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The impact of Children's gender on Parent's mental health and cognition -- evidence from China

Yanran Chen [a,*], Ruochen Sun [b]

[a] School of Economics, Capital University of Economics and Business, 121 Zhangjialukou, Fengtai District, Beijing, 100070, China
[b] Wharton School of Business, University of Pennsylvania, Philadelphia, PA, United States

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ABSTRACT

With the growing and aging population round the world, it becomes increasingly important to understand what factors impact the mental health and cognition of the older generations in order to design effective interventions. In this paper, we investigate the effect of a child's gender on parental mental health and cognition in the context of one of the world's largest developing countries and the unique one-child policy, using China Family Panel Studies (CFPS). We exploit the exogeneity of the first child's gender and find that having a son has significant protective effects on parents' mathematics performance and memory functions in one-child families, but such effects are absent in multi-child families. Moreover, we find that the protective effect is more pronounced among one-child families in rural areas than urban areas. Our results suggest the existence of gender inequality in China and reveal the hidden long-term social cost of the one-child policy.

1. Introduction

As the world's population ages and expands, aging well has become an increasingly important topic. China, the world's most populous country, is experiencing aging rapidly, in a trend that is likely to last for decades. While the early focus on aging research is on physical health, the mental health and cognition of the aging population have also become compelling; life expectancy continues to expand and the elderly's mental health has a greater impact on later life decisions, such as retirement and enrollment in a pension system, as well as life quality. Also, preventing the development of depression and delaying cognitive decline becomes a pressing issue.

One of the important factors that affect the older generation's mental health and cognition are their children, especially in China, where a high value is placed on family ties. Family relationships provide material and emotional support to family members, and happiness and memories are shared together. Through various channels, the children have a significant impact on the Chinese older generation, both physically and mentally. Furthermore, traditional Chinese society has had a long-standing preference for sons; sons were considered to be more helpful in providing support when parents were old, while daughters were thought to offer support mainly to their parents-in-law. Elderly parents who adhere to this belief are likely to be happier and in better overall health if they have sons rather than daughters.

However, due to great societal changes in recent decades, the "son preference" is becoming weaker, especially among young adults in China. Nowadays, with the freedom to choose to work outside the home, women are able to provide monetary support to their parents. Also, the traditional social norm that wives have to live with their parents-in-law has also changed. Instead, daughters can spend more time taking care of their own parents. To make things more complicated, the one-child policy implemented in the 1980s has made it impossible for parents to have both sons and daughters. The gender ratio is skewed (1.2:1.0, men to women),[1] which worries parents with sons more because they have to invest more in helping their sons find a wife. On the other side, some parents still hold the belief that to ensure a happier elderly life, they should have a son as "successor." The interaction of these factors makes the impact of the gender of children on their parents' mental health outcome unclear. Thus, it is worth exploring the effect of children's gender on their parents in a time when society's opinions are in transition.

Previous literature suggests that children generally play vital roles in

* Corresponding author.
E-mail addresses: yanran.chen@cueb.edu.cn (Y. Chen), ruochens@wharton.upenn.edu (R. Sun).

[1] 121 boys for every 100 girls in 2004, 113.5 boys for every 100 girls in 2015. Retrieved from Chinese Xinhua Net: http://www.xinhuanet.com//local/2017-02/13/c_1120452852.htm.

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parents' mental health, especially elderly parents. Intergenerational support between parents and children includes instrumental support (such as household chores, financial support, transportation, and shopping, etc.) and expressive support (such as emotional support, frequency of conversation, and going through important life events together, etc.), and these supports have a significant impact on depression (Byers et al., 2008; Weinstein et al., 2004). Parents with more support from their children are less likely to be depressed (L. Li et al., 2005; Zunzunegui et al., 2001), while the risk of depression rises if their adult children still rely on them (Byers et al., 2008).

As for the variable we are interested in, a child's gender, many studies investigate the different effects on parents of having sons or daughters. Some studies indicate that having a son is better for parents in terms of general health status and women's bargaining power in the family. In China, mothers with sons have a higher bargaining power within their family and are better nourished, compared to mothers with daughters (Li & Wu, 2011). In the United States, although the preference for sons is not significant, marriage stability is higher in families with sons (Raley & Blanchi, 2006). However, many other studies also find that daughters are slightly more valued as providing better care and therefore better health outcomes for the parents. In the aspect of instrumental support, daughters are more likely to become caregivers, and mothers are more satisfied with the care provided by daughters compared with sons (Zhang & Goza, 2006). As for financial support, the results vary across urban and rural areas. Married daughters tend to give more money to their parents (Xie & Zhu, 2009), but in rural areas sons provide more financial support than daughters do (Ran & Xi, 2011). In terms of expressive support, elderly parents benefit more from the emotional support and emotional comfort provided by daughters (Li et al., 2021). For one-child families, having a daughter is shown to bring significantly more happiness to parents compared with having a son, especially when their children are over 20 years old (Lu et al., 2017). This result indicates that China's traditional preference for sons is changing as society evolves.

Although previous research from different countries shows mixed effects of a child's gender on the parents' overall well-being and mental health outcomes, few studies in contemporary China have focused specifically on the effect of a child's gender on parents' general depression status and cognitive functions. In this paper, we aim to fill this gap in the literature and provide new empirical evidence to better understand gender preference in the context of contemporary China. By exploiting the exogeneity of the first child's gender and the one-child policy in China, we investigate the effect of a child's gender on parents' depression symptoms, mathematics performance, and memory functions in the context of contemporary Chinese society. We also examine the heterogeneity across urban and rural areas, different age groups and parent's gender. Understanding this effect of a child's gender on parents' mental health and cognition does not only contribute to the empirical work that investigates family dynamics and gender equality but also has important policy implementations for further public education and policy interventions to address gender inequality in China.

2. Data and methods

2.1. Data source

The individual-level data in this paper is from the China Family Panel Studies (CFPS) in 2010 and 2014. The data, designed and collected by the China Social Science Research Center of Peking University, aims to collect a high-quality nationally representative sample of Chinese residents to reflect changes in China's society, economy, population, education, and health, providing a database for academic research and public policy analysis. The China Family Panel Studies (CFPS) officially launched in 2010, which covers 25 provinces/cities, and the sample size is 16,000. The survey targets all family members in the sample households. From the perspective of questionnaire design and field implementation, CFPS has the characteristics of strong professionalism and high reliability, involving very detailed records and tracking information on individuals and families.[2]

2.2. Measure of mental health

The mental health variables this paper mainly focuses on include depression and cognitive ability test scores. Regarding the depression symptoms, CFPS uses the Center for Epidemiologic Studies Depression Scale (CES-D) test scores to measure the individual's depression as well as the psychological and emotional state, which is one of the most commonly used in household questionnaires. The CES-D is not only suitable for the adult population, but also for adolescents and the elderly. The measurement includes depression patterns, lack of value, despair, loss of appetite, poor attention and other depressive symptoms.

To our best knowledge, CFPS has released five waves of longitude survey data ranging from 2010 to 2020. However, in terms of the mental health and cognitive ability outcomes which this paper is mainly focused on, the survey has made some adjustments in questionnaire design among some of the waves, which makes it difficult to combine all the datasets together and compare the result from different scales. In 2010 and 2014, a simplified version of CES-D was used, which is modified with support from the U.S. government's National Center and World Health Organization (WHO) and asks six scenarios during the past 30 days (also known as K6). As for cognition tests, the survey involved word recall and math tests. However, the survey in the other two years (2012 and 2016) applies different scales of depression test and cognition test. The complete version of the CES-D test, which involves twenty questions and asks the frequency of twenty scenarios during the past week, was applied in CFPS 2012 and 2016. Besides, the words recall and math tests in 2012 and 2016 were completely different from 2010 to 2014, using a set of tests involving long memory, short memory and math test. However, it's worth noting that according to the official technical report from CFPS, they pointed out that the complete version of the CES-D test had poor performance in the field trip. As they mentioned, it indicated that the complete version of the CES-D test was too long for the CFPS individual questionnaire and was not well received by respondents. In CFPS 2016, they adapted the design to use a streamlined version of the scale, reducing the number of questions from 20 to 8. In order to effectively compare depression scores between rounds, they chose to continue using the CESD-20 for a random 1/5 of the population and the CESD-8 for the remaining 4/5 of the sample.[3] Considering the significant adjustments in questionaries and reliability of the data, we apply CFPS 2010 and 2014 waves in this paper as these two waves of data are more comparable in terms of the mental health and cognition.

The six scenes involved in CFPS 2010 and 2014 questionnaires are all negative questions. Referring to the general scoring method from the National Comorbidity Survey of Harvard Medicine School[4]: First, according to the options of each topic, they are assigned 0–4 points: "None of the time" is 0 point; "A little of the time" is 1 point; "Some of the time" is 2 points; "Most of the time" is 3 points; "All of the time" is 4 points. Then, we add the scores of the six questions to obtain a total score of the depression, which points to a unified depression indicator ranging from 0 to 24 points. The higher the score represents, the higher degree of depression. The cognitive ability tests in CFPS 2010 and 2014 share the same questionnaire, involving the respondent's verbal test (words

[2] More details could be found at the official website: http://www.isss.pku.edu.cn/cfps/en/index.htm.

[3] Although CFPS team has released the new outcome variables by equipercentile equating to make CES-D scores comparable with 2012 wave, the range of values for this calculated variable differs significantly from the 2012 results.

[4] More details of K6 could be found at: https://www.hcp.med.harvard.edu/ncs/k6_scales.php.

recall) and mathematics. Referring to official calculation and adjustment by CFPS, we use the comparable verbal test and mathematical test to measure individual cognitive abilities.

2.3. Estimation method

To analyze the effects of children's gender on parents' mental health, we use mental health outcomes in 2014 as the dependent variable and use children's gender as the key independent variable while controlling for a set of covariates. Considering that children's gender may be endogenously chosen by parents due to the son-preference tradition in China, we refer to Wu and Li (2014) and use the first child's gender as the proxy variable of children's gender to avoid possible endogenous problems. Since the gender choice of Chinese families is often not carried out on the first child (Ebenstein, 2010), the gender of the first child is considered to be naturally determined and has a strong exogenous nature. It could also be further supported by our descriptive analysis, which indicates that the boys account for around 50% of all households' first children, indicating the absence of the obvious manual intervention.

Besides, due to the cumulative and long-term nature of mental health, we include the individual's mental health status in 2010 as control variables, in order to capture unobservable factors, individual fixed effects and other time-invariant features related to mental health in 2014. Furthermore, China launched the one-child policy in 1979, which limits only one child in each family. Considering that our sample includes both single-child families and multiple-child and the two types of families significantly differ on the policy environment and their childbearing choice, we will discuss these two families separately. Equation (1) is used to estimate for one-child families and Equation (2) for multiple children's families, respectively.

$$Mental\,Health_{it}=\alpha_0+\boldsymbol{\beta}_1 FirstChild\,Gender_{it}+\beta_2 Mental\,Health_{it-1}+\beta_3 X_{it}+\eta_c+\varepsilon_{it} \quad (1)$$

Table 1
Descriptive result: Whole sample.

Variables	Observations	Mean	SD	Min	Max
Outcome Variables					
Depression (2014)	16019	3.24	3.96	0	24
Math Score (2014)	16094	9.53	6.26	0	24
Verbal Score (2014)	16096	16.6	10.7	0	34
Independent variable of interest					
Gender of first child-Male	17371	0.56	0.50	0	1
Control Variables					
Male	17420	0.47	0.50	0	1
Age	17418	47.9	12.9	19	95
Age_2	17418	168.7	224.5	0.25	2070.3
Married	17417	0.92	0.27	0	1
Political Preference	17406	0.068	0.25	0	1
Hukou Status	16995	0.27	0.45	0	1
Highest Education Level	17371	2.25	0.95	1	4
Work Status	14297	0.51	0.50	0	1
Self-reported Health Status	17415	1.85	0.67	1	3
Number of Children under 6	17420	0.22	0.52	0	5
Highest Education of Children	17371	23.1	12.7	0	92
Age of the First Child	17420	2.76	1.16	1	4
Number of Children	17420	1.62	0.81	0	9
Number of Daughters	17420	0.66	0.76	0	8
ln (Personal Income+1)	17304	3.92	4.50	0	13.0
ln (Household Income+1)	17409	10.6	0.88	6.22	15.4
ln (Household Savings+1)	17420	4.96	5.25	0	15.2
Urban	16756	0.49	0.50	0	1
Depression (2010)	17277	3.04	3.84	0	24
Math Score (2010)	17407	9.85	6.31	0	24
Verbal Score (2010)	17407	17.1	10.4	0	34

Note: (1) Education variable represents the highest education of the observation, which is categorized as four levels: 1 no education, 2 primary education, 3 middle school or high school, 4 colleges or higher education. (2) Working variable indicates if the survey participant working (either full-time or part-time) when the survey is conducted. (3) Highest Education of Children variable represents the highest education among all children in the household. (4) Political preference: 1 join the Communist Party of China, 0 otherwise.

$$Mental\,Health_{it}=\alpha_0+\boldsymbol{\beta}_1 FirstChild\,Gender_{it}+\beta_2 Mental\,Health_{it-1}+\beta_3 X_{it}+\beta_4 Number\,of\,children_{it}+\beta_5 Number\,of\,daughters_{it}+\eta_c+\varepsilon_{it} \quad (2)$$

Where subscript i represents the parent's individual identifier, and t represents the year code, and c represents the county code; while $Mental\,Health_{it}$ denotes the parent's individual mental health outcome variables in 2014; $First\,Child\,Gender_{it}$ represents the gender; $Mental\,Health_{it-1}$ indicates the individual mental health outcome variables in 2010. X_{it} involves all control variables; η_c is a fixed effect at the county level. As for multiple children's families, we add the number of all children and the number of all daughters as control variables. The coefficient of interest is β_1, which represents the average treatment effect of mental health outcomes for the boy as the first child, compared with the girl of the first child.

The key identification assumption of the empirical strategy is that the variation of the first child's gender over successive mental health status is uncorrelated with unobserved determinants of the mental health for a given individual. The first child's gender is considered an exogenous variable in the research design as there is an understanding that parents seldom make gender selection on the first child. The full set of control variables includes parent's gender, age, age square, hukou status, physical health, working status, personal income, household expenditure, household savings, the highest education among all children, the age of the first child, number of children and number of daughters in the family. The inclusion of the mental health status in the *t-1* period serves as an approximation of the underlying mental health trends and time-invariant fixed effects.

3. Results

3.1. Descriptive analysis

This paper mainly focuses on the impact of children's gender on the mental health of their parents, thus we drop the individuals or households who have no children. In Table 1, we describe the basic characteristics of the main variables. The statistics calculated in the table are adjusted according to the sample sampling weights provided by the CFPS database so that the sample can represent the characteristics of the population in the country. The descriptive statistics in Table 1 of the main outcome variables in 2014, which are depression scores, verbal scores, and mathematical scores. The results of descriptive statistics show the average depression score of the sample is 3.24 points; the verbal and math test scores are 16.6 and 9.53 points, respectively. The key independent variable of interest is the gender of the first child, which is the proxy variable of children's gender. The control variables in the model include parent's gender, age, education, married status,

Table 2
Descriptive Result: One-child family & Multiple-child family.

Variables	One-child family		Multiple-child family		Diff in Means	t-statistics
	Obs	Mean	Obs	Mean		
Outcome Variables						
Depression (2014)	7693	3.45	8194	3.03	0.42***	6.64
Math Score (2014)	7741	8.34	8221	10.7	−2.36***	−24.21
Verbal Score (2014)	7742	14.91	8222	18.34	−3.43***	−20.56
Independent variable of interest						
Gender of first child-Male	8351	0.5	8905	0.62	−0.13***	−16.93
Control Variables						
Male	8354	0.47	8920	0.47	−0.01	−1.17
Age	8354	46.55	8918	48.96	−2.40***	−12.38
Age^2	8354	127.03	8918	204.21	−77.17***	−23.2
Married	8351	0.95	8920	0.89	0.05***	13.01
Political Preference	8345	0.05	8915	0.09	−0.04***	−9.57
Hukou Status	8156	0.13	8694	0.41	−0.27***	−41.93
Highest Education Level	8337	2.08	8891	2.41	−0.33***	−23.36
Work Status	7271	0.4	6939	0.62	−0.22***	−26.6
Self-reported Health Status	8350	1.82	8919	1.88	−0.05***	−5.26
Number of Children under 6	8354	0.29	8920	0.15	0.14***	17.61
Highest Education of Children	8351	22.45	8905	23.49	−1.04***	−5.42
Age of the First Child	8354	2.86	8920	2.67	0.20***	11.11
Number of Children	8354	2.31	8920	1	1.31***	186.92
Number of Daughters	8354	1.05	8920	0.31	0.74***	72.88
ln (Personal Income+1)	8319	2.91	8843	4.87	−1.96***	−29.12
ln (Household Income+1)	8349	10.57	8915	10.73	−0.15***	−11.37
ln (Household Savings+1)	8354	4.35	8920	5.53	−1.18***	−14.9
Urban	7998	0.36	8614	0.6	−0.24***	−31.25
Depression (2010)	8276	3.17	8859	2.9	0.28***	4.7
Math Score (2010)	8350	8.78	8911	10.9	−2.13***	−22.46
Verbal Score (2010)	8350	15.47	8911	18.74	−3.27***	−20.98

Notes: *p < 0.05, **p < 0.01, ***p < 0.001.

political preference, income, physical health, urban or rural area, working status, number of children under six years old, the highest education level among children, and the mental health outcomes in 2010.

The sub-sample statistic of one-child families and multiple-child families is shown in Table 2. Generally, the mental health status in multiple-child families is worse than that in one-child families, which is indicated by higher depression scores and lower mathematic and verbal scores. The result of the *t*-test between one-child and multiple-child families shows that the parents from multi-child families tend to have stronger mental deterioration but better cognition outcomes. As for control variables, compared with one-child families, multiple families are younger, less educated, less healthy, have lower income, take more agricultural work and have more children under 6, which are all statistically significant at 1% level.

The result of the *t*-test shows that the two types of families greatly differ from each other on many characteristics, including household chores, financial support, emotional status and other basic personal and family characteristics. These factors are also considered as significant factors which affect parents' mental health status. Also, considering the one-child policy, two types of families are systematically different when making decisions on having children because the parent who is affected by the one-child policy has no choice but to have only one child, regardless of the child's gender. Thus, we would separate these two types of families in the following analysis based on the above statistical evidence and policy factors.

3.2. Basic model

The empirical result of the basic model is shown in Table 3. We examine the three outcomes (depression symptoms, mathematic performance and verbal tests) separately among one-child families and multiple-child families. For each outcome, we estimate both equation (1) and equation (2) with a full set of control variables and cluster standard errors at the county level.

Column (1) and column (2) in Table 3 show the result for depression symptoms. We didn't observe a significant effect of the gender of the first child on the parent's depression symptoms, neither in both one-child families nor multiple-child families. However, the results of cognition functions are quite different. Among one-child families, if the first child, also as the only child in the one-child family, is a son, their parent's performance in mathematics tends to be 0.130 units higher than the one-child family with a daughter, under the 10% significance level with all control variables. Similarly, if the child in a one-child family is a son, their parent's verbal test score is 0.290 units higher than the one-child family with a daughter, under the 10% significance level with all control variables fixed. In other words, the parents with a son have an increase of 1.56% in mathematic performance an increase of 1.95% in cognition performance. Noted that since we include the outcome variable value in the previous time period as the control variable, the estimation of the effect is based on the comparison among the parents with similar underlying mental health or cognition.

In multiple-child families, the effects of the first child's gender on the parent's mathematic function and memory function are small and positive but not statistically significant. It means that if the first child is a boy in the multiple-child family, their parent's mathematics test score and verbal test score are 0.133 units (p-value > 0.10) and 0.095 unit (p-value > 0.10) higher, respectively, compared with the multiple-child family with a daughter as the first child. Since this effect is not significant, we can't reject the null that the first child's gender has a significant impact on parents' cognition and mental health.

Interestingly, the number of children in the family and the number of girls show a significant effect in the models of multiple-child families. Although we can't argue that these coefficients indicate the causal effects since the number of children and number of daughters in a family are endogenous variables and they are determined by the complex dynamics within and outside of a family, the result of our model shows that one more child in a family is significantly associated with 0.380 unit (p-value < 0.10) decrease in verbal test score. One more girl in a family is significantly associated with an increase of 0.299 units (p-value < 0.10) in verbal tests score.

3.3. Sub-group analysis

Considering the imbalanced development in China, we further conduct the sub-sample analysis by separating the sample into subsamples based on rural or urban areas, parents' age groups and parents' gender.

We present the sub-group analysis based on urban or rural areas in Table 4 Panel A. The regression results consistently show that having a boy imposes a protective effect on parents' mental health and cognition in rural areas, especially in the one-child families in rural areas. For example, if the gender of the only child in a rural family is a boy, the

Table 3
Empirical result of basic model.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	One-child family	Multiple-child family	One-child family	Multiple-child family	One-child family	Multiple-child family
	Depression	Depression	Math	Math	Verbal	Verbal
Gender of first child - Male	−0.127	0.126	0.130*	0.133	0.290*	0.095
	(-1.29)	(0.98)	(1.70)	(1.62)	(1.75)	(0.42)
Male	−0.403***	−0.441***	0.129**	0.490***	0.076	0.645***
	(-4.76)	(-5.18)	(1.99)	(7.06)	(0.49)	(3.74)
Age	0.006	0.028*	0.002	−0.006	−0.056**	−0.053**
	(0.43)	(1.84)	(0.17)	(-0.54)	(-2.34)	(-2.16)
Age2	−0.000	0.000	0.000	0.000	0.002***	0.002*
	(-0.41)	(0.13)	(0.30)	(0.52)	(2.88)	(1.95)
Married	−0.617***	−1.302***	0.115	0.058	−0.287	0.173
	(-2.68)	(-4.48)	(0.84)	(0.38)	(-0.92)	(0.41)
Political Preference	0.101	−0.340*	0.320***	0.430***	0.460	0.851**
	(0.69)	(-1.80)	(2.78)	(3.05)	(1.60)	(2.44)
Hukou Status	0.070	0.345*	0.463***	0.342**	0.256	−0.409
	(0.46)	(1.82)	(3.86)	(2.43)	(0.87)	(-0.97)
Highest Education Level: Primary School	−0.205	−0.224	1.436***	1.229***	4.128***	3.573***
	(-1.10)	(-1.63)	(10.59)	(8.67)	(9.88)	(10.86)
Highest Education Level: Middle/High School	−0.310*	−0.508***	6.315***	6.278***	7.356***	6.421***
	(-1.78)	(-3.59)	(27.86)	(30.15)	(17.38)	(18.60)
Highest Education Level: College or Higher	−0.531**	−0.831**	8.313***	9.126***	9.357***	9.133***
	(-2.32)	(-2.60)	(30.27)	(29.52)	(18.51)	(14.27)
Work Status	−0.215	−0.124	−0.023	0.183*	0.490*	0.869***
	(-1.39)	(-0.96)	(-0.18)	(1.86)	(1.78)	(3.39)
Self-reported Health Status: 2 = So-so	0.866***	0.991***	0.038	0.137*	0.538***	0.585***
	(9.19)	(10.28)	(0.49)	(1.70)	(2.78)	(2.98)
Self-reported Health Status: 3 = Not healthy	2.812***	2.685***	−0.211**	−0.009	−0.464*	−0.023
	(12.28)	(13.12)	(-2.13)	(-0.08)	(-1.77)	(-0.07)
Number of Children under 6	0.594**	−0.033	−0.325**	−0.217***	−1.442***	−0.317
	(2.27)	(-0.29)	(-2.40)	(-2.92)	(-4.76)	(-1.57)
Age of the First Child	−0.014	−0.042**	−0.034***	−0.034***	−0.137***	−0.101***
	(-0.89)	(-2.32)	(-3.85)	(-2.63)	(-5.46)	(-3.11)
Highest Education of Children: Primary School	0.104	0.309	−0.014	0.131	0.466*	0.817**
	(0.55)	(1.29)	(-0.10)	(0.80)	(1.73)	(2.37)
Highest Education of Children: Middle/High School	0.043	0.208	0.171	0.256	1.134***	0.918**
	(0.22)	(0.81)	(1.17)	(1.59)	(3.75)	(2.22)
Highest Education of Children: College or Higher	−0.191	0.198	0.287*	0.311*	1.666***	1.291***
	(-0.92)	(0.66)	(1.70)	(1.73)	(4.85)	(2.64)
ln (Personal Income+1)	−0.014	−0.008	0.012	0.014	−0.005	0.001
	(-1.14)	(-0.66)	(1.54)	(1.43)	(-0.25)	(0.06)
ln (Household Income+1)	0.057	0.090	0.031	0.133***	0.154	0.427***
	(0.85)	(1.33)	(0.75)	(2.88)	(1.49)	(3.75)
ln (Household Savings+1)	−0.005	−0.027***	0.019**	0.012*	0.067***	0.064***
	(-0.54)	(-2.71)	(2.20)	(1.66)	(3.50)	(3.13)
Urban	−0.031	0.052	0.268**	−0.041	0.815**	0.153
	(-0.20)	(0.33)	(2.00)	(-0.34)	(2.27)	(0.38)
Number of Children		0.056		−0.101		−0.380*
		(0.41)		(-1.33)		(-1.86)
Number of Daughters		0.042		0.077		0.299*
		(0.42)		(1.22)		(1.82)
Depression in 2010	0.232***	0.227***				
	(12.85)	(12.91)				
Math in 2010			0.398***	0.369***		
			(22.25)	(22.69)		
Verbal in 2010					0.421***	0.465***
					(17.29)	(22.39)
Constant	2.002**	1.137	1.017*	0.831	4.124***	2.934*
	(2.35)	(1.25)	(1.93)	(1.36)	(2.76)	(1.87)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6324	6590	6375	6662	6375	6662
R-squared	0.247	0.233	0.864	0.806	0.711	0.645

Notes: (1) Data source: CFPS 2014, 2010 Survey Data. (2) All standard errors are clustered at county level. (3) All models include control variables and county-level fixed effects. (4) All models are fixed-effect models. (5) ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

depression symptoms are −0.278 unit lower than such families with a daughter. Also, the mathematic score and verbal performance among the parents living in rural areas with a son is higher than such families with a daughter by 0.239 units (p-value < 0.05) and 0.193 units (p-value < 0.10), respectively. While such phenomenon is absent among urban families—the effect of the first child's gender does not have a significant effect either match mathematic performance or memory in one-child families and multi-child families.

Table 4 Panel B presents the subsample analysis results from different age groups. The results indicate that having a son in a one-child

Table 4
Empirical result of sub-group analysis.

Panel A. By urban and rural area												
Variables	One-child family		Multiple-child family		One-child family		Multiple-child family		One-child family		Multiple-child family	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
	Depression	**Depression**	**Depression**	**Depression**	**Math**	**Math**	**Math**	**Math**	**verbal**	**verbal**	**verbal**	**verbal**
Gender of first child - Male	**−0.278***	−0.006	0.194	−0.050	**0.239****	0.074	**0.188****	0.068	**0.193***	0.263	0.161	−0.074
	(-1.71)	(-0.05)	(1.28)	(-0.24)	(2.18)	(0.82)	(2.16)	(0.36)	(0.11)	(1.13)	(0.61)	(-0.17)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mental Health in 2010	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.500	2.036*	0.720	1.941	0.929	1.033	1.335*	0.367	2.622	5.249**	4.321**	5.652**
	(1.13)	(1.73)	(0.73)	(0.92)	(1.15)	(1.23)	(1.88)	(0.32)	(1.28)	(2.49)	(2.37)	(2.04)
Observations	2701	3623	4398	2192	2728	3647	4454	2208	2728	3647	4454	2208
R-squared	0.287	0.250	0.244	0.280	0.841	0.852	0.798	0.817	0.710	0.667	0.662	0.624
Panel B: By age groups												
	One-child family		**Multiple-child family**		**One-child family**		**Multiple-child family**		**One-child family**		**Multiple-child family**	
Variables	**<60 Depression**	**>60 Depression**	**<60 Depression**	**>60 Depression**	**<60 Math**	**>60 Math**	**<60 Math**	**>60 Math**	**<60 verbal**	**>60 verbal**	**<60 verbal**	**>60 verbal**
Gender of first child - Male	−0.074	−0.591	0.079	0.736	**0.098***	0.195	0.221	0.689	**0.331****	0.822	0.162	−1.053
	(-0.75)	(-1.43)	(0.59)	(0.90)	(0.06)	(0.93)	−0.28	(1.25)	(2.13)	(0.64)	(0.72)	(-0.80)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mental Health in 2010	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.155**	1.806	1.205	22.957	0.546	−10.070	4.228	−33.711***	7.106***	9.582***	6.347***	−41.890
	(2.29)	(0.12)	(1.08)	(0.74)	(0.76)	(-1.29)	−3.335	(-2.81)	(4.00)	−2.008	(3.25)	(-1.00)
Observations	5486	838	6161	429	5516	859	733	444	5516	859	6218	444
R-squared	0.248	0.385	0.232	0.525	0.849	0.824	0.8	0.879	0.679	0.661	0.637	0.754
Panel C: By parent's gender												
	One-child family		**Multiple-child family**		**One-child family**		**Multiple-child family**		**One-child family**		**Multiple- child family**	
Variables	**Female Depression**	**Male Depression**	**Female Depression**	**Male Depression**	**Female Math**	**Male Math**	**Female Math**	**Male Math**	**Female verbal**	**Male verbal**	**Female verbal**	**Male verbal**
Gender of first child - Male	**−0.303***	0.011	0.185	0.042	0.083	**0.167***	−0.025	**0.235***	0.084	**0.505****	0.009	0.008
	(-1.92)	(0.09)	(1.00)	(0.25)	(0.78)	(1.65)	(-0.25)	(1.77)	(0.36)	(2.19)	(0.03)	(0.02)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mental Health in 2010	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.677	1.608	1.610	0.599	0.917	0.833	1.829**	1.592*	6.197***	0.903	2.963	6.611***
	(1.44)	(1.10)	(1.38)	(0.53)	(1.21)	(1.11)	(2.38)	(1.82)	(2.83)	(0.38)	(1.52)	(2.77)
Observations	3042	3282	3366	3224	3073	3302	3412	3250	3073	3302	3412	3250
R-squared	0.268	0.257	0.246	0.238	0.887	0.845	0.823	0.777	0.773	0.654	0.694	0.580

Notes: (1) Data source: CFPS 2014, 2010 Survey Data. (2) All standard errors are clustered at county level. (3) All models include control variables and county-level fixed effects. (4) All models are fixed-effect models. (5) ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

family has protective effects on parents' mathematic performance and memory function but not on mental health among the parents who are younger than 60 years old. Specifically, the young parent in the one-child families who is younger than 60 years old and has a son as the only child have a 0.098 units higher mathematic performance score and 0.331 units higher memory function score, compared to such families with a daughter as the only child. Yet, we don't observe any effects of child's gender on all three outcomes among the parents who are older than 60 years old.

Table 4 Panel C shows the results of subsample analysis divided by parent's gender. The results show that the protective effect of having a son is heterogeneous among fathers and mothers. Having a son in one-child families alleviates the depression symptoms of the mother by −0.303 units, but such protective effects on mental health are absent among fathers. For fathers, having a son in the one-child family improves their mathematic performance score and memory functioning by 0.167 units and 0.505 units, respectively. In other words, the impact of having a son is mainly on mental health for mothers but on cognition functioning for fathers in one-child families. In multi-child families, we barely observe any effect of a child's gender except for a protective effect of having a son on the father's mathematic performance.

3.4. Mechanisms

We further test five mechanisms of the effect of a child's gender on a parent's mental health (shown in Table 5) given the availability of the data. The mechanisms we test include family assets, health insurance, chronic disease management, living with children and living with parent's parent. The results of interaction terms in Panel A indicate that the increase of assets could provide additional protective effects on parent's depression in both one-child families and multiple-child families if having a son, and on memory functioning only in multiple-child families. Lu et al. (2017) find that rising house prices deteriorate the well-being of the boy's parents, while an increase in household income had a positive impact. This is very similar to our findings in Panel A that when household assets increase, it can further alleviate the depression of the boy's parents. In Panel B, we show that among one-child families, especially for families having a son, being covered by any health insurance leads to an additional reduction of 0.721 units reduction in parent's depressive symptoms. In panel C, the estimation suggests that although having any chronic disease is significantly correlated with parent's depression, math test performance and memory functioning, the existence of chronic diseases doesn't moderate the effect of child's gender on parent's mental health and cognition. In panel D and panel E, we find that living with children doesn't have a moderating effect on a child's gender on a parent's mental health. However, living with parent's parents has a protective effect on the parent's mathematic performance in multi-child families with a son as the first child, since grandparents may relieve parent's burden on raising children.

4. Discussion

In summary, we find that the gender of the first child doesn't significantly impact the parent's depression symptoms, but having a son significantly improves a parent's mathematics performance and verbal, especially in one-child families. In comparison, such effects are not observed in multiple-child families. To further investigate the heterogeneity across different areas, we apply three sets of sub-group analyses. We find that the improving effect is more pronounced among the one-child families in rural areas and parents who are younger than 60 years old. In terms of the gender difference, having a son improves the mother's mental health while improving the father's cognition functioning.

Our results show that the effect on depression is not significant, which seems inconsistent with the previous finding that having a son significantly reduces the happiness of parents when the sons grow up and marry, although the gender of children doesn't have a significant influence on a parent's subjective happiness when they are children or teenagers (Lu et al., 2017). It is partly because we use different measures of mental health. Lu et al. (2017) adopts subjective measurement of happiness while we use the CES-D depression score as the measurement of mental health status. Measurement error may exist in both measurements, especially in the depression measurement because depression symptoms are usually underreported due to the social stigma.

In terms of cognitive functions, we find that the effect of the first child's gender on parents differs between one-child and multiple-child families. Among multiple-child families, it is not surprising to find that the effect is not significant, as the effect of the first child might be alleviated by giving birth to more children in the family. If the parent wants a boy, but the first child is a girl, they may choose to have another child as a response to negative emotion toward the daughter. Among one-child families, our result shows that having a son has a significant protective effect on parents' mathematics function and memory function. The effect is small in scale because the son preference is likely to be weakened by several socioeconomic factors, such as modernization, the urbanization of Chinese society, and the development of the pension system. Although the size of the effect is relatively small, it is untrivial in the population scale. As around half of one-child families have a daughter, which is generally determined by the randomization of genes, the estimation from our model suggests that parents in half of the one-child families generally have a 1.56% worse mathematics function and a 1.95% worse memory function. This could also be considered an unexpected social effect of the one-child policy in China.

In general, the small scale but significant effect of a child's gender on parents' mathematics performance and memory function indicate that the preference for sons might still exist. There are several potential paths through which a child's gender might affect a parent's health, such as the financial aid and nutrition supplement, documented in the literature and discussed in the introduction, and these paths may still exist. The existence of such effect implies some extent of gender stereotypes and gender inequality—having a son which delays parents' cognitive decline by potentially bringing them more material or emotional support. Moreover, the preference for sons and gender inequality is shown to be more significant in rural areas, which is indicated by the significant difference between urban and rural areas, and the existence of gender inequality in Chinese rural areas. One study conducted in rural northwest China by the University of Pennsylvania shows that although most mothers expressed egalitarian views about girls' and boys' rights and abilities, the vast majority of mothers still expected to rely on sons for old-age support in 2000 (Hannum et al., 2009). Although research documents that daughters tend to give more financial support to their parents, formally or informally (Xie & Zhu, 2009), the preference for sons still exists due to gender stereotypes and the social stigma experienced by daughters in some areas. Our results call for future policy interventions to reduce the social stigma of gender as well as providing targeted supports to the elderly in one-child families.

This study has two main limitations. First, due to the changing measurement of outcomes, we can only use a short panel in the estimation. Second, we can only test a few mechanism of the effect, due to the limitation of data. CFPS doesn't survey the financial support and informal care provision in 2014. Also, even in the other years, CFPS only surveys the financial support and informal care from children among those who are at least 60 years old. Future research should explore more mechanisms, such as financial support and care provision, if such data becomes available.

Table 5
Mechanisms analysis.

Panel A: Family Assets						
Variables	One-child family	Multiple-child family	One-child family	Multiple-child family	One-child family	Multiple-child family
	Depression		Math		Verbal	
Gender of first child - Male	−0.178	0.167	0.155*	0.106	0.228	0.100
	(-1.64)	(1.29)	(1.87)	(1.29)	(1.33)	(0.42)
Gender of first child x Family Assets	**−0.212*** **	**−0.148***	0.035	0.037	0.118	**0.268***
	(2.86)	(1.71)	(0.60)	(0.56)	(1.05)	(1.82)
Family Assets	−0.097*	−0.199***	−0.014	0.065	0.029	0.089
	(-1.79)	(-3.22)	(-0.37)	(1.60)	(0.35)	(0.91)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Mental Health in 2010	Yes	Yes	Yes	Yes	Yes	Yes
Constant	4.081***	3.677***	1.411*	0.521	4.971***	3.643*
	(3.63)	(3.29)	(1.83)	(0.78)	(2.75)	(1.85)
Observations	6033	6257	6075	6328	6075	6328
R-squared	0.251	0.235	0.865	0.807	0.712	0.646
Panel B: Health Insurance						
Variables	One-child family	Multiple-child family	One-child family	Multiple-child family	One-child family	Multiple-child family
	Depression		Math		Verbal	
Gender of first child - Male	−0.129	0.115	0.132*	0.131	0.283*	0.097
	(-1.31)	(0.89)	(1.73)	(1.59)	(1.70)	(0.43)
Gender of first child x Any Health Insurance	**−0.721***	0.442	−0.001	0.085	0.399	0.021
	(1.88)	(0.90)	(-0.01)	(0.25)	(0.58)	(0.03)
Any health insurance	−0.253	−0.495**	0.386***	0.256	0.736**	0.516
	(-1.19)	(-2.27)	(3.02)	(1.27)	(2.17)	(1.17)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Mental Health in 2010	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.541***	1.786*	0.681	0.683	3.684**	2.549*
	(2.89)	(1.94)	(1.30)	(1.09)	(2.44)	(1.68)
Observations	6321	6588	6372	6659	6372	6659
R-squared	0.248	0.234	0.864	0.806	0.711	0.645
Panel C: Chronic Disease Management						
Variables	One-child family	Multiple-child family	One-child family	Multiple-child family	One-child family	Multiple-child family
	Depression		Math		Verbal	
Gender of first child - Male	−0.132	0.119	0.129*	0.130	0.284*	0.082
	(-1.32)	(0.93)	(1.68)	(1.61)	(1.70)	(0.36)
Gender of first child x Have chronic disease	0.146	0.010	0.052	−0.096	−0.100	−0.477
	(0.51)	(0.03)	(0.29)	(-0.55)	(-0.21)	(-1.10)
chronic	0.812***	1.037***	−0.217**	0.020	−0.524***	0.155
	(5.20)	(6.50)	(2.53)	(0.21)	(2.62)	(0.63)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Mental Health in 2010	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.313***	1.370	1.096**	0.823	4.279***	2.910*
	(2.71)	(1.50)	(2.09)	(1.35)	(2.88)	(1.85)
Observations	6324	6590	6375	6662	6375	6662
R-squared	0.253	0.240	0.864	0.806	0.711	0.645
Panel D: Living with Children						
Variables	One-child family	Multiple-child family	One-child family	Multiple-child family	One-child family	Multiple-child family
	Depression		Math		Memory	
Gender of first child - Male	−0.155	0.102	0.178**	0.122	0.318*	0.216
	(-1.51)	(0.75)	(2.11)	(1.58)	(1.91)	(0.89)
Gender of first child x Live with children	0.267	0.156	−0.061	−0.285	−0.273	−0.779
	(1.22)	(0.60)	(0.43)	(-1.59)	(-0.71)	(-1.58)
Live with children	0.013	−0.038	−0.074	0.029	−0.191	0.258
	(0.10)	(-0.23)	(-0.79)	(0.31)	(-0.77)	(1.09)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Mental Health in 2010	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.145**	1.221	1.039**	0.677	4.076***	2.453
	(2.50)	(1.31)	(1.98)	(1.10)	(2.73)	(1.57)
Observations	6315	6589	6366	6661	6366	6661
R-squared	0.248	0.233	0.864	0.806	0.711	0.645

(*continued on next page*)

Table 5 (*continued*)

Panel E: Living with Parent's Parent						
Variables	One-child family	Multiple-child family	One-child family	Multiple-child family	One-child family	Multiple-child family
	Depression		Math		Memory	
Gender of first child - Male	−0.155	0.090	0.140*	0.090	0.324*	0.063
	(-1.52)	(0.65)	(1.69)	(0.97)	(1.82)	(0.28)
Gender of first child x Live with parents	−0.112	0.228	0.187	**0.309***	−0.138	−0.424
	(-0.52)	(0.81)	(1.13)	(-1.67)	(-0.41)	(-0.99)
Live with parents	0.076	−0.298**	0.042	0.004	−0.119	−0.095
	(0.50)	(2.31)	(0.40)	(0.04)	(-0.52)	(-0.32)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Mental Health in 2010	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.294**	0.874	0.802	0.266	4.140***	1.927
	(2.46)	(0.99)	(1.40)	(0.40)	(2.60)	(1.17)
Observations	5615	5844	5659	5910	5659	5910
R-squared	0.249	0.236	0.860	0.807	0.697	0.644

Notes: (1) Data source: CFPS 2014, 2010 Survey Data. (2) All standard errors are clustered at county level. (3) All models include control variables and county-level fixed effects. (4) All models are fixed-effect models. (5) ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

5. Conclusion

In conclusion, our research shows that a son in a one-child family significantly increases the performance of parents' mathematics and memory functions, and the effect is more pronounced in rural areas and among young parents, and varies by parent's gender. Although Chinese families have undergone several major social-economic changes which make them different from the traditional "son-preferred" families, parents' cognition still benefit from having a son in the one-child family. These results imply the existence of gender inequality, especially in rural areas, and reveal the long-term hidden cost of such inequality on the human capital of the aging population.

CRediT authorship contribution statement

Yanran Chen: Study design, Data clean, Data analysis, Writing – review & editing. **Ruochen Sun:** Study design, Validation, Writing – original draft & revise.

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