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SON BIASED INVESTMENTS AND OLD AGE SUPPORT

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Son Biased Investments and Old Age Support*

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Abstract

Son biased investments are common in many Asian countries where sons are customarily responsible for providing old age support to parents. Using data from the China Health and Retirement Longitudinal Study, I find that parents invested nearly twice more in sons than in daughters in terms of college education spending and marriage gifts value. Conversely, parents received relatively higher marginal returns to investment from daughters than from sons in terms of living proximity, monetary and in-kind transfers, and help with instrumental activities of daily living. Family fixed effects models as well as an instrumental variable strategy are employed to control for the potential endogeneity of parental investments in children. The results indicate that daughters may be reciprocating parental monetary investments in their education and marriage by increasing old age support. The findings suggest that daughters may be a viable source of support to parents and that encouraging parental investments in them may lead to an increase in family provided old age support.

JEL: D13, I26, J13, J14, J16
Keywords: son bias, parental investment, old age support, reciprocity

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1. Introduction

Son biased parental investments are prevalent in many societies (Alderman and Gertler 1997; Chen et al. 2014; Lee 2007; Lhila and Simon 2008; Lillard and Willis 1997; Rosenzweig and Schultz 1982). It has been hypothesized that such son bias may be attributed to the fact that, in patriarchal societies, sons are responsible for providing old age support to parents whereas daughters leave the family upon marriage (Das Gupta et al. 2003; Jayachandran 2015). There is indeed evidence that children may be an important source of support in developing Asian countries, with transfers flowing predominantly from children to parents and where a large proportion of elderly also live with their adult children (Cai, Giles, and Meng 2006; National Research Council 2012).[1]

Reciprocity from children is traditionally enforced by social norms such as the Confucian philosophy where filial piety and altruism are highly valued. Parents may also manipulate children towards providing old age support through investments in their human capital (Becker et al. 2016). Yet, in 2013, the People's Republic of China (PRC) deemed it necessary to introduce a new law requiring children to provide for the needs of their parents or face fines and potential jail time (Russo 2013). This leads us to the following questions: Do investments in children pay off in terms of old age support? Are there gender differences in realized marginal parental old age support returns to investment?

This paper first describes how parental investments in children and old age support differed by children's gender using data from the 2013 China Health and Retirement Longitudinal Study (CHARLS), a nationally representative data set of Chinese residents aged 45 and above. Parents invested nearly twice more in sons than in daughters in terms of education spending and marriage gifts (inclusive of house and betrothal gifts). Whereas parents received higher old age support from sons in terms of living proximity (inclusive of coresidence), parents were more likely to receive monetary and in-kind support from non-coresident daughters.

I next estimate the differences in realized marginal parental old age support returns to investment in sons and daughters. Investment is measured in terms of college education and marriage spending whereas old age support receipt is measured in terms of living proximity, monetary and in-kind support, and help with instrumental activities of daily living (IADL). Gender-household group analysis estimates the parental returns to total investment by gender group on the sample of families with children whereas child level analysis estimates the parental returns to investment per child by gender on the sample of families with at least one son and one daughter.

I employ family fixed effects models as well as an instrumental variable approach to control for the potential endogeneity of investment. In particular, family fixed effects control for fixed family level unobserved factors that may correlate with both parental investments and old age support. On the other hand, the instrumental variable approach exploits the fact that the allocation of parental investments among children of different genders may have varied over time such that *interaction terms* between the first born child's gender and birth year are used as exogenous instruments for parental investments. I posit that

[1]This is in contrast to the US where Social Security is well established and where intergenerational transfers flow predominantly from parents to children (McGarry and Schoeni 1995). The evidence on gender preference in the US also tends to be mixed (Baker and Milligan 2013; Dahl and Moretti 2008).

gender of the *first born* child is exogenous based on the fact that sex ratios for first births were similar prior to and after the introduction of the one child policy (Chen et al. 2013; Ebenstein 2010). Sensitivity analyses are also performed on the sample of families that are unlikely to have been affected by the one child policy.

Gender differences in the marginal increase in probability of receiving old age support (from sons minus daughters) ranged from -1.1% to -4.2% at the gender-household group level and from -2.3% to -4.8% at the child level per 10,000 yuan (≈1,600 USD) invested. Tests of differences suggest that marginal returns to investment in daughters were higher relative to marginal returns to investment in sons. The results also hold for the subsamples of rural and urban households, and were robust to alternative specifications and estimation strategies. Taking into account the levels of reciprocity and market returns of children suggests that gender differences in the value of annual marginal parental old age support returns ranged from -374 yuan to -1,870 yuan at the gender-household level and from -618 yuan to -723 yuan at the child level per 10,000 yuan invested.

This paper contributes to the literature on gender differences in investment in children and to the literature linking investment in children to old age support. The first literature has documented evidence suggestive of son biased investments in various forms such as larger family sizes when the first born is a girl (Dahl and Moretti 2008; Lee 2007), higher school enrolment rates for boys (Alderman and Gertler 1997; Bauer et al. 1992), and higher spending on sons' private education (Choi and Hwang 2015). Such biased investments have been attributed to various reasons such as persistence in patriarchal values and the perception that sons may generate greater economic returns and provide greater old age support (Das Gupta et al. 2003; Jayachandran 2015).

The second literature has linked higher fertility to higher old age support (Caldwell 1976; Cunningham et al. 2013; Oliveira 2016; Zimmer and Kwong 2003) and documented positive correlations between education attainment and financial transfers from children (Lee and Xiao 1998; Lillard and Willis 1997; Raut and Tran 2005), suggesting that children may be reciprocating parental investments in their education. Sons are still viewed as an important source of support in the PRC. Ebenstein and Leung (2010) found that parents who have at least one son were less likely to enroll in a pension program whereas Huang et al. (2015) found that parents who expect old age support from sons were more likely to match-make their sons to daughters-in-laws who would be more suited to household production. There are also accounts of daughters providing support or comfort to older parents in Asia (Salaff 1976; Teerawichitchainan 2016), suggesting that daughters may also be of help to parents. Children may provide support to parents due to numerous reasons such as filial duty stemming from social norms, altruism where children care about the well-being of parents, and exchange motives where children reciprocate parental transfers (Altonji et al. 1992; Andreoni 1990; Cox and Rank 1992).

This study merges the two strands of the literature by first, directly linking past parental *monetary* investments in children to old age support receipt and by second, estimating the differential parental returns by gender of the children. I focus on parental spending on college education and marriage which represent two major components of investment in children.[2] This study also takes into account various forms of old age support such as

[2] While the literature tends to use education attainment or marital status as proxies for parental invest-

living proximity to children, monetary and in-kind transfers from non-coresident children and help with IADL. I focus on old age support returns from a pure production efficiency point of view and do not attempt to distinguish between the different hypotheses behind intergenerational transfers. In particular, this paper studies whether parental investments stimulate old age support and whether there are gender differences in returns.

Given the reliance of parents on children for old age support in developing countries, it is important to understand whether son biased investments were optimal from an old age support receipt perspective and whether daughters were as "useless" in that respect as customarily believed.[3] In the light of a rapidly aging population, this study raises some important policy implications for parental investments in children and for the future of old age support in the PRC. In particular, encouraging parental investments in daughters may help increase informal old age support provisions.

I next document gender differences in investment and old age support. The following sections sketch an old age support production model and present the empirical strategy. Results on marginal parental returns from sons and daughters are then presented. The last section concludes.

2. Descriptive Statistics

2.1 Data

I use data from the 2013 China Health and Retirement Longitudinal Study (CHARLS). The study surveyed one person per household who was 45 years or older and the spouse, totaling 17,708 individuals living in 10,257 households in 28 of the PRC's provinces (CHARLS Research Team 2013). Besides containing detailed information on demographic characteristics of parents and coresident and non coresident children, CHARLS also contains information on intergenerational transfers. The survey includes past transfers made from parents to children in terms of college education expenditure and marriage gifts. The survey also includes details on living arrangements, monetary and in-kind transfers from non coresident children, and help with IADL.

I drop families where the family respondent (parent) was aged less than 40 or had children aged less than 21, so as to ensure that parents' fertility decisions and investment provisions for most children were likely to have been completed.[4] Summary statistics for the sample of 8,424 families are presented in Table 1.

The average age of parents was 62 while the average age of children was 34.7. 78% of parents were married while the corresponding percentage for children was 79%. The average number of children was 2.80 among which 56% were male. The higher proportion of male children is consistent with the PRC's well-known skewed gender ratio (Qian 2008;

ments, they are imperfect measures of the actual amount spent by parents. Wei and Zhang (2011) reported that 85% of Chinese households save primarily for children's education and marriage expenses.

[3] Li and Lavely (2003) documented that 85% of rural Chinese women believed that it was important to have a son and that 75% (3%) expected to receive financial support from sons (daughters).

[4] The family respondent was either the main respondent or the spouse, and was responsible for answering questions related to family transfers. Results from the subsample of (older) parents with children born prior to the 1979 one child policy were similar to those from the main sample. Approximately 2% of children had birth year missing and were dropped from the sample.

Wei and Zhang 2011), and is a potential indicator that parents may have a preference for sons.

26% of families had at least one college educated child and 89% of parents in such families reported incurring positive college expenditure to the question: "*How much did you and your spouse spend to support this [child name]'s college education?*". The mean of total college education support to all children was 20,868 yuan per family at 2013 prices.[5]

Brandt et al. (2015) documented parental education expenditure (including tuition fees, books, room and board) since elementary school from a sample of 140 rural households with parents aged 50-69 and with at least two married sons in Hebei Province. The average education expense for rural households in CHARLS was similar to their estimate, suggesting that college education expenses may be the biggest component of education investment that a family may incur.[6]

Another major component of parental investment is marriage gifts to children. Marriage gifts are defined as the sum of betrothal gifts and house gifts to children from the respective questions: "*Did you give betrothal gifts when [child name] got married? At that time, how much was the total value of the betrothal gifts*?" and "*Did you buy a house for him/her when [child name] got married? At that time, how much was the total value of the house?*". Approximately 89% of families had at least one married child and 66% of parents made a marriage gift. The mean of total marriage gifts value to all children was 18,845 yuan per family at 2013 prices.[7] In total, 74% of parents invested in children either in terms of college education spending or marriage gifts. The mean of investment in children was 39,713 yuan per family.

55% of parents had at least one resident child in the same household and 72% of parents had at least one child living in the same household or in the same village or neighborhood. Over the year prior to the interview, 69% of parents received monetary or in-kind support from non-coresident children, with an average value of 3,333 yuan per family. Monetary support included help with living expenses while in-kind support included gifts of food or clothing.[8]

Support provided to parents suffering from an IADL limitation is documented in Table 1. Such activities are based on the questions "*Who most often helps you with [dressing/bathing/eating/ getting (in/out of) bed/using the toilet]?*" and "*Who most often helps you with [do household chores/preparing hot meals/shopping/making telephone calls/taking medications]?*" Approximately 35% of respondents reported having difficulty performing at least one of such tasks and 33% of such respondents received help from children (including children's spouse).

[5]Education expenditure was converted to 2013 prices assuming that the expenses were incurred when the child was aged 20. 2% of families had missing college expenditure for at least one child, which was imputed as zero. Dropping those families from the sample did not change any of the results. The conditional mean of total college education support to all children among families with positive expenditure was 90,477 yuan per family.

[6]The means of education expenses for rural households in the CHARLS sample and in Brandt et al. (2015) were, respectively, 8,147 yuan per son and 8,173 yuan per son at 2013 prices.

[7]Marriage gifts value for each child was converted to 2013 prices assuming that the expenses were incurred in the year when the child got married. The conditional mean of total marriage gifts value to all children among families with positive expenditure was 29,595 yuan per family.

[8]In contrast, support to non-coresident children were much lower: Only 23% of parents provided support to children over the past year. Since the main interest is to estimate parental returns to investment by child gender, I focus on support received by parents.

Living proximity, monetary or in-kind transfers and help with IADL seem to be important ways in which children provided old age support to parents. From t-tests of differences in means, parents who lived with (close to) an adult child were 16% (8%) less likely to receive support from non coresidents compared to parents who did not live with (close to) an adult child ($p < 0.05$). Conversely, parents who lived with or close to an adult child were 16% more likely to receive help with IADL ($p < 0.05$). This suggests that there may be some substitution or complementarity between the means of support from children.

Table 1 Summary Statistics

	Mean/Proportion	Standard Deviation
Age of parent	62.04	10.09
Prop. of parents male	0.47	0.50
Prop. of parents married	0.78	0.41
No. of children	2.80	1.45
Prop. of parents with primary school	0.40	0.49
Prop. of parents with secondary school	0.20	0.40
Prop. of parents with high school	0.12	0.32
Prop. of parents with college degree	0.02	0.15
Age of children	34.66	8.46
Prop. of children male	0.56	0.32
Prop. of children married	0.79	0.33
No. of grandchildren per child	1.24	3.70
Prop. of children with primary school	0.31	0.39
Prop. of children with secondary school	0.33	0.37
Prop. of children with high school	0.16	0.29
Prop. of children with college degree	0.17	0.32
Amount spent on college education	2.09	7.08
Prop. gave marriage gift to children	0.66	0.47
Amount given to children	1.88	4.03
Prop. of parents who invested in children	0.74	0.44
Amount invested	3.97	8.32
Prop. with resident children	0.55	0.50
Prop. with children living close	0.72	0.45
Prop. receiving support from children	0.69	0.46
Amount of support	0.33	1.05
Prop. of parents with IADL limitation	0.35	0.48
Prop. receiving children's help with IADL	0.33	0.47
Prop. of parents living in urban area	0.40	0.49
Prop. of parents Han	0.93	0.26
No. of families	8,424	

Note: The parent refers to the family respondent in CHARLS. All monetary values are in 10,000 Yuan ≈ 1,600 USD and were converted to 2013 prices using the GDP deflator from Index Mundi for years prior to 1986 and the CPI from World Bank for years 1986 onwards.

2.2 Gender Differences

Table 2 documents the means of parental investment and old age support by gender of children. The means are documented by gender-household group (total by gender) from the sample of all families and by child gender (per child) from the sample of children in families with at least one son and one daughter. t-tests of differences in means by gender are reported in the last column.

Table 2 Investment in Children and Old Age Support by Children's Gender

	Sons Mean (sd)	Daughters Mean (sd)	Difference in Means
Gender-Household Group (all families)			
Lifetime investment in children			
Prop. with college education	0.16 (0.37)	0.13 (0.34)	0.03**
Amount spent on college education	1.21 (5.08)	0.88 (3.60)	0.33**
Prop. gave marriage gift	0.53 (0.50)	0.36 (0.48)	0.17**
Value of marriage gifts	1.42 (3.61)	0.47 (1.50)	0.95**
Prop. invested in children	0.58 (0.49)	0.41 (0.49)	0.17**
Amount spent on education and marriage	2.63 (6.34)	1.35 (4.07)	1.28**
Annual old age support from children			
Prop. with best living proximity	0.53 (0.50)	0.25 (0.43)	0.28**
Prop. receiving support	0.43 (0.50)	0.54 (0.50)	-0.11**
Amount of support received	0.18 (0.72)	0.16 (0.08)	0.02†
Prop. receiving help with IADL	0.27 (0.44)	0.10 (0.30)	0.17**
No. of families	8,424	8,424	
No. of children	12,356	10,642	
Child Sample (families with at least one son and one daughter)			
Lifetime investment per child			
Prop. with college education	0.10 (0.30)	0.09 (0.28)	0.02**
Amount received for college education	0.61 (3.59)	0.47 (2.72)	0.14**
Prop. received marriage gift	0.51 (0.50)	0.39 (0.49)	0.12**
Value of marriage gifts received	0.85 (2.34)	0.31 (0.97)	0.54**
Prop. received investment	0.56 (0.50)	0.44 (0.50)	0.12**
Amount received for education and marriage	1.47 (4.36)	0.78 (2.97)	0.68**
Annual old age support to parent			
Prop. with best living proximity	0.54 (0.50)	0.22 (0.41)	0.32**
Prop. giving support	0.49 (0.50)	0.72 (0.45)	-0.24**
Amount of support given	0.12 (0.62)	0.12 (0.64)	0.00
Prop. giving help with IADL	0.21 (0.41)	0.07 (0.26)	0.13**
No. of families	5,302	5,302	
No. of children	8,766	8,760	

Note: Means, proportions, standard deviations (in parentheses) and two-tailed t-test of differences are reported. Gender-household group is based on all families while the child sample is based on children in families with at least one son and one daughter. Investment and support are in 10,000 Yuan ≈ 1,600 USD. †p < .10; *p < .05; **p < .01.

On average, parents invested 3,319 yuan (9,491 yuan) more in sons than in daughters in terms of college education spending (marriage gifts value) by gender-household group. Similarly, parents invested 1,397 yuan (5,411 yuan) more per son than per daughter in terms of college education spending (marriage gifts value) in families with both sons and daughters. In terms of total investment in education and marriage, parents invested nearly twice more in sons than in daughters.

Since living proximity may be helpful to either parents or to adult children, taking into account parents' preferred living arrangement in old age may provide a more accurate measure of old age support.[9] I construct a dummy variable that takes a value of 1 if the parent had a child coresident or living in the same village or neighborhood and the parent deemed such arrangement to be the best for an elderly person, and a value of 0 otherwise. The best living arrangement is based on the questions: *"Suppose an elderly person has (a spouse / no spouse) and adult children, and has good relationship with them, what do you think is the best living arrangement for the elderly person?"* The dummy variable was strongly correlated with actual living proximity ($\rho \approx 0.91$, $p < 0.05$).

On average sons were 28% to 32% more likely to provide support in terms of living proximity. Parents with an IADL limitation were also 13% to 17% more likely to receive IADL help from sons (and daughters-in-law). On the other hand, parents were 11% to 24% more likely to receive monetary and in-kind support from non coresident daughters than from non coresident sons.

The descriptive statistics suggest that parents invested relatively more in sons than in daughters in terms of college education and marriage gifts. Parents received higher old age support from sons in terms of living proximity and IADL help whereas parents were also more likely to receive monetary and in-kind support from non coresident daughters.

3. Model

I sketch below a simple model of old age support from a pure production efficiency perspective to highlight the mechanisms by which parental investments may affect old age support. The model incorporates elements of filial duty, altruism and reciprocity: Children who care more about parents' old age support provide higher support and children who receive higher parental investments generate higher market returns which enable them to provide higher old age support. I also show that pure old age support production efficiency implies that parents equalize the marginal returns to investments between sons and daughters. The condition implies that if marginal returns were not equalized between children of different genders, then by reallocating parental investments across genders, one may achieve higher old age support.

3.1 Framework

Consider a two stage model where parents make investment decisions in the first stage and children make old age support decisions in the second stage. Parents care about

[9] In particular, grandchild care may be an important source of support that coresident parents provide to their adult children (Compton and Pollak, 2014; Ho, 2015a,b). Parents were 22% (19%) more likely to provide grandchild care to sons (each son) than to daughters (each daughter). Controlling for receipt of grandchild care in the baseline models below yielded similar results and conclusions.

their consumption C_p and about total old age support received from children $\bar{O} = \sum_{i=1}^{n} O_i$, where O_i is support received from child i and n is the total number of children. Parents' utility is given by $u\left(C_p, \bar{O}\right)$, where u is separable, increasing, and concave in its arguments: $u_x > 0$ and $u_{xx} < 0$, $x = C_p, \bar{O}$. Parents are endowed with exogenous income M_p in the first stage and decide how much to allocate to consumption C_p and to investment I_i in each child i.

In the second stage, each child cares about his or her consumption C_i and old age support provided to parents O_i. Child i's utility is given by $v_i\left(C_i, O_i\right)$, where v_i is separable, increasing, and concave in its arguments: $v_{ix} > 0$ and $v_{ixx} < 0$, $x = C_i, O_i$. Children care about their old age support provision to parents which may stem from the historically grounded Confucian norm of filial duty and altruism (Das Gupta et al., 2003; Jayachandran, 2015; Zimmer and Kwong, 2003).[10]

Each child has market returns, $M_i\left(I_i\right)$, which is an increasing and concave function of parental investment from the first stage: $M_i' > 0$ and $M_i'' < 0$. For instance, higher investment in children's education and marriage may lead to higher labor market earnings as well as better prospects to marry a spouse with high earnings capacity. This may result in higher overall child family income which may influence children's ability to provide old age support.

I assume that children of the same gender have the same preferences and market returns but that preferences and market returns may differ by gender. It follows that parents invest the same amount in each child of the same gender but investment per child may differ by gender. The model is solved using backward induction.

3.2 Children's Problem

Taking parental investment as given, each child i maximizes utility:

$$\underset{C_i, O_i}{Max} \quad v_i\left(C_i, O_i\right),$$

subject to the budget constraint

$$C_i + O_i = M_i\left(I_i\right).$$

The following results hold ceteris paribus: (i) Optimal support from child i, O_i^*, is increasing in I_i, and (ii) Total optimal support from children of gender g, $\sum_{i=1}^{n_g} O_i^*$, is increasing in I_i and n_g, where n_g is the total number of children of gender g (see Appendix for derivation). The intuition behind those results is straightforward. An increase in parental investment per child increases market returns of the child, which in turn, relax the budget constraint. The child may thus increase both consumption and old age support O_i^*. If parents invest more in children of a certain gender, then it follows that total support from

[10] Whereas transfers from children do not seem to stem from strategic bequest motives nor from payment for grandchild care services (Oliveira, 2016), there is some empirical evidence that support the altruism motive (Cai et al., 2006) in the PRC. The qualitative predictions presented in this section would still hold in an extended model of altruism where children care about total old age support received by the parents $\bar{O}$ (see Appendix).

all children of that gender $\sum_{i=1}^{n_g} O_i^*$ increase. Similarly, all else equal, total old age support from children of the same gender $\sum_{i=1}^{n_g} O_i^*$ increase in the number of children of that gender. This gives rise to the following hypothesis:

Hypothesis 1 (Marginal Returns): There exists a positive relationship between old age support and parental investments.

3.3 Parents' Problem

Let S denote sons and D denote daughters. Parents choose consumption and investment in sons and daughters taking into account the fact that such investments will affect old age support:

$$\underset{C_p, I_S, I_D}{Max} \quad u\left(C_p, \sum_{i=1}^{n_S} O_S\left(I_S\right) + \sum_{i=1}^{n_D} O_D\left(I_D\right)\right),$$

subject to the budget constraint

$$C_p + \sum_{i=1}^{n_S} I_S + \sum_{i=1}^{n_D} I_D = M_p.$$

Parents therefore equate the marginal returns to investment between sons and daughters:

$$O'_S\left(I_S\right) = O'_D\left(I_D\right). \tag{1}$$

Note that the equality in marginal returns from sons and daughters also hold at the gender-household group level (see Appendix for derivation). This gives rise to the following hypothesis:

Hypothesis 2 (Gender Differences in Marginal Returns): Failure to reject (satisfy) old age support optimality condition Eq. 1 indicates that parents may (not) be optimally allocating resources between sons and daughters from a *pure old age support production efficiency* perspective.[11]

4. Empirical Strategy

In gender-household group analysis, each family has two observations (one for each gender group) and the marginal returns to total investment in each gender group are estimated on the sample of all families. Total investment by gender is given by $\sum_{i=1}^{n_g} I_i$ such that the effect of increases in per child investment and in the number of children in a given gender group are simultaneously captured. In child level analysis, each family has several observations (one for each child) and the marginal returns to investment per child is estimated

[11] Note that failure to reject or rejection of the production efficiency condition in the empirical exercize does not invalidate the various potential reasons for gender differences in parental investments offered in the literature but rather sheds light on whether investment across children of different genders were optimal from a pure old age support production efficiency criteria.

on the sample of children in families with children of both genders. Per child investment is given by I_i such that only the effect of increases in per child investment is captured.[12]

Old age support, O, is defined as an index that takes a value of 1 if the parent had a child living close and reported that this was the best living arrangement, or received support of more than 1,000 yuan from non-coresidents, or received IADL help; and a value of 0 otherwise. The index therefore captures any support provided by children, irrespective of whether the support was in the form of living proximity (inclusive of coresidence that may also capture shared public goods), or monetary and in-kind transfers, or IADL help. O is defined according to gender-household group or per child in the relevant analyses. From the sample of all families, 70% and 50% of parents received such support from sons and daughters respectively, and from the sample of children in families with both sons and daughters, 73% of sons and 49% of daughters provided such support.

Several empirical models are used to estimate marginal parental returns to investment. Baseline models consist of ordinary least squares (OLS) models that treat old age support as a linear variable and of probit models that take into account the discrete nature of old age support. Family fixed effects (FE) models and two-stage least squares (2SLS) models take into account the potential endogeneity of investments. Both strategies attempt to control for unobserved characteristics that may correlate with both investments and old age support, which may bias the baseline estimates.

4.1 Baseline Models

The following model is estimated by *gender-household group* using OLS and probit:

$$O_g = \beta_{g0} + \beta_{g1} I_g + \beta_{g2} I_g^2 + \beta_{g3} X + u_g, \tag{2}$$

O_g represents old age support from children of gender $g = S, D$; I_g denotes the total amount of parental investment in college education and marriage of children in 10,000 yuan; X is a vector of covariates that include characteristics of parents: gender, second order polynomials in age, dummy variables for primary, secondary, high school and college education, marital status, first born son, first born twin children, Han ethnicity, IADL limitation, urban area of residence and province dummies; and characteristics averaged across all children: second order polynomials in age, proportion of children with primary, secondary and high school education, and number of grandchildren; and u_g is an error term.[13]

[12] Note that while the model sheds light on that fact that parents optimally equate marginal returns between sons and daughters at both the gender-household group level and at the child level, estimated marginal parental returns from the two levels may not necessarily be equal. First, while the child level analysis only captures the effects of an increase in per child investment, the gender-household group analysis captures the effect of increases in total investment, which may arise due to an increase in the number of children in a certain gender group, which in turn, may lead to a change in per child investment. Second, the sample of families with both sons and daughters may be different from the sample of all families. For instance, such families may have a stronger son preference if they chose to have children until a son is born: While the child sample is evenly made up of 50% male and female children, 55% (45%) of children had a sister (brother) as the eldest sibling. If stronger son preference implies stronger son biased investments, then the estimated gender differences in returns from the child sample are likely to represent upper bounds.

[13] A flexible second order polynomial is specified for investment: The estimated $\hat{\beta}_{g1}$ was positive and $\hat{\beta}_{g2}$ was negative suggesting diminishing marginal returns. Sensitivity analysis performed using a logarithmic function in investment or by dropping families with more than 100,000 yuan investment (approximately 9.8%

Since family size may be endogenous, I control for variables that may proxy for the number of children such as the presence of a first born son and the presence of first born twins (Dahl and Moretti 2008; Lee 2007; Li et al. 2008; Oliveira 2016; Rosenzweig and Zhang 2009). Families with a first born son had on average 0.32 fewer children ($p < 0.05$) while families with first born twins had on average 0.73 more children ($p < 0.05$). The old age support equation may therefore be interpreted as a reduced form version where the equation for family size has been substituted in and where family size is a function of the presence of a first born son, the presence of first born twins, and family characteristics captured in X. Explicitly controlling for family size in sensitivity analysis yielded quantitatively similar results.

Whereas one may worry about the exogeneity of gender of the first born child, Ebenstein (2010) reported that the male ratios for first births in China Census were similar across families who were subject to and not subject to the 1979 one child policy rule. Similarly, Chen et al. (2013) documented relatively stable gender ratios for first births between 1975 to 1992 and found no evidence that the diffusion of ultra sound technology was linked to the probability of having a first born son from the Chinese Children Survey. 52.8% of parents had a first born male child in the CHARLS sample, which is close to the gender ratio for first births reported in the literature. There were no statistically significant differences in parental age, marital status and education among families with and without a first born son. Sensitivity analyses on the subsamples of families with children born prior to 1979 (which was also prior to the diffusion of ultrasound technology in the mid-1980s) and families where the parent holds an agricultural hukou (and thus faced less strict fertility rules (Wang 2005)) yielded similar results to those from the main sample.

1.38% of families had first born twins and 1.7% of children in families with children of both genders had first born twin siblings. There were no statistically significant differences in parental age, marital status and education among families with and without first born twins. Sensitivity analysis using twins at any parity yielded quantitatively similar results.

The estimates for sons and daughters are combined as seemingly unrelated estimations in order to compute gender differences in marginal returns. The marginal returns to investment from OLS models are computed as $\left(\hat{\beta}_{g1} + 2\hat{\beta}_{g2}\bar{I}_g\right)$, where $\bar{I}_g$ is the average investment in gender g. In probit models, the marginal returns to investment are computed as $\phi\left(\hat{\beta}_{g0} + \hat{\beta}_{g1}\bar{I}_g + \hat{\beta}_{g2}\bar{I}_g^{\,2} + \hat{\beta}_{g3}\bar{X}\right)\left(\hat{\beta}_{g1} + 2\hat{\beta}_{g2}\bar{I}_g\right)$, where ϕ is the normal probability density function and $\bar{X}$ are the average values of X in the sample. Standard errors are computed using the delta method (Wooldridge 2010).

The following model is estimated at the *child level* using OLS and probit:

$$O_{ij} = b_0 + b_1 I_{ij} + b_2 I_{ij}^2 + b_3\left(I_{ij} \times boy_{ij}\right) + b_4\left(I_{ij}^2 \times boy_{ij}\right) + b_5 X_{ij} + u_{ij}, \quad (3)$$

O_{ij} represents old age support from child i in family j; I_{ij} is investment in education and marriage in 10,000 yuan; boy_{ij} is a dummy variable taking a value of 1 if child i is male and a value of 0 otherwise; X_{ij} is a vector of covariates that include characteristics of

of the sample) yielded similar results. Controlling for household wealth or excluding controls for parents' marital status and IADL limitation, children's primary, secondary and high school education, and number of grandchildren also yielded quantitatively similar results.

parents as defined above and characteristics specific to child i as listed above, and is also inclusive of child gender and birth order; u_{ij} is an error term.[14]

The marginal returns to investment from OLS models are computed as $\left(\hat{b}_1 + 2\hat{b}_2\bar{I}\right)$ for daughters and $\left(\hat{b}_1 + 2\hat{b}_2\bar{I} + \hat{b}_3 + 2\hat{b}_4\bar{I}\right)$ for sons, where $\bar{I}$ is the average per child investment. The marginal returns from probit models are computed as $\phi\left(\hat{\mathbf{b}}'\bar{\mathbf{X}}\right)\left(\hat{b}_1 + 2\hat{b}_2\bar{I}\right)$ for daughters and $\phi\left(\mathbf{b}'\bar{\mathbf{X}}\right)\left(\hat{b}_1 + 2\hat{b}_2\bar{I} \;\; +\hat{b}_3 + 2\hat{b}_4\bar{I}\right)$ for sons, where $\bar{\mathbf{X}}$ represent the average values of all covariates.

4.2 Family Fixed Effects Models

The model presented in the previous section suggests that investments in children depend on parents' *perceived* old age support returns from children. Generous parents may believe that their children would also be generous such that there may be a postive correlation between investment and the error terms in the old age support equations, which in turn, would lead to overestimation of the marginal returns in the baseline models. Conversely, parents who are prone to spoil their children may not only spend more on them but may also raise them as self-entitled individuals so that the children may be less inclined to provide old age support. Not controlling for such endogeneity would lead to underestimation of the marginal returns in the baseline models.

In an attempt to control for such endogeneity, I estimate FE models. In particular, the error terms in Eq. 2 and Eq. 3 can be decomposed into a family fixed effect and a random component. The identifying assumption is that investment may be correlated with the family fixed effects but not with the random error terms. The FE models are estimated using first differences between son and daughter groups in the gender-household group analysis and using within-group family differences in the child level analysis. Any fixed family level charateristic such as unobserved family taste is therefore differenced out.

4.3 Two-Stage Least Squares

I also employ 2SLS models in an attempt to control for the potential endogeneity of investment. For the sake of clarity, the intuition behind the instrumental variable strategy is interpreted in conjuction with the model presented in the previous section. From the second stage children's problem, old age support depends on children's reciprocity (say, the preference weight on old age support relative to consumption) and market returns to parental investments within the year prior to the respondents' interview in 2013.

Conversely, from the first stage parents' problem, investments in children depend on parents' income as well as parents' perceived reciprocity and market returns by child gender *at the different timings at which the investment decisions were made*, that is, when the

[14] I control for birth order as it may be correlated with parental investments or with old age support (Black et al. 2005; Wakabayashi and Horioka 2009). The coefficient of birth order was statistically insignificant at the 5% level in all regressions from the CHARLS sample. Sensitivity analysis performed by controlling for children's marital and college status or by dropping children who received zero parental investments in their education and marriage yielded quantitatively similar results. A previous version of the paper also estimated marginal returns at the extensive margin (for any investment) in children and the results were qualitatively similar to the findings in the current paper.

children went to college or got married. Such perceived reciprocity or market returns may have varied over time. For instance, a series of economic reforms were implemented in the PRC in the 1980s aiming at shifting the PRC from a planned economy to a more market based economy. While market returns to education have been found to be low prior to the mid-1980s (Maurer-Fazio 1999), such returns increased dramatically from 1988 and especially for women (Zhang et al. 2005).

Such considerations may have influenced parental allocation of investment resources to sons and daughters. For example, with females experiencing relatively higher market returns in the PRC, parents may change their perception that female children generate lower returns than males and therefore be more inclined to invest in female children. Conversely, with such improvement in female economic status, parents may instead be more willing to invest in sons so as to increase their chances of finding a suitable marriage match. Appendix Figure A1 illustrates the variations in means of parental investments in sons and daughters by birth cohort of the first child.

I use *interaction terms* between birth year dummies and gender of the first born child as instruments to control for the potential endogeneity of investment. As argued above, gender of the first born child is likely exogenous based on the fact that sex ratios for first births were similar prior to and after the introduction of the one child policy (Chen et al. 2013; Ebenstein 2010). The interaction terms are meant to capture the allocation of parental investments by gender at the different timings at which investment decisions were made.[15] Thus, the main identifying assumption is that the interaction terms affect old age support only through investments in children.

In the empirical analysis, F-tests of the hypothesis that the coefficients of the instrumental variables were zero in the first stage investment regressions were rejected at the 5% significance level. The Sargan and Basmann tests of the hypothesis that the over-identifying restrictions are valid could not be rejected at the 5% significance level in both the gender-household group ($p \in (0.15, 0.19)$) and child level ($p \in (0.47, 0.48)$) analyses.

The following first stage equations are estimated by *gender-household group* using OLS:

$$Inv_g = \alpha_{g0} + \alpha_{g1}\left(first\ birth \times boy\ first\right) + \alpha_{g2}X + \psi_g, \tag{4}$$

where Inv_g represent the investment related terms in Eq. 2; X is a vector of covariates as defined in the baseline model; $first\ birth$ are birth year dummies of the first born child; $boy\ first$ is a dummy variable taking a value of 1 if the first born child is male and a value of 0 otherwise; and ψ_g is an error term. Old age support Eq. 2 are estimated using the predicted values for the investment related terms from Eq. 4.

The following first stage equations are estimated at the *child level* using OLS:

$$Inv_{ij} = a_0 + a_1\left(first\ birth_j \times boy\ first_j\right) + a_2 X_{ij} + \psi_{ij}, \tag{5}$$

where Inv_{ij} represent the investment related terms in Eq. 3; X_{ij} is a vector of covariates

[15] Note that, as described above, parents' and children's ages as well as gender of the first born child are separately controlled for in the vector of covariates X and are therefore allowed to affect both old age support and investment. Conversely, the interaction terms between birth year dummies and gender of the first born child only enter the investment equations so that the 2SLS model is identified from the additional exogenous variation captured by the interaction terms. Sensitivity analysis on the sample of families with children born prior to the one child policy or with an agricultural hukou yielded quantitatively similar estimates.

as defined in the baseline model; $first\ birth_j$ and $boy\ first_j$ are as defined above; and ψ_{ij} is an error term. Old age support Eq. 3 is estimated using the predicted values for the investment related terms from Eq. 5.[16]

4.4 Hypothesis Testing

Denote the estimated marginal returns from sons and daughters as $\hat{r}_S$ and $\hat{r}_D$ respectively. In line with Eq. 1, I test the hypothesis that the estimates for sons and daughters were equal, $H_0 : \hat{r}_S - \hat{r}_D = 0$. The Wald statistics is given by:

$$\frac{(\hat{r}_S - \hat{r}_D)^2}{Var(\hat{r}_S) + Var(\hat{r}_D) + 2Cov(\hat{r}_S, \hat{r}_D)} \sim \chi^2_{(1)}.$$

I also test the hypotheses that the estimates for sons were greater or smaller than for daughters: $H_1 : \hat{r}_S - \hat{r}_D > 0$ or $H_2 : \hat{r}_S - \hat{r}_D < 0$ respectively, using one-tailed z tests.

5. Parental Old Age Support Returns to Investment

5.1 Marginal Parental Returns

Table 3 reports the marginal parental returns to investment in sons and in daughters, as well as the differences in marginal returns between sons and daughters. The marginal effects per 10,000 yuan invested are reported at the gender-household group level from the sample of all families and at the child level from the sample of children in families with both sons and daughters.

From the gender-household group analysis, a 10,000 yuan increase in parental investment in sons was associated with an increase in the probability of receiving old age support from sons. The increase in probability ranged from a low of 1.6% in the OLS model to a high of 2.3% when controlling for family fixed effects. Moreover, a 10,000 yuan increase in parental investment in daughters was associated with an increase in the probability of receiving old age support from daughters. The increase in probability ranged from a low of 2.7% in the OLS model to a high of 5.9% in the 2SLS model. Similarly, from the child level analysis, daughters increased the probability of providing old age support from a low of 1.8% per 10,000 invested in the FE model to a high of 5% per 10,000 yuan invested in the 2SLS model. Marginal parental returns from daughters were statistically significant ($p < 0.05$) in all specifications. On the other hand, marginal parental returns from sons were statistically significant ($p < 0.05$) at the gender-household level but statistically insignificant in most specifications at the child level.[17]

[16] Control function models, where the old age support equations are estimated using probit and including the predicted residuals from the investment equations as additional covariates (Rivers and Vuong 1988; Wooldridge 2010), yielded similar results. Amemiya-Lee-Newey tests of the hypothesis that the over-identifying restrictions are valid could also not be rejected at the 5% significance level.

[17] As can be seen from Appendix Tables A1, A2 and A3, the generally negative marginal returns from sons in the child level analyses seem to be driven by education investment in rural households and living proximity. It is possible that once a sibling provides old age support, the other sons are less likely to provide such support, with the highly educated ones moving away for work. This would be consistent with Rosenzweig and Zhang (2014), who found that coresidence is lower for higher income children. t-tests of differences in means reveal that college educated sons (daughters) were 11% less (20% more) likely ($p < 0.05$) to provide support than their non-college educated counterparts. I leave such interesting considerations on inter-sibling allocations of support by gender for future research.

Table 3 Marginal Parental Returns to Investment in Sons and Daughters

	Gender-Household Group			Child Level Analysis		
	Sons	Daughters	Diff.	Sons	Daughters	Diff.
OLS Marginal effect	0.016**	0.027**	**-0.011****	-0.002	0.020**	**-0.023****
(SE)/[Wald]	(0.001)	(0.002)	[19.24]	(0.002)	(0.003)	[49.02]
R-squared	0.18	0.20		0.09	0.09	
Probit Marginal effect	0.018**	0.036**	**-0.018****	-0.003	0.021**	**-0.023****
(SE)/[Wald]	(0.002)	(0.003)	[25.48]	(0.002)	(0.003)	[42.77]
Log-likelihood	-4,352	-4,935		-10,931	-10,931	
FE Marginal effect	0.023**	0.038**	**-0.015****	-0.006*	0.018**	**-0.024****
(SE)/[Wald]	(0.002)	(0.003)	[20.08]	(0.002)	(0.003)	[62.26]
R-squared	0.26	0.26		0.10	0.10	
2SLS Marginal effect	0.017**	0.059**	**-0.042****	0.002	0.050**	**-0.048****
(SE)/[Wald]	(0.006)	(0.008)	[20.38]	(0.013)	(0.013)	[29.54]
R-squared	0.16	0.18		0.10	0.10	
No. of families	8,424	8,424		5,302	5,302	
No. of children	12,356	10,642		8,766	8,760	

Note: Marginal effects from *OLS*, *Probit*, family fixed effects (*FE*) and two-stage least squares (*2SLS*). Robust standard errors (in parentheses) and Wald statistics [in parentheses] for testing differences between sons and daughters (H_0). Regressions control for characteristics of parents: gender, second order polynomials in age, dummy variables for primary, secondary, high school and college education, marital status, first born son, first born twin children, Han ethnicity, IADL limitation, urban area of residence and province dummies; and characteristics of children: second order polynomials in age, proportion of children with primary, secondary and high school education, and number of grandchildren, as well as child gender and birth order in child level analysis. $^{\dagger}p < .10$; $^{*}p < .05$; $^{**}p < .01$.

Gender differences in the marginal increase in probability of receiving old age support from sons and daughters were negative and statistically significant ($p < 0.05$) across all models. In particular, the increase in the probability of receiving old age support from sons was lower than the increase in the probability of receiving old age support from daughters per 10,000 yuan invested. At the gender-household group level, the differences between the increases in the probability of receiving old age support (from sons minus from daughters), ranged from a low magnitude of -1.1% in the OLS model to a high magnitude of -4.2% in the 2SLS model. At the child level, the differences between the increases in the probability receiving old age support (from a son minus from a daughter), ranged from a low magnitude of -2.3% in the OLS model to a high magnitude of -4.8% in the 2SLS model.

The Wald statistics from tests of differences in marginal returns [reported in squared parentheses in the fourth and seventh columns of Table 3] indicate that the hypothesis that marginal returns from sons and daughters were the same (H_0) is always rejected ($p < 0.05$). The hypothesis that marginal returns from sons were higher than from daughters (H_1) is also always rejected ($p < 0.05$) whereas the hypothesis that marginal returns from sons were lower than from daughters (H_2) can never be rejected at the 5% statistical significance level.

5.2 Further Results and Sensitivity Analysis

I now report further results and sensitivity analysis. Interested readers may refer to the Appendix for additional figures and tables relevant to this sub-section. The distribution of marginal parental returns are illustrated in Figure A2. Results focused on best living proximity as well as the value of monetary and in-kind support are presented in Table A1. Results focused on education and marriage investments are presented in Table A2. The evidence once again suggests that marginal returns from daughters were relatively higher than from sons.

Son preference and reliance on children for old age support may differ across rural and urban families. In particular, rural families may rely more on children because they have lower access to pensions (Cai et al. 2006; Oliveira 2016). I therefore estimate the marginal parental returns separately for families where the parent lives in a rural area and for families where the parent lives in an urban area. Parents invested more than twice more in sons than in daughters in rural areas: Parents invested on average 23,944 yuan (9,768 yuan) in sons (daughters) and 13,329 yuan (6,457 yuan) per son (daughter). Son biased investments were less pronounced in urban areas although still existent: Parents invested on average 29,762 yuan (19,017 yuan) in sons (daughters) and 17,513 yuan (10,638 yuan) per son (daughter). From Table A3, marginal parental old age support returns from daughters seem to have been higher than from sons for both rural and urban households, with larger gender differences for rural households.

Tables A4 and A5 present a decomposition of old age support returns into reciprocity and market returns of children, which are both functions of parental investments. In particular, old age optimality condition Eq. 1 now takes into account the *levels* of reciprocity and market returns of children, which also allows one to put a monetary value on old age support returns. The statistically significant ($p < 0.05$) gender differences in marginal parental returns from sons and daughters ranged from a low magnitude of -374 yuan in the FE model to a high magnitude of -1,870 yuan in the 2SLS model at the gender-household level and from a low magnitude of -618 yuan in the OLS model to a high magnitude of -723 yuan in the FE model at the child level. The results once again suggest that the marginal parental old age support returns to investment in daughters were relatively higher than the marginal parental old age support returns to investment in sons. Interested readers may refer to the Appendix for more details.

One concern is that parental investments may be proxying for parental contemporary transfers to children such that the positive relationship between parental investments and old age support may be reflecting contemporary exchanges. McGarry (2016) found that the distribution of transfers among siblings tend to become more unequal over time in the US, suggesting that parents who invest more in some children at a certain point in time also invest more in those children throughout the lifecycle. From the CHARLS sample, parents provided on average 1,174 yuan more to sons than to daughters and 502 yuan more to each son than to each daughter in terms of monetary and in-kind support ($p < 0.05$), suggesting that parental contemporary transfers still favor sons. Reassuringly, controlling for contemporary monetary and in-kind support from parents yielded similar results to those in Table 3.

Finally, even though the literature has found relatively stable gender ratios for first births in the PRC, there is evidence of skewed gender ratios at higher birth parities, especially for the later censuses and especially if the family had a first born female child (Chen et al. 2013; Ebenstein 2010). Higher sex ratios may increase the bargaining power of women (Angrist 2002), who may then be in a better position to provide old age support to their own parents. In sensitivity analysis, I used data from China Census 2000 to control for the local sex ratios associated with the 5 year birth cohort of the first born child. The results were quantitatively very similar to those in Table 3.

6. Conclusion

This study examined whether parental investments in children paid off in terms of old age support, and estimated the realized marginal parental old age support returns to invesment by gender of children using data from the 2013 CHARLS. Whereas parents invested nearly twice more in sons than in daughters, realized marginal returns to investment in daughters were relatively higher than realized marginal returns to investment in sons. The results suggest that daughters may be reciprocating parental monetary investments in their education and marriage by increasing old age support in terms of living proximity, monetary and in-kind transfers and help with IADL.

I note that this study may be subject to several limitations. First, there may be additional parental investments that are not observed in the data. For example, parents may also invest more in sons' health (Barcellos et al. 2014; Jayachandran and Kuziemko 2011) such that gender differences in investments may be underestimated, thereby resulting in the estimates of gender differences in marginal parental returns between sons and daughters to be underestimated. In particular, diminishing marginal returns to investment (see footnote 13) implies that marginal old age support returns from sons would be even lower if sons experienced even greater parental investments.

Second, there may be additional forms of old age support that are valued by parents. For instance, parents may feel comforted by the idea of having ancestral rituals performed by children after death (Das Gupta et al. 2003; Jayachandran 2015). To the extent that such forms of support are performed primarily by sons, gender differences in parental returns may be overestimated. Conversely, if parents' well-being improve more under daughters' rather than sons' care (Zeng et al., 2015), then gender differences in parental returns may be underestimated. Nevertheless, this study may still shed light on old age support returns in terms of living proximity, monetary and in-kind transfers and help with IADL.

While the PRC has been rapidly expanding its New Rural Pension Program since 2009, the incentives to participate in the program have been found to be relatively low (Lei et al. 2011). There is also evidence that parents who have at least one son may be less likely to enroll in a pension program (Ebenstein and Leung 2010; Zhang 2011), indicating the possible reliance on sons for old age support. I, however, find that parents may have received higher marginal old age support returns from daughters than from sons. The study suggests that policies geared towards reducing gender differences in parental investments in children may be desirable. For example, education subsidies for females or baby girl bonuses may help encourage higher investments in daughters. Exploiting the higher returns from female workers may not only help with informal old age support provisions but may also result in higher tax contributions to the expanding social security system. It may also be interesting to study whether brothers may have been increasingly relying on their sisters to provide old age support such that the allocation of old age support among siblings may have also varied over time and according to the gender composition of siblings. I leave such interesting considerations for future research.

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A. Appendix

A.1 Model Derivations

A.1.1 Partial Effects from Children's Problem.

The optimal level of support to parents, O_i^*, is obtained by equating the marginal utility of consumption to the marginal utility of old age support:

$$v_{iC}\left(M_i\left(I_i\right)-O_i^*, O_i^*\right)=v_{iO}\left(M_i\left(I_i\right)-O_i^*, O_i^*\right). \tag{A1}$$

Under the assumption that children's utility is separable in its arguments, one can rewrite optimality condition Eq. A1 as follows:

$$v_{iC}\left(M_i\left(I_i\right)-O_i^*\right)=v_{iO}\left(O_i^*\right).$$

Totally differentiating with respect to O_i^* and I_i, it follows that:

$$\frac{\partial O_i^*}{\partial I_i}=\frac{v_{iCC}}{v_{iCC}+v_{iOO}}M_i'>0,$$

where the inequality stems from the fact that $v_{ixx}<0$ for $x=C_i, O_i$ and that $M_i'>0$. Thus, (i) old age support from child i increases in investment in child i.

One can also rewrite optimality condition Eq. A1 as a function of total support from children of gender g, $\bar{O}_g=\sum_{i=1}^{n_g} O_i^*$:

$$v_{iC}\left(M_i\left(I_i\right)-\frac{\bar{O}_g}{n_g}\right)=v_{iO}\left(\frac{\bar{O}_g}{n_g}\right).$$

Totally differentiating with respect to O_i^* and I_i, and with respect to O_i^* and n_g, we have:

$$\frac{\partial \bar{O}_g}{\partial I_i}=n_g\frac{v_{iCC}}{v_{iCC}+v_{iOO}}M_i'>0 \quad and \quad \frac{\partial \bar{O}_g}{\partial n_g}=\frac{\bar{O}_g}{n_g}>0.$$

Thus, all else equal, (ii) total old age support from children of gender g increase in investment per child of gender g and in the number of children of gender g.

A.1.2 Gender-Household Group Optimality Condition

Parents choose total investment per gender:

$$\underset{C_p,\bar{I}_S,\bar{I}_D}{Max} \quad u\left(C_p,\bar{O}_S\left(\bar{I}_S\right)+\bar{O}_D\left(\bar{I}_D\right)\right) \quad s.t. \quad C_p+\bar{I}_S+\bar{I}_D=M_p,$$

where $\bar{O}_g=\sum_{i=1}^{n_g} O_i$ and $\bar{I}_g=\sum_{i=1}^{n_g} I_i$. It follows that parents equate marginal returns to total investment in sons and daughters:

$$\bar{O}_S'\left(\bar{I}_S\right)=\bar{O}_D'\left(\bar{I}_D\right).$$

A.2 Extended Model of Altruism

I now show that the key predictions of the model would still hold in an extended model of altruism where children care about total old age support received by the parents. Child i's utility is thus given by $v_i\left(C_i,\bar{O}\right)$, where v_i is separable, increasing, and concave in its arguments: $v_{ix}>0$ and $v_{ixx}<0$, $x=C_i,\bar{O}$. Under the assumption the private and public goods are normal for all children, there exists a unique Nash equilibrium where children of the same gender as child i provide O_i^* of care and children of a different gender from child i provide O_j^* of care.

A.2.1 Partial Effects from Children's Problem

The optimality condition Eq. A1 now depends on total old age support received by the parent:

$$v_{iC}\left(M_i\left(I_i\right)-O_i^*\right)=v_{iO}\left(n_iO_i^*+n_jO_j^*\right).$$

Totally differentiating with respect to O_i^* and I_i, it follows that:

$$\frac{\partial O_i^*}{\partial I_i}=\frac{v_{iCC}}{v_{iCC}+v_{iOO}n_i}M_i'>0,$$

where the inequality stems from the fact that $v_{ixx}<0$ for $x=C_i,\bar{O}$ and that $M_i'>0$. Thus, (i) old age support from child i increases in investment in child i.

One can also rewrite the optimality condition as a function of total support from children of gender g, $\bar{O}_g=\sum_{i=1}^{n_g}O_i^*$:

$$v_{iC}\left(M_i\left(I_i\right)-\frac{\bar{O}_g}{n_g}\right)=v_{iO}\left(\bar{O}_g+\bar{O}_{-g}\right).$$

Totally differentiating with respect to O_i^* and I_i, and with respect to O_i^* and n_g, we have:

$$\frac{\partial\bar{O}_g}{\partial I_i}=\frac{v_{iCC}}{v_{iCC}+v_{iOO}\frac{1}{n_g}}M_i'>0\quad and\quad\frac{\partial\bar{O}_g}{\partial n_g}=\frac{v_{iCC}}{v_{iCC}+v_{iOO}\frac{1}{n_g}}\frac{\bar{O}_g}{n_g^2}>0,$$

Thus, all else equal, (ii) total old age support from children of gender g increase in investment per child of gender g and in the number of children of gender g.

Note that the derivation of the old age support production efficiency optimality condition from the parent's problem is as before: Parents will optimally equate marginal returns between sons and daughters. The qualitative predictions of the model therefore still holds in an extended model of altruism where children care about total old age support received by parents.

A.3 Reciprocity and Market Returns

Let old age support provided by children of gender $g=S,D$ be given by $O_g\left(I_g\right)=R_g\left(I_g\right)M_g\left(I_g\right).$ This can be derived from, say, a logarithmic utility function: Let children's utility be $ln\left(C_i\right)+\alpha_i ln\left(O_i\right)$, where α_i is the weight that children put on old age support of parents and is a function of parental investment. α_i is assumed to be the same for children of the same gender but different across children of different genders. It follows that old age support from a child of gender g is: $O_g=R_g\left(I_g\right)M_g\left(I_g\right)$, where $R_g=\frac{\alpha_g}{1+\alpha_g}$ is interpreted as a reciprocity function.

Reciprocity to investment $R_g\left(I_g\right)$ reflects the propensity of children to provide old age support as a function of parental investment. For instance, higher parental investment may make children feel compelled to be more filial (or increase the prospects of gaining a filial child-in-law). Market returns to investment $M_g\left(I_g\right)$ are interpreted as before.

The optimality condition Eq. 1 can be rewritten as:

$$R_S'\left(I_S\right)M_S\left(I_S\right)+R_S\left(I_S\right)M_S'\left(I_S\right)=R_D'\left(I_D\right)M_D\left(I_D\right)+R_D\left(I_D\right)M_D'\left(I_D\right).\qquad\text{(A2)}$$

As can be seen from Eq. A2, marginal returns are now made up of a combination of marginal reciprocity to investment and market returns level as well as a combination of reciprocity level and marginal market returns to investment.

Reciprocity for each gender is now interpreted as the index of old age support receipt while market returns, M_g, are defined as total child income in 1,000 yuan. The family respondent is asked to report annual income of each child (and spouse) in threshold levels and the average is imputed as child income. Although all families reported income for at least one child, approximately 24% of all children had their income missing. I report results below after dropping children with missing income from the sample. Results based on imputing the income of those children (by projecting income on children's characteristics) were similar to those reported below.

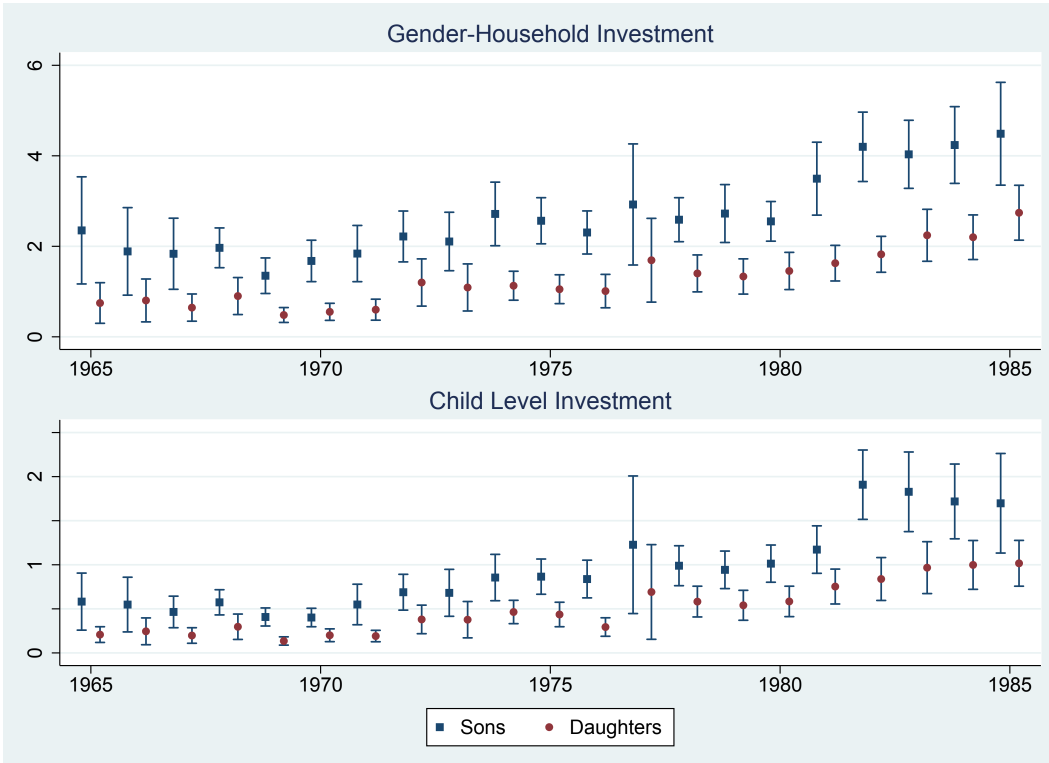
Marginal market returns are estimated using similar models as before.[18] In 2SLS market returns models, the Sargan and Basmann tests of the hypothesis that the over-identifying restrictions are valid could not be rejected at the 5% significance level neither at the gender-household level ($p \in (0.08, 0.12)$) nor at the child level ($p \in (0.64, 0.65)$) analysis. The second, third and fourth columns of Tables A4 and A5 report the marginal reciprocity to total investment analogous to the estimates in Table 3. The fifth, sixth, and seventh columns of Tables A4 and A5 report results related to marginal market returns to investment. The statistically significant ($p < 0.05$) marginal market returns to investment in sons ranged from 2,766 yuan to 3,045 yuan at the gender-household level and from 557 yuan to 4,050 yuan at the child level per 10,000 yuan invested. Similarly, marginal market returns to investment in daughters ranged from 1,326 yuan to 4,331 yuan at the gender-household level and from 695 yuan to 2,266 yuan at the child level per 10,000 yuan invested.

Marginal parental old age support returns are computed according to Eq. A2 at the average reciprocity and market return levels, and reported in the last three columns of Tables A4 and A5. The statistically significant ($p < 0.05$) marginal returns to investment in sons ranged from 839 yuan to 2,780 yuan at the gender-household level and from 250 yuan to 2,887 yuan at the child level per 10,000 yuan invested. Similarly, marginal returns to investment in daughters ranged from 1,213 yuan to 3,218 yuan at the gender-household level and from 973 yuan to 2,528 yuan at the child level per 10,000 yuan invested.[19]

[18] Probit models estimate marginal reciprocity using probit and marginal market returns using OLS.

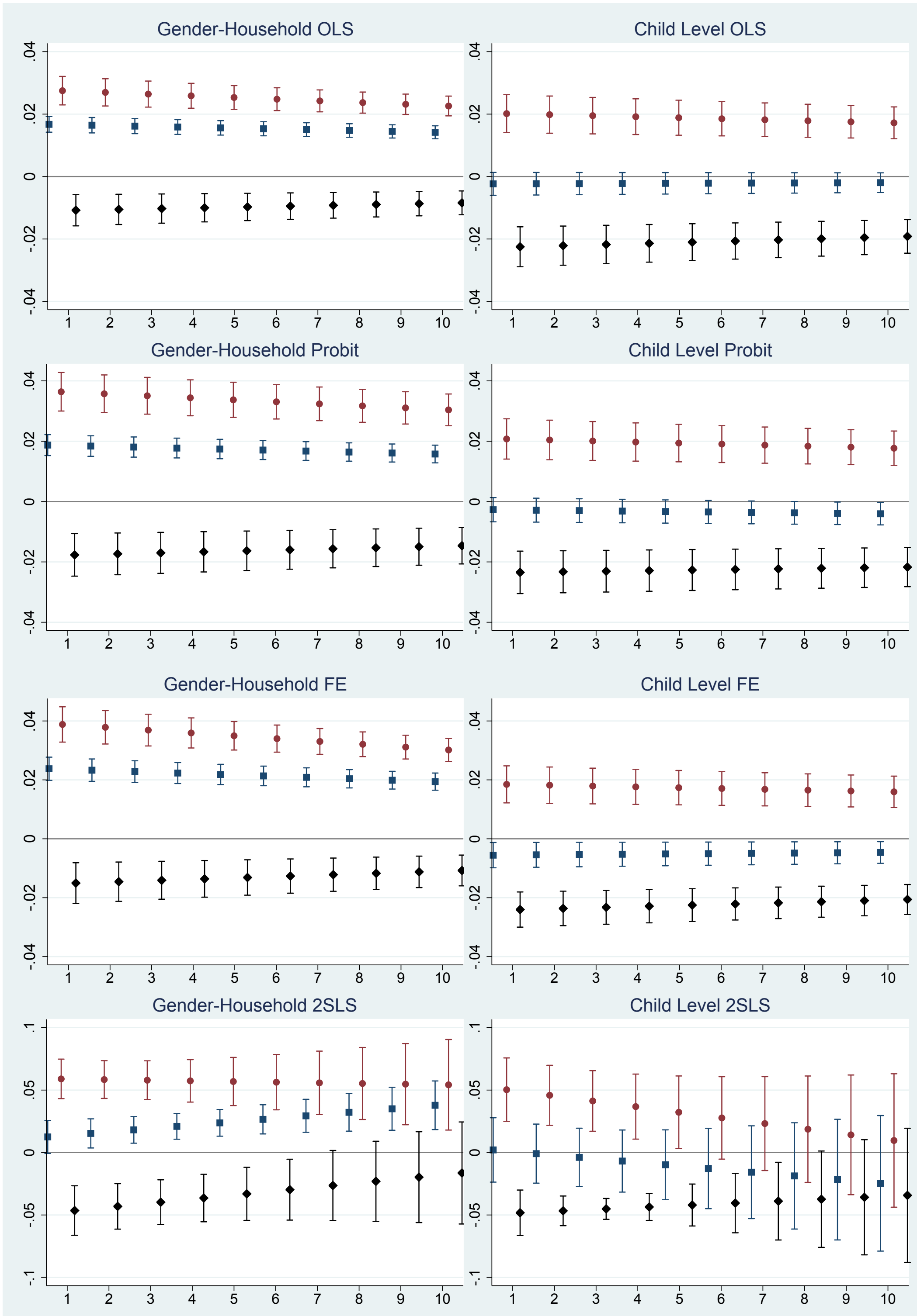
[19] For the sake of comparison, real interest rate in the PRC was 3.7% in 2013 (World Bank).

Figure A1 Parental Investments across Birth Cohort



Note: Vertical axes denote investment in 10,000 yuan and horizontal axes denote year of birth of the first child. The squares and circles denote respectively, mean investment in sons and in daughters. 95% confidence intervals are illustrated.

Figure A2 Distribution of Marginal Parental Old Age Support Returns



Note: Vertical axes denote marginal returns and horizontal axes denote investment in 10,000 yuan. The squares, circles, and diamonds denote respectively, returns from sons, returns from daughters, and differences in returns. 95% confidence intervals are illustrated.

Table A1 Marginal Living Proximity and Monetary and In-Kind Support Returns

	Gender-Household Group			Child Level Analysis		
	Sons	Daughters	Diff.	Sons	Daughters	Diff.
Best Living Proximity						
OLS Marginal Effect	0.009**	0.010**	**-0.001**	-0.007**	0.010**	**-0.017****
(SE)/[Wald]	(0.001)	(0.002)	[0.14]	(0.002)	(0.002)	[41.12]
R-squared	0.12	0.08		0.14	0.14	
Probit Marginal Effect	0.011**	0.010**	**0.001**	-0.007**	0.025**	**-0.032****
(SE)/[Wald]	(0.002)	(0.002)	[0.19]	(0.002)	(0.006)	[27.16]
Log-likelihood	-5,288	-4,374		-10,287	-10,287	
FE Marginal effect	0.017**	0.020**	**-0.003**	-0.002	0.017**	**-0.019****
(SE)/[Wald]	(0.002)	(0.003)	[0.64]	(0.002)	(0.003)	[41.71]
R-squared	0.15	0.15		0.19	0.19	
2SLS Marginal effect	0.012†	0.033**	**-0.021***	0.005	0.030**	**-0.025****
(SE)/[Wald]	(0.007)	(0.007)	[5.03]	(0.014)	(0.013)	[8.20]
R-squared	0.11	0.09		0.15	0.15	
No. of families	8,424	8,424		5,302	5,302	
No. of children	12,356	10,642		8,766	8,760	
Amount of Support (10k yuan)						
OLS Marginal Effect	0.016**	0.031**	**-0.015†**	0.017	0.028*	**-0.011**
(SE)/[Wald]	(0.004)	(0.007)	[3.65]	(0.011)	(0.014)	[0.62]
R-squared	0.03	0.04		0.02	0.02	
Tobit Marginal Effect	0.050**	0.077**	**-0.027**	0.027*	0.037*	**-0.010**
(SE)/[Wald]	(0.009)	(0.021)	[1.45]	(0.014)	(0.017)	[0.38]
Log-likelihood	-7,899	-8,297		-17,048	-17,048	
FE Marginal effect	0.013**	0.026**	**-0.012**	0.012**	0.021**	**-0.008***
(SE)/[Wald]	(0.004)	(0.008)	[1.44]	(0.003)	(0.004)	[3.92]
R-squared	0.04	0.04		0.01	0.01	
2SLS Marginal effect	-0.009	0.016**	**-0.025***	0.029*	0.033**	**-0.004**
(SE)/[Wald]	(0.008)	(0.005)	[6.51]	(0.013)	(0.010)	[0.14]
R-squared	0.02	0.03		0.02	0.02	
No. of families	8,424	8,424		5,302	5,302	
No. of children	12,356	10,642		8,766	8,760	

Note: Robust standard errors (in parentheses) and Wald statistics [in parentheses] for testing differences between sons and daughters (H_0). †p < .10; *p < .05; **p < .01.

Table A2 Marginal Parental Returns to Education and Marriage Investments

	Gender-Household Group			Child Level Analysis		
	Sons	Daughters	Diff.	Sons	Daughters	Diff.
Education Investment						
OLS Marginal effect	0.017**	0.025**	**-0.008****	-0.011**	0.016**	**-0.027****
(SE)/[Wald]	(0.002)	(0.002)	[6.94]	(0.003)	(0.004)	[46.54]
R-squared	0.17	0.19		0.09	0.09	
Probit Marginal effect	0.018**	0.033**	**-0.014****	-0.012**	0.016**	**-0.028****
(SE)/[Wald]	(0.002)	(0.004)	[11.11]	(0.003)	(0.004)	[45.35]
Log-likelihood	-4,394	-4,980		-10,934	-10,934	
FE Marginal effect	0.023**	0.034**	**-0.011***	-0.012**	0.017**	**-0.028****
(SE)/[Wald]	(0.003)	(0.003)	[6.40]	(0.003)	(0.004)	[62.87]
R-squared	0.25	0.25		0.10	0.10	
2SLS Marginal effect	0.026**	0.068**	**-0.042****	0.014	0.061**	**-0.047****
(SE)/[Wald]	(0.007)	(0.009)	[13.92]	(0.016)	(0.012)	[11.70]
R-squared	0.16	0.18		0.09	0.09	
No. of families	8,424	8,424		5,302	5,302	
No. of children	12,356	10,642		8,766	8,760	
Marriage Investment						
OLS Marginal effect	0.023**	0.059**	**-0.035****	0.006†	0.043**	**-0.037****
(SE)/[Wald]	(0.002)	(0.007)	[22.45]	(0.003)	(0.008)	[19.19]
R-squared	0.18	0.19		0.09	0.09	
Probit Marginal effect	0.026**	0.071**	**-0.045****	0.006†	0.043**	**-0.036****
(SE)/[Wald]	(0.003)	(0.008)	[25.09]	(0.004)	(0.008)	[16.03]
Log-likelihood	-4,378	-4,981		-10,943	-10,943	
FE Marginal effect	0.033**	0.080**	**-0.048****	0.001	0.031**	**-0.029****
(SE)/[Wald]	(0.003)	(0.009)	[26.74]	(0.004)	(0.009)	[10.44]
R-squared	0.25	0.25		0.10	0.10	
2SLS Marginal effect	0.026*	0.355**	**-0.329****	-0.045	0.051	**-0.095****
(SE)/[Wald]	(0.012)	(0.036)	[74.24]	(0.042)	(0.039)	[14.12]
R-squared	0.16	0.19		0.09	0.09	
No. of families	8,424	8,424		5,302	5,302	
No. of children	12,356	10,642		8,766	8,760	

Note: Robust standard errors (in parentheses) and Wald statistics [in parentheses] for testing differences between sons and daughters (H_0). †p < .10; *p < .05; **p < .01.

Table A3 Marginal Parental Returns to Investment for Rural and Urban Families

	Gender-Household Group			Child Level Analysis		
	Sons	Daughters	Diff.	Sons	Daughters	Diff.
Rural Households						
OLS Marginal effect	0.014**	0.032**	**-0.018****	-0.003	0.024**	**-0.027****
(SE)/[Wald]	(0.002)	(0.003)	[26.74]	(0.002)	(0.005)	[33.84]
R-squared	0.13	0.17		0.10	0.10	
Probit Marginal effect	0.015**	0.044**	**-0.029****	-0.006†	0.024**	**-0.030****
(SE)/[Wald]	(0.002)	(0.005)	[25.96]	(0.003)	(0.005)	[32.97]
Log-likelihood	-2,591	-3,054		-7,353	-7,353	
FE Marginal effect	0.019**	0.040**	**-0.021****	-0.008**	0.022**	**-0.030****
(SE)/[Wald]	(0.003)	(0.004)	[19.76]	(0.003)	(0.004)	[50.74]
R-squared	0.20	0.20		0.13	0.13	
2SLS Marginal effect	0.018*	0.078**	**-0.060****	-0.024	0.026†	**-0.050****
(SE)/[Wald]	(0.007)	(0.013)	[16.05]	(0.016)	(0.015)	[17.04]
R-squared	0.11	0.15		0.11	0.11	
No. of families	5,069	5,069		3,355	3,355	
No. of children	8,043	6,782		5,982	5,849	
Urban Households						
OLS Marginal effect	0.017**	0.024**	**-0.007***	-0.000	0.017**	**-0.017****
(SE)/[Wald]	(0.002)	(0.003)	[5.56]	(0.003)	(0.004)	[15.23]
R-squared	0.25	0.27		0.07	0.07	
Probit Marginal effect	0.025**	0.047**	**-0.022****	-0.000	0.025**	**-0.026****
(SE)/[Wald]	(0.003)	(0.005)	[14.70]	(0.003)	(0.006)	[16.58]
Log-likelihood	-1,720	-1,814		-3,513	-3,513	
FE Marginal effect	0.026**	0.038**	**-0.012****	-0.001	0.013*	**-0.014****
(SE)/[Wald]	(0.003)	(0.003)	[8.71]	(0.004)	(0.006)	[9.72]
R-squared	0.36	0.36		0.06	0.06	
2SLS Marginal effect	0.024**	0.054**	**-0.030****	0.026	0.061**	**-0.035****
(SE)/[Wald]	(0.007)	(0.009)	[6.91]	(0.021)	(0.020)	[13.71]
R-squared	0.23	0.26		0.08	0.08	
No. of families	3,355	3,355		1,773	1,773	
No. of children	4,313	3,860		2,778	2,917	

Note: Robust standard errors (in parentheses) and Wald statistics [in parentheses] for testing differences between sons and daughters (H_0). †p < .10; *p < .05; **p < .01.

Table A4 Decomposition: Marginal Parental Returns to Investment by Gender-Household Group

	Reciprocity (R)			Market Return (M)			Old Age Support Return (O)		
	Sons	Daughters	Diff.	Sons	Daughters	Diff.	Sons	Daughters	Diff.
OLS Marginal Effect	0.016**	0.027**	**-0.011****	3.045**	4.229**	**-1.184****	2.711**	2.943**	**-0.232**
(SE)/[Wald]	(0.001)	(0.002)	[19.24]	(0.220)	(0.299)	[10.53]	(0.164)	(0.178)	[1.00]
R-squared	0.18	0.20		0.18	0.17				
Probit Marginal effect	0.018**	0.036**	**-0.018****	3.045**	4.229**	**-1.184****	2.780**	3.218**	**-0.438†**
(SE)/[Wald]	(0.002)	(0.003)	[25.48]	(0.220)	(0.299)	[10.53]	(0.173)	(0.197)	[2.96]
Log-L/R-squared	-4,352	-4,935		0.18	0.17				
FE Marginal effect	0.023**	0.038**	**-0.015****	2.766**	4.331**	**-1.566****	0.839**	1.213**	**-0.374****
(SE)/[Wald]	(0.002)	(0.003)	[20.08]	(0.264)	(0.328)	[14.00]	(0.069)	(0.094)	[10.81]
R-squared	0.26	0.26		0.19	0.19				
2SLS Marginal effect	0.017**	0.059**	**-0.042****	-0.001	1.326*	**-1.327**	0.610	2.448**	**-1.870****
SE/Wald	(0.006)	(0.008)	[20.38]	(0.657)	(0.675)	[1.85]	(0.516)	(0.460)	[7.33]
Log-L/R-squared	0.16	0.18		0.13	0.13				
Sample average	0.70	0.50		35.81	31.03				
No. of families	8,424	8,424		8,424	8,424				
No. of children	9,566	7,730		9,566	7,730				

Note: Robust standard errors (in parentheses) and Wald statistics [in parentheses] for testing differences between sons and daughters (H_0). Regressions control for characteristics of parents and children. $^{†}p < .10$; $^{*}p < .05$; $^{**}p < .01$.

Table A5 Decomposition: Marginal Parental Returns to Investment per Child

	Reciprocity (R)			Market Return (M)			Old Age Support Return (O)		
	Sons	Daughters	Diff.	Sons	Daughters	Diff.	Sons	Daughters	Diff.
OLS Marginal effect	-0.004*	0.017**	**-0.021****	1.305**	1.720**	**-0.415**	0.832**	1.451**	**-0.618***
(SE)/[Wald]	(0.002)	(0.003)	[37.87]	(0.222)	(0.343)	[1.29]	(0.184)	(0.224)	[5.70]
R-squared	0.08	0.08		0.14	0.14				
Probit Marginal effect	-0.005*	0.017**	**-0.022****	1.305**	1.720**	**-0.415**	0.823**	1.454**	**-0.631***
(SE)/[Wald]	(0.002)	(0.004)	[34.53]	(0.222)	(0.343)	[1.29]	(0.187)	(0.231)	[5.68]
Log-L/R-squared	-7,962	-7,962		0.14	0.14				
FE Marginal effect	-0.005*	0.018**	**-0.024****	0.557**	0.695**	**-0.138**	0.250*	0.973**	**-0.723****
(SE)/[Wald]	(0.002)	(0.004)	[49.33]	(0.165)	(0.239)	[0.39]	(0.145)	(0.173)	[10.26]
R-squared	0.09	0.09		0.04	0.04				
2SLS Marginal effect	-0.014	0.040**	**-0.054****	4.050**	2.266*	**1.785***	2.887**	2.528**	**0.359**
SE/Wald	(0.013)	(0.012)	[38.41]	(0.841)	(1.006)	[4.49]	(0.813)	(0.647)	[0.20]
Log-L/R-squared	0.09	0.09		0.13	0.13				
Sample average	0.75	0.51		30.85	33.73				
No. of families	5,302	5,302		5,302	5,302				
No. of children	6,715	6,220		6,715	6,220				

Note: Robust standard errors (in parentheses) and Wald statistics [in parentheses] for testing differences between sons and daughters (H_0). Regressions control for characteristics of parents and children. $^{\dagger}p < .10$; $^{*}p < .05$; $^{**}p < .01$.