of a potential non-additive effect of the endowed risk aversion. Finally, we use a linear probability model to facilitate the interpretation of the estimate coefficients, and our results remain robust when we use a logit or probit estimator.

5. Conclusion

This paper studies the relationship between parental risk aversion and son preference. On one hand, parents with sons may be less risk averse than those with daughters because sons provide support and security for their elderly parents in traditional patriarchal societies. On the other hand, endowed risk-averse families may have a stronger demand for sons than those that are not. Therefore, the OLS estimates are generally biased because of the unobservable heterogeneity in endowed risk aversion. We elicit the risk attitudes of Chinese adult twins together with a within-twin-pair FE estimator to address the concern of the omitted-variable bias. Assuming that endowed risk aversion is similar across twin siblings, the FE estimates will be less biased than OLS estimates in rendering a causal interpretation to our findings. In this sense, our FE esti-

the correlation between the self and the cross-twin sibling reported one's schooling years is 0.94, which is higher than that in other major twin survey data in economic research, such as the Twinsburg and Minnesota Twin Registry.

mates indicate that having sons significantly decrease parental risk aversion. Moreover, we compare the OLS and the FE estimates and show that endowed risk-averse families are more likely to have sons than those that are not.

The identified positive effect of endowed risk aversion on the demand for sons offers an explanation for the origin of gender preferences. Parents in traditional patriarchal societies have a demand for sons to protect themselves against environmental, health, economic, and social risks. Furthermore, the positive effect of endowed risk aversion on the demand for sons implies that the increasing sex ratios in Eastern Asian countries, such as China, India, and Vietnam, may be in part systematically related to the socioeconomic risks in these countries. For example, Ebenstein and Leung (2010) find that the rural old-age pension program in China mitigates the sex ratio imbalance in areas where the program is available. Moreover, parents who fail to have a son are more likely to participate in old-age pension programs than those who have a son. Future studies are highly desirable to explore related issues with a larger sample size, more complete social, economic, and demographic data, and more comprehensive measures of preferential traits elicited in incentivized choice experiments.

References

Abdellaoui, M., Baillon, A., Placido, L., and Wakker, P. (2010). The Rich Domain of Uncertainty: Source Functions and Their Experimental Implementation. *American Economic Review*, 101(2), 1-39.

Almond, D., Edlund, L. and Milligan K. (2013). Son Preference and the Persistence of Culture: Evidence from Asian Immigrants to Canada. *Population and Development Review*, 39(1), 75-95.

Almond, D., & Edlund, L. (2008). Son-biased sex ratios in the 2000 United States Census. *Proceedings of the National Academy of Sciences*, *105*(15), 5681-5682.

Baillon, Aurélien, Han Bleichrodt, Zhenxing Huang, & Rogier Potter van Loon. "Robustness: (extended) multiplier preferences for the American and the Dutch population." *Working paper*

Behrman, J. and Taubman, P. (1976). Intergenerational Transmission of Income and Wealth. *American Economic Review*, 66(3), 436-440.

Behrman, J and Rosenzweig, M. (1999). Ability Biases in Schooling Returns and Twins: A Test and New Estimates. *Economics of Education Review*, 18, 159-167.

Cain, M. (1981). Risk and Insurance: Perspectives on Fertility and Agrarian Change in India and Bangladesh. *Population and Development Review*, 435-74.

Chew, S., Yi, J., Zhang, J. and Zhong, S. (2012) Education and Preferences: Experimental Evidence from Twins. Working paper.

Chew, S. H. and J. S. Sagi. (2008) Small Worlds: Modeling Attitudes toward Sources of Uncertainty. *Journal of Economic Theory*, 139(1), 1-24.

Chu, C. Y., Xie, Y., & Yu, R. R. (2011). Coresidence with elderly parents: A comparative study of southeast China and Taiwan. *Journal of Marriage and Family*, *73*(1), 120-135.

Das Gupta, M. (2005). Explaining Asia's 'Missing Women': A New Look at the Data. *Population and Development Review*, 31, 529-535.

Das Gupta, M., Ebenstein, A., and Sharygin, J. (2013) China's Marriage Market and Upcoming Challenges for Elderly Men. *Population Studies*, 67(1), 39-59.

Davies, J. and Zhang, J. (1995). Gender Bias, Investments in Children and Bequests. *International Economic Review*, 36(3), 795-818.

Dimmock, Stephen G., Roy Kouwenberg, & Peter P. Wakker (2015) "Ambiguity Attitudes in a Large Representative Sample," *Management Science*, forthcoming.

Ebenstein, A. (2011). Estimating a Dynamic Model of Sex Selection in China. *Demography*, 48(2): 783-811.

Ebenstein, A. (2010). The 'Missing Girls' of China and the Unintended Consequences of the one-child Policy. *Journal of Human Resources*, 45(1), 87-115.

Ebenstein, A. and Leung, S. (2010). Son Preference and the Missing Market for Social Insurance: Evidence from China's Rural Pension Program. *Population and Development Review*, 36(1): 47-70.

Evdokimov, K. Identification and Estimation of a Nonparametric Panel Data Model with Unobserved Heterogeneity. Working paper.

Fox, R. and Tversky, A. (1995). Ambiguity Aversion and Comparative Ignorance. *Quarterly Journal Of Economics*, 110, 585-585.

Griliches, Z. (1979). Sibling Models and Data in Economics: Beginnings of Survey. *Journal of Political Economy*, 5, 37-64.

Heckman, J., Moon, S., Pinto, R. and Savelyev, P. (2010) Analyzing Social Experiments as Implemented: A Reexamination of the Evidence From the HighScope Perry Preschool Program. *Quantitative Economics*, 1(1), 1–46.

Holt, A. and Laury, K. (2002). Risk Aversion and Incentive Effects. *American Economic Review*, 92(5), 1644-1655.

Leung, S. F. (1991). A stochastic dynamic analysis of parental sex preferences and fertility. *The Quarterly Journal of Economics*, 1063-1088.

Li, H., Rosenzweig, M. and Zhang, J. (2010). Altruism, Favoritism, and Guilt in the Allocation of Family Resources: Sophie's Choice in Mao's Mass Send Down Movement. *Journal of Political Economy*, 118(1), 1-38.

Li, H., Yi, J. and Zhang, J. (2011). Estimating the Effect of the One-Child Policy on Sex Ratio Imbalance in China: Identification Based on the Difference-in-Differences. *Demography*, 48(4), 1535-1557.

National Bureau of Statistics (NBS). (2009). *China Statistical Yearbook 2009* [2009 nian zhong guo tong ji nian jian]. Beijing: China Statistics Press.

Noussair, C.N., S.T. Trautmann, and G. van de Kuilen (2014). Higher Order Risk Attitudes, Demographics, and Financial Decisions. *Review of Economic Studies* 81, 325−355.

Rosenzweig, M. (1993). "Women, Insurance Capital, and Economic Development in Rural India." *Journal of Human Resources*, 28(4), 735-58.

Rosenzweig, M. and Schultz, T. (1982). Market Opportunities, Genetic Endowments, and Intrafamily Resource Distribution: Child Survival in Rural India. *American Economic Review*, 72(4), 803-15.

Rosenzweig, R. (1988a). Risk, Private Information, and the Family. *American Economic Review*, 78(2), 245-50.

Rosenzweig, Mark. (1988b). Risk, Implicit Contracts and the Family in Rural Areas of Low-Income Countries." *Economic Journal*, 98(393), 1148-70.

Sen, A. (1992). Missing women. *British Medical Journal*, 304, 587-588.

Scharping, T. (2002). *Birth Control in China 1949-2000: Population Policy and Demographic Development*. Publisher: Routledge.

Sutter, M., M. Kocher, D. Rützler, and S. T. Trautmann (2013). Impatience and Uncertainty: Experimental Decisions Predict Adolescents' Field Behavior. *American Economic Review* 103, 510–531.

Townsend, R. (1994). Risk and Insurance in Village India. *Econometrica*, 62(3), 539-591.

Wei, S. J., & Zhang, X. (2011). The Competitive Saving Motive: Evidence from Rising Sex Ratios and Savings Rates in China. *Journal of Political Economy*, 119(3), 551-564.

Zhong, S., Chew, S. H., Set, E., Zhang, J., Xue, H., Sham, P. C., Israel, S. (2009). The Heritability of Attitude toward Economic Risk. *Twin Research and Human Genetics*, 12(1), 103-107.

Table 1: Summary Statistics of Variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Experimental measure					
Risk aversion	96	0.43	0.50	0	1
Children gender composition					
Have at least one son	96	0.60	0.49	0	1
The first child is a son	96	0.49	0.50	0	1
Sex ratio (sons / all children)	96	0.52	0.46	0	1
Control variables					
Age	96	51.92	9.07	30	67
Male	96	0.33	0.47	0	1
High school	96	0.43	0.50	0	1
Technical school and college	96	0.27	0.45	0	1
Family annual income (RMB ￥1000)	96	19.80	17.52	4	120

Table 2: OLS and Within-Twin-Pair FE Estimates of the Effects of the Gender Composition of Children on Parental Risk Attitude

	Dependent variable: Parents are risk averse					
	OLS			FE		
	(1)	(2)	(3)	(4)	(5)	(6)
Have at least one son	-0.088			-0.231**		
	[0.095]			[0.101]		
The first child is a son		-0.086			-0.161**	
		[0.101]			[0.077]	
Sex ratio			-0.049			-0.196**
(sons / all children)			[0.098]			[0.099]
Age	-0.104*	-0.102	-0.098*			
	[0.063]	[0.065]	[0.055]			
Age-squared (1/100)	0.101*	0.097	0.093*			
	[0.057]	[0.060]	[0.052]			
Male	-0.066	-0.07	-0.066			
	[0.098]	[0.101]	[0.107]			
Observations	96	96	96	96	96	96
Twin pairs				48	48	48
R-squared	0.11	0.11	0.10	0.09	0.05	0.07

Note: Bootstrapped standard errors are in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%; a city dummy is included in each OLS estimation.

Table 3: Robust Tests of the Effects of the Gender Composition of Children on Parental Risk Attitude (Within-Twin-Pair FE Estimation)

	Dependent variable: Parents are risk averse					
	(1)	(2)	(3)	(4)	(5)	(6)
Have at least one son	-0.211**			-0.203*		
	[0.104]			[0.118]		
The first child is a son		-0.145*			-0.147*	
		[0.084]			[0.080]	
Sex ratio			-0.176**			-0.166*
(sons / all children)			[0.086]			[0.091]
High school	-0.172	-0.197	-0.185	-0.132	-0.147	-0.145
	[0.227]	[0.172]	[0.216]	[0.253]	[0.237]	[0.203]
College	-0.254	-0.291	-0.274	-0.192	-0.218	-0.212
	[0.202]	[0.184]	[0.233]	[0.286]	[0.267]	[0.235]
ln (Family annual income)				-0.116	-0.13	-0.117
				[0.074]	[0.101]	[0.124]
				[0.090]	[0.141]	[0.116]
Observations	96	96	96	96	96	96
Twin pairs	48	48	48	48	48	48
R-squared	0.11	0.08	0.09	0.14	0.11	0.11

Note: Bootstrapped standard errors are in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix I: Experiment Instruction

GAME (RISK AVERSION)

We will randomly draw one card from a deck of 20 cards: 10 red and 10 black. You have two options.

- Guess the color of the card drawn. You will receive ¥40 if your guess is correct and nothing if your guess is wrong.
- Receive a sure amount of money if you do not wish to guess.

Tick "√" of your choice. **TICK ONLY ONE.** *You will be paid based on your decision.*

1.) Guess: Red ___ Black ___

You will receive ¥40 if your guess is correct and nothing if your guess is wrong.

2.) Receive ¥20 ___

Appendix II: Proof of Proposition

Both the OLS and the FE estimates are biased when ϑ_{1i} is not equal to ϑ_{2i}. $\hat{\beta}^{OLS}$ and $\hat{\beta}^{FE}$ should be biased toward the same direction, as $\sigma_{\Delta\vartheta\Delta s} / \sigma^2{}_{\Delta s}$ and $\sigma_{\vartheta s} / \sigma^2{}_{s}$ are of the same sign. If $\hat{\beta}^{OLS} > \hat{\beta}^{FE}$, the following two cases must be considered: $\hat{\beta}^{OLS} > \hat{\beta}^{FE} > \beta$ or $\beta > \hat{\beta}^{OLS} > \hat{\beta}^{FE}$.

Case 1: $\hat{\beta}^{OLS} > \hat{\beta}^{FE} > \beta$. In this case, we can derive that $|\sigma_{\Delta\vartheta\Delta s} / \sigma_{\Delta s}{}^2| < |\sigma_{\vartheta s} / \sigma_s{}^2|$ because of Equations (5) and (7) and $\gamma > 0$. This derivation is consistent with the identification assumption.

Case 2: $\beta > \hat{\beta}^{OLS} > \hat{\beta}^{FE}$. In this case, putting Equations (5) and (7) together, when $\gamma > 0$, both $\sigma_{\Delta\vartheta\Delta s} / \sigma_{\Delta s}{}^2$ and $\sigma_{\vartheta s} / \sigma_s{}^2$ are negative. Moreover, $\sigma_{\Delta\vartheta\Delta s} / \sigma^2{}_{\Delta s}$ is more negative than $\sigma_{\vartheta s} / \sigma^2{}_{s}$. Therefore, $|\sigma_{\Delta\vartheta\Delta s} / \sigma_{\Delta s}{}^2| > |\sigma_{\vartheta s} / \sigma_s{}^2|$. However, this finding contradicts the identification assumption. Therefore, Case 2 is impossible under the identification assumption.

In sum, only Case 1 is plausible under the identification assumption, $\hat{\beta}^{OLS} > \hat{\beta}^{FE}$ and $\hat{\beta}^{FE} < 0$. Note that, if $\vartheta_{1i} = \vartheta_{2i}$, $\hat{\beta}^{FE}$ will be unbiased and then $\hat{\beta}^{OLS} > \hat{\beta}^{FE}$. The proposition in Section 2 directly follows when $\hat{\beta}^{OLS} > \hat{\beta}^{FE} > \beta$.