The One-Child Policy and Household Savings

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Abstract

We investigate how the 'one-child policy' has impacted China's household saving rate and human capital in the last three decades. In a life-cycle model with endogenous fertility, intergenerational transfers and human capital accumulation, we show how fertility restrictions provide incentives for households to increase their offspring's education and to accumulate financial wealth in expectation of lower support from their children. Our quantitative OLG model calibrated to household level data shows that the policy significantly increased the human capital of the only child generation and can account for a third to 60% of the rise in aggregate savings. Equally important, it can capture much of the distinct shift in the level and shape of the age-saving profile observed from micro-level data estimates. Using the birth of twins (born under the one child policy) as an exogenous deviation from the policy, we provide an empirical out-of-sample check to our quantitative results; estimates on savings and education decisions are decidedly close between model and data.

Keywords : Life Cycle Savings, Fertility, Human Capital, Intergenerational Transfers.
JEL codes: E21, D10, D91

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1 Introduction

China's 'one-child policy' has been a truly unique and radical birth-control scheme. Introduced in the late 1970s, and strictly enforced in the urban areas by the early 1980s, the policy aimed at curbing the population growth that had spiralled out of control during the Maoist, pro-natality era. The urban fertility rate fell drastically over a short period of time—from on average 3 per family in the early 1970s to just about 1 in the early 1980s. Yet, the one child policy is a largely under-studied event. In this paper, we study the quantitative effects of the one child policy– building up from its micro-level impact at the household level to its aggregate implications. We focus on the policy's impact on savings and human capital—and their interaction. China's household saving rate has been increasing at a rapid rate: between 1982 and 2012, the average urban household saving rate rose steadily from 12.0% to 32.1%. Human capital accumulation has also accelerated over the last thirty years, with the average years of schooling increasing by about 50%, from 5.8 years to 8.9 for an adult aged 25 (Barro and Lee (2010); see also Liang et al. (2013)).

In the Chinese society, children act as a source of old-age support. Parents rear and educate children when they are young, while children make financial transfers and provide in-kind benefits to their retired parents. Not only is the custom commonplace, it is also stipulated by constitutional law. As revealed by the data, the amount of transfers parents receive increases with the number of children. Now imagine that families are constrained to having only one child. The reduction in expected transfers means that parents now have to save more on their own. In other words, parents shift their investment in the form of children towards financial assets. This is what we call the 'transfer channel'. Additionally, the reduction in overall expenditures owing to fewer children also raises the household saving rate. When education costs can amount to 10 to 20% of all household expenditures depending on child's age, the fall in expenditures from having fewer children can be substantial. These additional resources are partly saved—what we label as the 'expenditure channel'. Both channels tend to exert upward pressure on the household saving rate and constitute the micro-channels of the policy on savings. On the aggregate level, demographic compositional changes driven by a reduction in fertility also affect the aggregate saving rate, as well-understood through the classic formulations of the life-cycle motives for savings (Modigliani (1986)). Our approach shows that the aforementioned micro-impacts on savings are however more important in the Chinese context where intergenerational transfers within families are large in magnitude.

The second consequence is that the one child policy may have led to a rapid accumulation of human capital of the only child generation. When parents can substitute quantity for quality, the expected reduction in transfers implied by the policy can be partly compensated by raising the child's education investment and expected future income. The importance of the interaction between savings and human capital decisions becomes immediately apparent: the degree of substitution of quantity for quality determines the impact on savings of the one child policy. That is, if parents can perfectly compensate for quantity with quality—for instance, if human capital adjusts at no cost— then the one child policy would have little effect on savings and the transfer channel in particular would disappear.

In investigating the joint impact on human capital and savings of the one child policy, the paper makes three main contributions: (i) a tractable model linking fertility, intergenerational transfers and human capital accumulation; (ii) its quantitative version calibrated to micro data; (iii) an empirical

test of the theory using the births of twins as exogenous deviations from the policy.

Our theoretical framework incorporates two new elements to the standard lifecycle theory of savings: intra-family transfers and human capital accumulation. Agents make decisions on the number of children to bear, the level of human capital to endow them, and on how much to save for retirement. Children are costly, but are at the same time, an investment opportunity—providing support to their retired parents. An exogenous reduction in fertility lowers total expenditures spent on children and raises household savings ('expenditure channel'); this holds notwithstanding a substitution of 'quantity' for 'quality'—leading to a rise in education investment in the only child. The rise in the child's future wages owing to human capital accumulation is in general not enough to compensate for the overall reduction in transfers that parents receive when retired, providing further incentives to save ('transfer channel'). Our model thus sheds light on the interaction between human capital and savings decisions. A stronger policy response of human capital—driven for instance by weaker diminishing returns to education—, severely limits the savings response. Also, we show that under certain conditions, one can identify the micro-channel on savings and the human capital response over time through a *cross-sectional* comparison of twin households and only-child households. This forms the basis of our later empirical analysis and counterfactual exercises.

Our second contribution lies in the quantitative exploration of our theory. A quantitative version of the model is developed and is calibrated to micro-level Chinese data. We evaluate the quantitative performance of our model through three angles. First, turning to aggregate implications, we find that the model imputes at least a third and at most 60% of the rise in the household saving rate over 1982-2009 to the one child policy—depending on the natural fertility rate that would have prevailed without the policy change. Regarding human capital accumulation, matching our estimates to the data is less straightforward but our model predicts that the policy has significantly increased the human capital of the only child generation by at least 20% compared to their parents.

Second, our multi-period model implies different savings behaviour across age groups. Taking one step further, we thus examine the changes in the *age-saving profile* over time. We find that our model can capture quantitatively the overall shift in saving rates across ages as well as a portion of the change in its shape.[1] We also show that the evolution of the profile is, however, vastly inconsistent with the predictions from a standard OLG model without old-age support and human capital accumulation. In the absence of the transfer channel, savings of parents in their 50s (whose children have departed from households) should have fallen following the policy—the opposite of what is observed in the data.

Third, the predictions of the model at the micro-level—that is, the impact of the policy on household behavior—are evaluated through a 'twin experiment', comparing the cross-sectional differences in savings and human capital outcomes between only-child and twin families with the differences estimated from micro-data. The birth of twins under the one child policy can be largely seen as exogenous—thereby serving as a reasonable instrument and an 'out-of-sample' test of the quantitative performance of the model. We find that the impact of an additional child as implied by the model is very close to data estimates based on twin observations: in the data, twin households are estimated to save on average 6-7 percentage points less (as a % of income) than only-child households. We find that

[1] In particular, the saving rate of the young workers rose faster over this period (see also Song and Yang (2011) and Chamon and Prasad (2011)). Though seemingly paradoxical, it is in fact consistent with our (modified) lifecycle model, where workers in their early 30s are the most affected by the policy, being only child and expecting to have only one child.

this difference remains, once children have left the household—a strong indication that the transfer channel is operative. Moreover, while overall education expenditures (as a % of wage income) are about 6 percentage points higher in twin households, education expenditures *per child* are about 2.5 percentage points less on twins than on an only child—twins being thus less educated than an only child. The proximity of these empirical findings to model estimates suggests reasonable quantitative predictability of our model.

Related literature. Our paper closely relates to the literature explaining the staggeringly high saving rate in China, starting with Modigliani and Cao (2004) ('Chinese Saving Puzzle'). In a sense, a distinguishing feature of our paper is our endeavor to bridge the micro-level approach with the macro-level approach.[2] The ability to match these micro-evidence gives further credence to the model's macroeconomic implications. Storesletten and Zilibotti (2013) provide an exposition of the transformation of the Chinese society and the perplexingly high household savings in the recent years, and discusses some recent developments in the literature.[3] Our paper relates to theoretical work linking fertility and savings starting with Barro and Becker (1989),[4] but also focuses on the interaction between human capital and savings decisions. The interaction is quantitatively critical for our results and largely absent in those studies.[5] Note also that the nature of intergenerational altruism differs from that of Barro and Becker (1989)——in our view, the assumption that parents rear children to provide for old-age more aptly captures the family arrangements of a developing country like China than the notion that children's lives are a continuation of their parents'. Finally, our paper builds on a large literature linking fertility changes and human capital accumulation, from theory (starting with Becker and Lewis (1973)) to the use of twin births as identification strategy (Rosenzweig and Wolpin (1980)).[6] Our theory, however, differs from the quantity-quality trade-off derived from utility assumptions, as it appears endogenously in the presence of old-age support.

A few caveats are in order. The form of intergenerational transfers occurs within households in this economy, in contrast to intergenerational transfers taking place through social security—which has until now been virtually non existent in China, and unreliable to say the least. We treat these transfers towards elderly as a social norm and thus *exogenously* given in our model, contrary to Boldrin and Jones (2002). Our model also treats interest rates as exogenous and abstracts from general equilibrium effects of savings on capital accumulation and interest rates. We believe this to be realistic in the Chinese context where households face interest rates largely determined by the

[2]Modigliani and Cao (2004), Horioka and Wan (2007), Curtis, Lugauer, and Mark (2011) find ample evidence supporting the link between demographics and savings at the aggregate level, but meet difficulty when confronting micro-data.

[3]Some compelling explanations of the puzzle include: (1) precautionary savings (Blanchard and Giavazzi (2005), Chamon and Prasad (2010) and Wen (2011)); (2) income growth and credit constraints (Coeurdacier, Guibaud and Jin (2013)), potentially also in housing expenditures (Bussiere et al. (2013)); (3) changes in income profiles (Song and Yang (2010), Guo and Perri (2012)); (4) gender imbalances and competition in the marriage market (Wei and Zhang (2011)); (5) habit formation (Carroll and Weil, 1994); (6) demographics (Modigliani and Cao (2004), Horioka and Wan (2007), Curtis, Lugauer, and Mark (2011) and Banerjee et al. (2014)); Yang, Zhang and Zhou (2011) provide a thorough treatment of aggregate facts pertaining to China's saving dynamics, and at the same time present the challenges that some of these theories face.

[4]See also Boldrin and Jones (2002), Chakrabarti (1999), Cisno and Rosati (1996), Raut and Srinivasan (1994).

[5]Manuelli and Seshadri (2007) extends Barro and Becker (1989) to include human capital but does not explore the role of savings.

[6]See Angrist et al. (2010) for references. The closest paper to our empirical results, Rosenzweig and Zhang (2009), uses the birth of Chinese twins to measure the 'quantity-quality' trade-off in children and find also comforting evidence to the main mechanisms of our model (see also Hongbin et al. (2008) and Qian (2013)).

government.[7] A theoretical general equilibrium analysis may be found in Banerjee et al. (2014) and our subsequent work (Coeurdacier et al. (2014)).

The paper is organized as follows. Section 2 provides certain background information and facts that motivate some key assumptions underlying our framework. Section 3 provides our theoretical model that links fertility, education and savings decisions in an overlapping generations model. Section 4 develops a calibrated quantitative model to simulate the impact of the policy. The empirical tests based on twins and model counterfactuals are conducted in Section 5. Section 6 concludes.

2 Motivation and Background

Based on various aggregate and household level data sources from China, this section provides stylized facts on (1) the background of the 'one-child policy' and its consequences on the Chinese demographic composition; (2) the direction and magnitude of intergenerational transfers—from parents to children in financing their education, and from children to parents in support of their old age. The quantitative relevance of these factors motivates the main assumptions underlying the theoretical framework. Micro and macro data sources used are described in Appendix A.

2.1 The One-Child Policy and the Chinese demographic transition

The one-child policy decreed in 1979 was intended to curb the population growth that the Maoist pro-natality agenda had precipitated. The consequence was a sharp drop in the nation-wide fertility rate— from 5.5 children per woman in 1965-1970 to 2.6 between 1980-1985. The policy was strictly enforced in urban areas and partially implemented in rural provinces. Figure 1 displays the evolution of the fertility rate for urban households, based on Census data: a bit above three (per household) before 1970, it started to decline during the period of 1972-1980—when the one-child policy was progressively implemented—and reached a value very close to one after its strict implementation by 1982.[8]

Binding fertility constraints is a clear imperative for the purpose of our study. Household-level data (Urban Household Survey, UHS) reveals a strict enforcement of the policy for urban households, although to a much less extent for rural households: over the period 2000-2009, 96% of urban households that had children had only one child.[9] *Urban* households are therefore a natural focal point in our analysis. It is important to note that the rise in savings in China is mostly driven by urban households, which account for 82% of the increase between 1982-2012.[10]

The demographic structure evolved accordingly, ensuing fertility controls (Table 1). Some prominent patterns are: (1) a sharp rise in the median age— from 19.7 years in 1970 to 34.5 years in 2010;

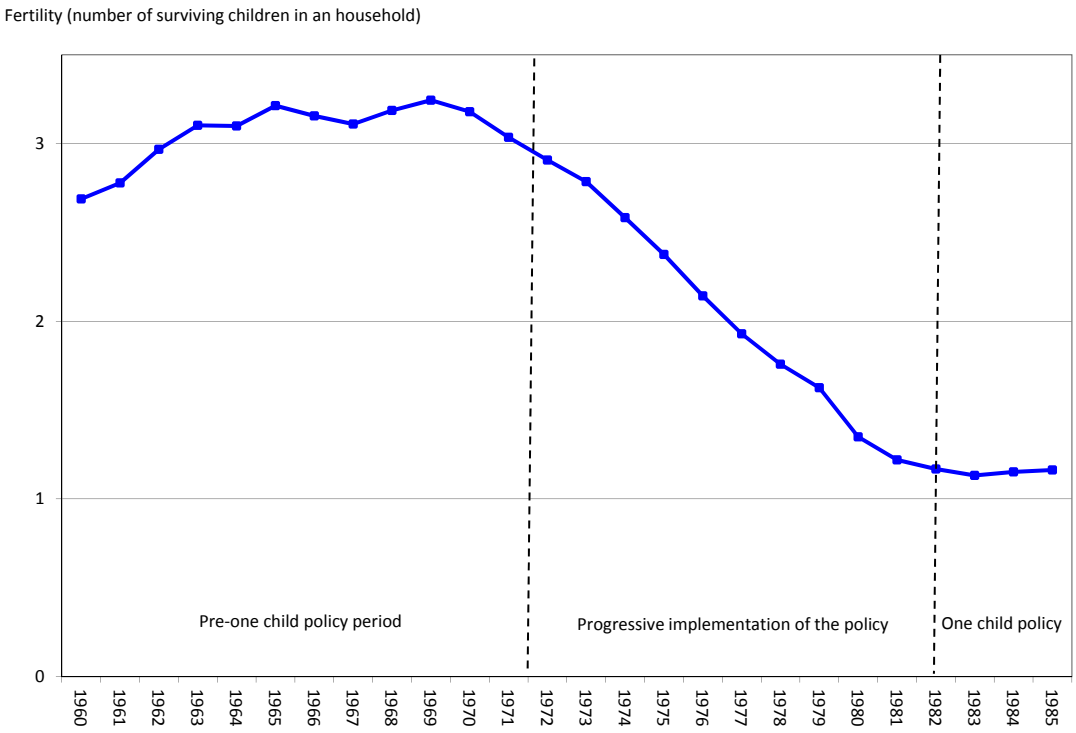
[7] Despite capital controls, China is also a semi-open economy where household savings are largely channeled abroad.

[8] After 1970, citizens were encouraged to marry at later ages and have only two children, later allowing the birth of two children only in the event of a first-born girl. See Banerjee et al. (2014) for a more detailed description of the progressive implementation of the policy in the 1970s.

[9] Some urban households had more than one child. If we abstract from the birth of twins, accounting for about 1% of households, the remaining 3% households may include households of minority ethnicities (not subject to the policy)—accounting for a sufficiently small portion to be discarded.

[10] Urban household saving rate grew by about 20 percentage points, whereas rural household saving rate grew by 6 percentage points (from 18.5% to 25.4%). Source: CEIC.

Figure 1: Fertility in Chinese urban areas



Notes: Data source: Census, restricted sample where only urban households are considered.

Table 1: Demographic structure in China

	1970	2010	2050
Share of young (age 0-20/Total Population)	51%	27%	18%
Share of middle-aged (age 30-60/Total Population)	28%	44%	39%
Share of elderly (age above 60/Total Population)	7%	14%	33%
Median age	19.7	34.5	48.7
Fertility (children per women, urban areas)	3.18 (1965-70)	1.04 (2004-09)	- n/a -

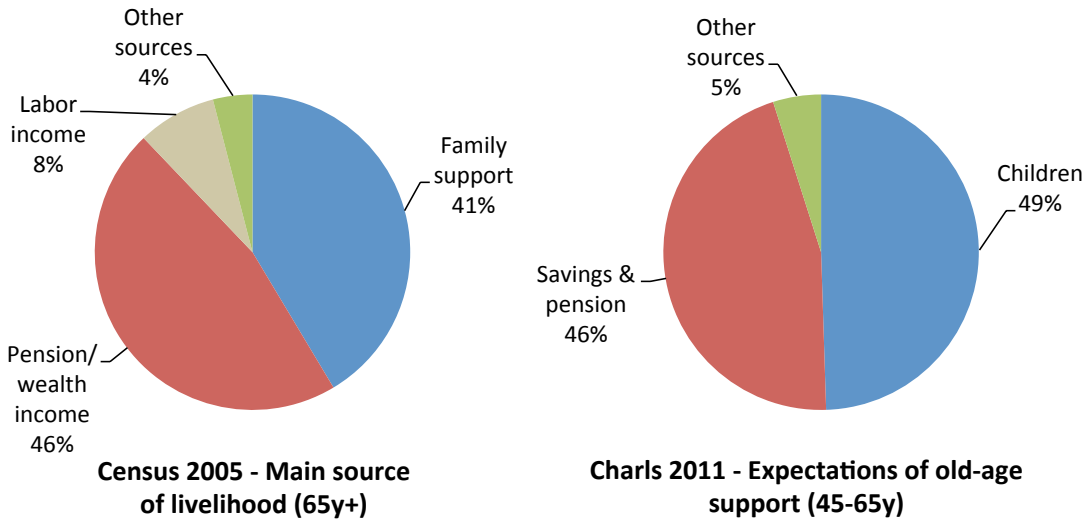
Note: UN World Population Prospects (2011).

(2) a rapid decline in the share of young individuals (ages 0-20) from 51% to 27% over the period, and (3) a corresponding increase in the share of middle-aged population (ages 30-60). While the share of the young is expected to drop further until 2050, the share of the older population (above 60) will increase sharply only after 2010— when the generation of the only-child ages. In other words, the 'one-child policy' leads first to a sharp fall in the share of young individuals relative to middle-aged adults, followed by a sharp increase in the share of the elderly only one generation later.

2.2 Intergenerational Transfers

Old-age support. Intergenerational transfers from children to elderly are the bedrock of the Chinese society. Beyond cultural norms, it is also stipulated by Constitutional law: "children who have come to age have the duty to support and assist their parents" (Article 49). Failure in this responsibility may even result in law suits. According to Census data in 2005, family support is the main source of income for almost half of the elderly (65+) urban population (Figure 2, left panel). From the China Health and Retirement Longitudinal Study (CHARLS), individuals of ages 45-65 in 2011 expect this pattern to continue in the coming years: half expect transfers from their children to constitute the main source of income for old age (Figure 2, right panel).

Figure 2: Main Source of Livelihood for the Elderly (65+) in urban areas



Notes: Left panel, Census (2005). Right panel, CHARLS (2011), urban households, whole sample of adults between 45-65 (answer to the question: Whom do you think you can rely on for old-age support?).

CHARLS provides further detailed data on intergenerational transfers in 2008 for two provinces: Zhejiang (a prosperous coastal province) and Gansu (a poor inland province). We restrict the sample to urban households in which at least one member (respondent or spouse) is older than 60 years of age. Old age support can take on broadly two forms: financial transfers ('direct' transfers) and 'indirect' transfers in the form of co-residence or other in-kind benefits. According to Table 2, 45% of the elderly reside with their children in urban households. Positive (net) transfers from adult children to parents occur in 65% of households and are large in magnitude—constituting a significant share of old-age income of on average 28% of all elderly's pre-transfer income (and up to 47% if one focuses on the sample of transfer receivers). Table 2 also shows that the average transfers (as a % of pre-transfer income) are increasing in the number of children. The flip side of the story is that restrictions in fertility will therefore likely reduce the amount of transfers conferred to the elderly. This fact bears the central assumption underlying our theoretical framework.

Education expenditures. An important feature of our theory is that education expenditures for children are important for understanding lifecycle savings across age-groups and over time, following fertility changes. Education expenses are a prominent source of transfers from parents towards their

Table 2: Transfers towards elderly: Descriptive Statistics

Number of households	321
Average number of adult children (25+)	3.4
Share living with adult children	45%
Incidence of positive net transfers	
- from adult children to parents	65%
- from parents to adult children	4%
Net transfers in % of parent's pre-transfer income	
- All parents	28%
- Transfer receivers only	47%
Of which households with:	
- One or two children	10.5%
- Three children	34.6%
- Four children	45.9%
- Above Five children	69.7%

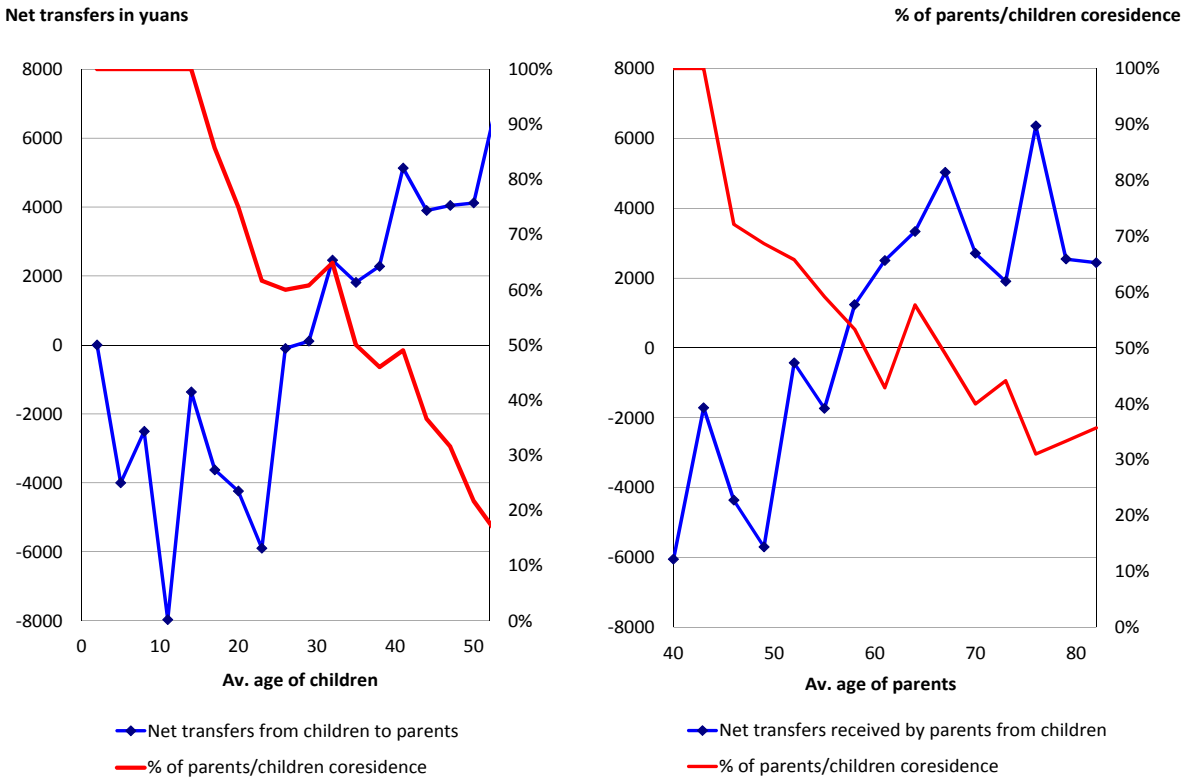
Notes: Data source: CHARLS (2008). Restricted sample of urban households with a respondent/spouse of at least 60 years of age with at least one surviving adult children aged 25 or older. Transfers is defined as the sum of regular and non-regular financial transfers in yuan. Net Transfers are transfers from children to parents less the transfers received by children.

Figure 3: Education Expenditures by Age (% of total expenditures)

Notes: Data source: UHS (2006) and RUMiCI (2008). Samples are restricted to urban households with an only child. This graph plots the average education expenditure (as a share of total expenditures) by the age of the only child.

children according to Urban Household Surveys (UHS) in 2006 and RUMiCI in 2008.[11] Restricting our attention to families with an only child, Figure 3 displays the share of education expenditures (in total expenditures) in relation to the age of the child; it increases from roughly 10% for child below 15 to up to 15-25% between the ages of 15 and 22. Data from the Chinese Household Income Project (CHIP) in 2002 (not displayed) provides some evidence on the relative importance of 'compulsory' and 'non-compulsory' (or discretionary) education costs: not surprisingly, the bulk of expenditures (about 80%) incurred for children above 15 are considered as 'non-compulsory', whereas the opposite holds for children below 15. This evidence motivates our assumption that education costs are more of a fixed-cost (per child) for young children, and a choice variable subject to a quantity-quality trade-off for older children.

Figure 4: Timing of intergenerational transfers



Notes: CHARLS (2008), whole sample of urban households. The left panel plots the average amount of net transfers of children to his/her parents (left axis) and the % of coresidence (right axis) by the average age of child. The right panel plots the average amount of net transfers received by parents from their children (left axis) and the % of coresidence (right axis) by the average age of parents.

Timing of transfers from children to parents. The timing and direction of transfers—paid and received at various ages of adulthood (computed from CHARLS (2008))—guide the assumptions adopted by the quantitative model. Figure 4 (left panel) displays the evolution of the average net transfers of children to parents (in monetary values; left axis) as a function of the (average) age of children. The right panel displays the net transfers received by parents as a function of their

[11] We use as a robustness check the alternative dataset —the Chinese Household Income Project (CHIP)— in 2002, which yields similar estimates albeit slightly smaller in magnitude.

age. Observing the left panel, one can mark that net transfers are on average negative at young ages (children receiving transfers from parents), and increase sharply at the age of 25. This pattern accords with the notion that education investment is the main form of transfers towards children. After this age, children confer increasing amounts of transfers towards their parents—received by parents upon retirement (right panel). If co-residence (right axis) is also considered as a form of transfers, a similar pattern emerges: children leave the parental household upon reaching adulthood (left panel). When parents reach 60, the degree of co-residence no longer falls with parental age, remaining around 40–50% as parents return to live with their children (right panel).

3 Theoretical Analysis

We develop a tractable multi-period overlapping generations model with intergenerational transfers, endogenous fertility and human capital accumulation. The parsimonious model yields a semi-closed form solution that serves two main purposes. First, it reveals the fundamental channels driving the fertility-human capital-savings relationships. Second, the model motivates our empirical strategy, showing how one can identify the impact of the one child policy on human capital accumulation and savings through a cross-sectional comparison between two-children (twin) households and only-child households. A quantitative version of the model developed in the subsequent section gives rise to a more detailed age-saving profile, although the main mechanisms are elucidated in the following model.

3.1 Set-up

Consider an overlapping generations economy in which agents live for four periods, characterized by: childhood, youth (y), middle-age (m), and old-age (o).

Timing. An individual born in period $t-1$ does not make decisions on his consumption in childhood, which is assumed to be proportional to parental income. The agent supplies inelastically one unit of labor in youth and in middle-age, and earns a wage rate $w_{y,t}$ and $w_{m,t+1}$, which is used, in each period, for consumption, transfers and asset accumulation $a_{y,t}$ and $a_{m,t+1}$. At the end of period t, the young agent makes the decision on the number of children n_t to bear. In middle-age, in $t+1$, the agent chooses the amount of human capital h_{t+1} to endow each of his children, and transfers a combined amount of $T_{m,t+1}$ to his n_t children and parents—to augment human capital of the former, and consumption of the latter. In old-age, the agent consumes all available resources, coming from gross returns on accumulated assets $a_{m,t+1}$ and transfers from children $T_{o,t+2}$.

Preferences and budget constraints. An individual maximizes the life-time utility which includes the consumption $c_{\gamma,t}$ at each age γ and the benefits from having n_t children:

$$U_t = \log(c_{y,t}) + v\log(n_t) + \beta\log(c_{m,t+1}) + \beta^2\log(c_{o,t+2})$$

where $v > 0$ reflects the preference for children, and $0 < \beta < 1$. The sequence of budget constraints

for an agent born in $t-1$ obeys

$$\begin{aligned} c_{y,t} + a_{y,t} &= w_{y,t} \\ c_{m,t+1} + a_{m,t+1} &= w_{m,t+1} + Ra_{y,t} - T_{m,t+1} \\ c_{o,t+2} &= Ra_{m,t+1} + T_{o,t+2}. \end{aligned} \tag{1}$$

Agents lend (or borrow) through bank deposits, earning a constant and exogenously given gross interest rate R.[12] Because of parental investment in education, the individual born in period $t-1$ enters the labor market with an endowment of human capital h_t, which, along with an experience parameter $e < 1$, and a deterministic level of economy-wide productivity z_t, determines the wage rates:

$$\begin{aligned} w_{y,t} &= ez_t h_t^{\alpha} \\ w_{m,t+1} &= z_{t+1} h_t^{\alpha}. \end{aligned} \tag{2}$$

Intergenerational transfers. The cost of raising kids is assumed to be paid by parents in middle-age, in period $t+1$, for a child born at the end of period t. The total cost of raising n_t children is proportional to current wages, $n_t \phi(h_{t+1}) w_{m,t+1}$, where $\phi(h) = \phi_0 + \phi_h h$, $\phi_0 > 0$ and $\phi_h > 0$. The 'mouth to feed' cost, including consumption and compulsory education expenditures (per child), is a fraction ϕ_0 of the parents' wage rate; the discretionary education cost $\phi_h h_{t+1}$ is increasing in the level of human capital chosen by the parents.[13]

Transfers made to the middle-aged agent's parents amount to a fraction $\psi n_{t-1}^{\omega-1}/\omega$ of current wages $w_{m,t+1}$, with $\psi > 0$ and $0 < \omega \leq 1$. This fraction is decreasing in the number of siblings—to capture the possibility of free-riding among siblings sharing the burden of transfers. We treat these transfers as an institutional norm in China; children supporting their parents is not only socially expected, but is even stipulated by law. The assumed functional form for transfers is analytically convenient, but (i) its main properties are tightly linked to the data and therefore somewhat justifiable (see Section 4.2); (ii) these properties are also qualitatively retained with endogenous transfers but at the expense of tractability and facility of parametrization.[14]

The combined amount of transfers made by the middle-aged agent in period $t+1$ to his children and parents thus satisfy: $T_{m,t+1} = \left(n_t \phi(h_{t+1}) + \psi n_{t-1}^{\omega-1}/\omega\right) w_{m,t+1}$. An old-age parent receives transfers from his n_t children: $T_{o,t+2} = \psi \frac{n_t^{\omega}}{\omega} w_{m,t+2}$.

[12] This is analogous to a model in which the central bank intermediates household savings abroad. This modelling choice is adopted for the purpose of distilling the most essential forces governing the fertility-savings relationship without undue complication of the model. This is also reasonable in the Chinese context, where interest rates on households deposits are largely set by the government. However, omitting capital accumulation in this model potentially severs the feedback effect of interest rates onto fertility and savings.

[13] This is an important departure from the quantity-quality trade-off models of Becker and Lewis (1973), later adopted by Oliveira (2012). They assume that costs to quality are independent of the level of quality.

[14] As shown in Section 4.2, transfers given by each child are indeed decreasing in the number of offspring, and the income elasticity of transfers is close to 1—as assumed by our transfer function. In a model in which transfers are endogenously determined— where children place a weight on parents' old-age utility of consumption—, the main properties hold in the steady-state: transfers are decreasing in the number of offspring, and the income elasticity of transfers is 1. While parents may desire to undertake less savings knowing that more savings beget less transfers from children, this effect amounts to a reduced discount rate. See also Boldrin and Jones (2002) for a model with endogenous old-age support.

3.2 Household decisions and model dynamics

Consumption decisions. Optimal consumption can be solved given fertility and human capital decisions. The following assumption,

Assumption 1 *The young are subject to a credit constraint, binding in all periods:*

$$a_{y,t} = -\theta \frac{w_{m,t+1}}{R}$$

specifies that the young can borrow up to a constant fraction θ of the present value of future wage income. For a given θ, the constraint is more likely to bind if productivity growth is high (relative to R) and the experience parameter e is low. This assumption is necessary for obtaining a realistic savings behavior of the young—one that avoids a counterfactual sharp borrowing that emerges under fast growth and a steep income profile (see also Coeurdacier, Guibaud and Jin (2013)).
Assumption 1 and the absence of bequests mean that the only individuals that optimize their savings are the middle-aged. The assumption of log utility implies that the optimal consumption of the middle-age is a constant fraction of the present value of lifetime resources, which consist of current disposable income—net of debt repayments and current transfers to children and parents—and the present value of transfers to be received in old-age:

$$c_{m,t+1} = \frac{1}{1+\beta}\left[\left(1-\theta-n_t\phi(h_{t+1})-\psi\frac{n_{t-1}^{\omega-1}}{\omega}\right)w_{m,t+1}+\frac{\psi}{R}\frac{n_t^{\omega}}{\omega}w_{m,t+2}\right]. \tag{3}$$

It follows from Eq. 1 that the optimal asset holding of a middle-aged individual is

$$a_{m,t+1} = \frac{\beta}{1+\beta}\left[\left(1-\theta-n_t\phi(h_{t+1})-\psi\frac{n_{t-1}^{\omega-1}}{\omega}\right)w_{m,t+1}-\frac{\psi}{\beta R}\frac{n_t^{\omega}}{\omega}w_{m,t+2}\right]. \tag{4}$$

Eq. 4 illuminates the link between fertility and savings: parents with more children accumulate less wealth because they have less available resources for savings (term $n_t\phi(h_{t+1})$) and because they expect larger transfers (last term).

Fertility and Human Capital. Fertility decisions hinge on equating the marginal utility of bearing an additional child with the net marginal cost of raising the child:

$$\begin{aligned}\frac{v}{n_t} &= \frac{\beta}{c_{m,t+1}}\left(\phi(h_{t+1})w_{m,t+1}-\frac{\psi n_t^{\omega-1}w_{m,t+2}}{R}\right)\\ &= \frac{\beta}{c_{m,t+1}}\left(\phi(h_{t+1})-\mu_{t+1}\psi n_t^{\omega-1}\left(\frac{h_{t+1}}{h_t}\right)^{\alpha}\right)w_{m,t+1},\end{aligned} \tag{5}$$

where $\mu_{t+1} \equiv z_{t+2}/Rz_{t+1} \equiv (1+g_{z,t+1})/R$ is the productivity growth-interest rate ratio. The right hand side is the net cost, in utility terms, of having an additional child. The net cost is the current marginal cost of rearing a child, $\partial T_{m,t+1}/\partial n_t$ less the present value of the benefit from receiving transfers next period from an additional child, $\partial T_{o,t+2}/\partial n_t$. In this context, children are analogous to investment goods—and incentives to procreate depend on the factor μ_{t+1}— productivity growth relative to the gross interest rate. Higher productivity growth raises the number of children—by raising

future benefits relative to current costs. But saving in assets is an alternative form of investment, which earns a gross rate of return R. Thus, the decision to have children as an investment opportunity depends on this *relative* return.[15]

The optimal choice on the children's endowment of human capital h_{t+1} is determined by

$$\frac{\psi}{R}\frac{n_t^{\omega}}{\omega}\frac{\partial w_{m,t+2}}{\partial h_{t+1}} = \phi_h n_t w_{m,t+1},$$

where the (discounted) marginal gain of having children more educated and thus providing more old-age support is equalized to the marginal cost of further educating them. Using Eq. 2, the above expression yields the optimal choice for h_{t+1}, given n_t and the predetermined parent's own human capital h_t:

$$h_{t+1} = \left[\frac{\psi}{\omega\phi_h}\frac{\alpha\mu_{t+1}}{h_t^{\alpha}n_t^{1-\omega}}\right]^{\frac{1}{1-\alpha}}. \tag{6}$$

A greater number of children n_t reduces the gains from educating them—a quantity and quality trade-off. This trade-off arises from the fact that the marginal benefit in terms of transfers is decreasing in the number of children ($\omega < 1$). Given any number of children n_t, incentives to provide further education is increasing in the productivity growth relative to the interest rate μ_{t+1}—which gauges the relative benefits of investing in children. Greater altruism ψ of children for parents also increases parental investment in them.

The optimal number of children n_t, combining Eq. 3, 5 and 6, satisfies, with $\lambda = \frac{v+\omega\beta(1+\beta)}{\alpha v+\alpha\beta(1+\beta)}$:

$$n_t = \left(\frac{v}{\beta(1+\beta)+v}\right)\left(\frac{1-\theta-\psi\frac{n_{t-1}^{\omega-1}}{\omega}}{\phi_0+\phi_h\left(1-\lambda\right)h_{t+1}}\right). \tag{7}$$

Equations 6 and 7 are two equations that describe the evolution of the two state variables of the economy $\{n_t; h_{t+1}\}$. Eq. 6 describes the human capital response to a change in fertility n_t—with h_{t+1} decreasing in n_t. Eq. 7 measures the response of fertility to a change in the children's human capital h_{t+1}. There are two competing effects governing this relationship: the first effect is that higher levels of education per child raises transfers per child, thus motivating parents to have more children. The second effect is that greater education, on the other hand, raises the cost per child, and reduces the incentives to have more children. The first effect dominates if diminishing returns to transfers are relatively weak compared to diminishing returns to education, $\lambda > 1$—in which case n_t is increasing in h_{t+1}.

Steady-State. The steady state is characterized by a constant productivity growth-interest rate ratio, $\mu_t = \mu$, and constant state variables $h_t = h_{ss}$ and $n_t = n_{ss}$. Eqs. 6 and 7 are, in the long run:

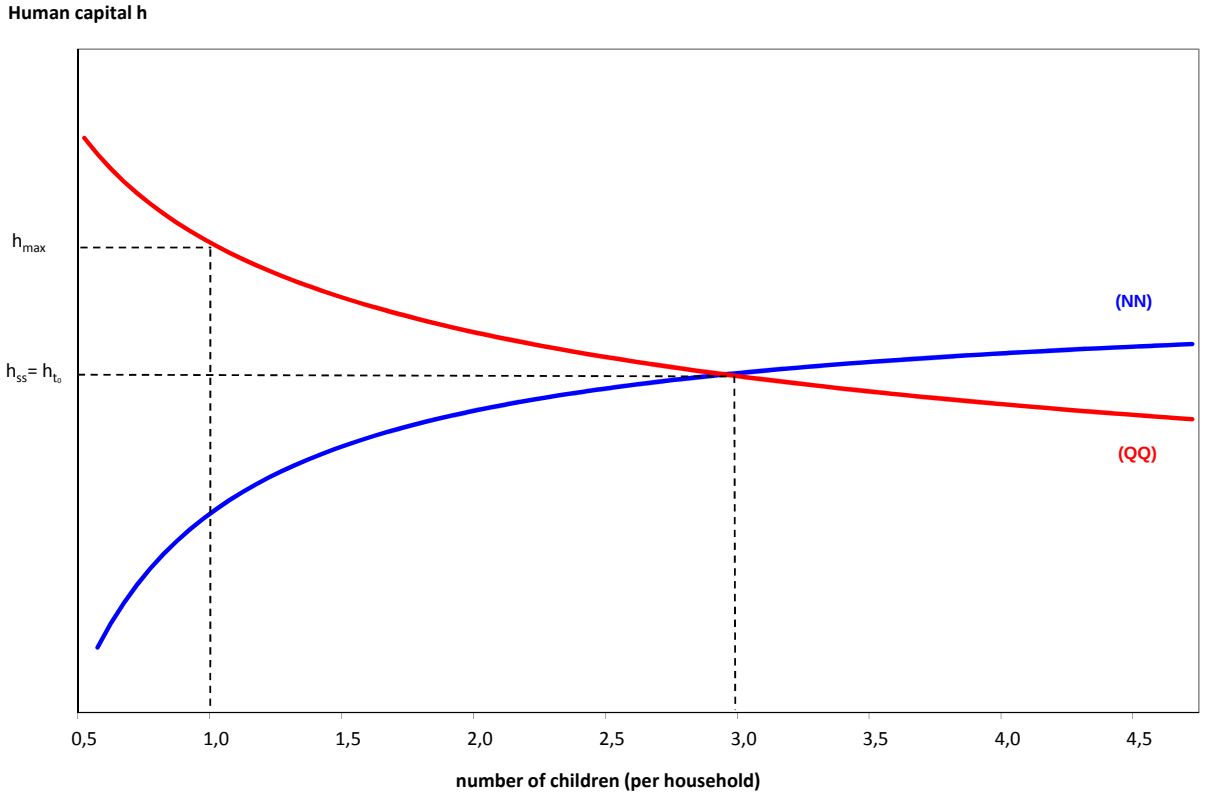
$$\frac{n_{ss}}{1-\theta-\psi n_{ss}^{\omega-1}/\omega} = \left(\frac{v}{\beta(1+\beta)+v}\right)\left(\frac{1}{\phi_0+\phi_h\left(1-\lambda\right)h_{ss}}\right) \qquad \textbf{(NN)}$$

$$h_{ss} = \left(\frac{\psi\alpha\mu}{\phi_h}\right)\frac{n_{ss}^{\omega-1}}{\omega}. \qquad \textbf{(QQ)}$$

[15] All else constant, the relationship between fertility and interest rates is negative—as children are considered as investment goods. This relationship is the opposite of the positive relationship in a dynastic model (Barro and Becker (1989)).

Figure 5 depicts graphically the two curves for an illustrative calibration. The (NN) curve describes the response of fertility to higher education. Its positive slope (for $\lambda > 1$) captures the greater incentive of bearing children when they have higher levels of human capital. The downward sloping curve (QQ) shows the combination of n and h that satisfies the quantity/quality trade-off in children.

Figure 5: Steady-State Human Capital and Fertility Determination



Notes: Steady-state, with an illustrative calibration using $\phi_0 = 0.1$, $\phi_h = 0.1$, $\psi = 0.2$, β=0.985 per annum (0.75 over 20 years), $R = 4\%$ per annum, $g_z = 4\%$ (per annum), $\theta = 0$, $\omega = 0.7$, $\alpha = 0.4$. $v = 0.055$ set such that $n_{ss} = 3/2$.

Assumption 2 *Parameters are restricted such that* $\omega \geq \alpha$, *implying* $\lambda > 1$.

Assumption 2 ensures model convergence to a stable steady-state—avoiding divergent dynamics whereby parents constantly reduce their children's education for cost reduction and increase their number (or vice-versa). This leads to the following proposition:

Proposition 1 There is a unique steady-state for the number of children $n_{ss} > 0$ and their human capital $h_{ss} > 0$ to which the dynamic model defined by Eqs. 6 and 7 converges. Also, comparative statics yield

$$\frac{\partial n_{ss}}{\partial \mu} > 0 \text{ and } \frac{\partial h_{ss}}{\partial \mu} > 0 \; ; \; \frac{\partial n_{ss}}{\partial v} > 0 \text{ and } \frac{\partial h_{ss}}{\partial v} < 0; \; \frac{\partial n_{ss}}{\partial \phi_0} < 0 \text{ and } \frac{\partial h_{ss}}{\partial \phi_0} > 0.$$

Proof: See Appendix C.1.

Higher productivity growth relative to the interest rate increases the incentives to invest in children, both in terms of quantity and quality. A stronger preference towards children (or lower costs of raising them) makes parents willing to have more children, albeit less educated (lower 'quality') ones.

3.3 The One-Child Policy

Fertility constraint. The government is assumed to enforce a law that compels each agent to have up to a number $n_{\max}$ of children over a certain period $[t_0; t_0 + T]$ with $T \geq 1$. In the case of the one-child policy, the maximum number of children per individual is $n_{\max} = 1/2$. We now examine the transitory dynamics of the key variables following the implementation of the policy, starting from an initial *steady-state* of unconstrained fertility characterized by $\{n_{t_0-1}; h_{t_0}\}$, with $n_{t_0-1} > n_{\max}$. The additional constraint $n_t \leq n_{\max}$ is now added to the original individual optimization problem. We focus on the interesting scenario in which the constraint is binding ($n_t = n_{\max}$ for $t_0 \leq t \leq t_0 + T$). Under constrained fertility, one needs an additional assumption for the model to converge if $T \to \infty$:

Assumption 3 $\alpha < 1/2$.

Assumption 3 is necessary to avoid divergent paths of human capital accumulation where higher education increases expected transfers and gives further incentives to raise education without any offsetting feedback on fertility decisions. Note that the assumed values for α are well within the range of the macro literature (Mankiw et al. (1992) and survey by Sianesi and van Reenen (2000)).

3.3.1 Human Capital and Aggregate Savings

Human capital. The policy aimed at reducing the population inadvertently *increases* the level of per-capita human capital, thus moving the long-run equilibrium along the (QQ) curve, as shown in Figure 5 and stated by the following Lemma:

Lemma 1 As $T \to \infty$, human capital converges to a new (constrained) steady-state $h_{\max}$ such that:

$$h_{\max} = \left(\frac{\psi\alpha\mu}{\phi_h}\right) \frac{n_{\max}^{\omega-1}}{\omega} > h_{t_0}.$$

The first generation of only child also features higher level of human capital than their parents:

$$\frac{h_{t_0+1}}{h_{t_0}} = \left(\frac{n_{t_0-1}}{n_{\max}}\right)^{\frac{1-\omega}{1-\alpha}} > 1.$$

Proof: See Appendix C.1.

Aggregate savings. The aggregate savings of the economy is the sum of the aggregate savings of each generation $\gamma = \{y, m, o\}$ coexisting in a given period t. The aggregate savings to aggregate labour income ratio defines the aggregate saving rate s_t— a weighted average of the young, middle-aged and old's individual saving rates, where the weights depend on both the population and relative income of the contemporaneous generations (see Appendix C.1 for details). Assuming constant productivity growth to interest rate ratio μ, the impact of the one-child policy on the dynamics of the aggregate saving rate between t_0 and $t_0 + 1$ is given by the following Proposition:

Proposition 2 With binding fertility constraints in period t_0, the aggregate saving rate increases *unambiguously* over a generation:

$$s_{t_0+1} - s_{t_0} > 0.$$

Proof: See Appendix C.1.

For a given level of human capital of the generation of only child h_{t_0+1}, the change in aggregate saving rate over the period after the implementation of the policy can be written as,

$$s_{t_0+1} - s_{t_0} = \underbrace{\frac{(n_{t_0-1} - n_{\max})\, e}{1 + n_{\max} e} s_{t_0} + \frac{1}{1 + n_{\max} e} \theta\mu \left(n_{t_0-1} - n_{\max} \left(\frac{h_{t_0+1}}{h_{t_0}} \right)^{\alpha} \right)}_{\text{macro-channel (composition effects)}} + \frac{1}{1 + n_{\max} e} \underbrace{\frac{\beta}{1+\beta} \left[\phi_0 \left(n_{t_0-1} - n_{\max} \right) + \left(\alpha + \frac{1}{\beta} \right) \frac{\psi\mu}{\omega} \left(n_{t_0-1}^{\omega} - n_{\max}^{\omega} \left(\frac{h_{t_0+1}}{h_{t_0}} \right)^{\alpha} \right) \right]}_{\text{micro-channel}}. \tag{8}$$

where the initial steady-state aggregate saving rate s_{t_0} is given in Appendix C.1. The expression can be decomposed into a macro-channel and a micro-channel. The macro-economic channels comprise changes in the composition of population, and the composition of income attributed to each generation. A fall in fertility of size $(n_{t_0-1} - n_{\max})$ reduces the proportion of young borrowers, relative to the middle-aged savers (population composition); it also places more weight on the aggregate income attributed to the middle-aged savers of the economy and less to young borrowers (income composition), although the latter effect depends on the endogenous human capital response h_{t_0+1}. In our framework, the response of human capital does not offset the fall in fertility for $\omega > \alpha$ such that both forces exert upward pressure on the aggregate saving rate (see Appendix C.1 for a proof).[16]

The micro-channel corresponds to the change in savings of middle aged-parents and encapsulates two effects. The first effect is the reduction in the total cost of children— fewer 'mouths to feed' (the first term $\phi_0 \left(n_{t_0-1} - n_{\max} \right)$) and a fall in total (discretionary) education costs— in spite of the rise in human capital per child (the second term multiplied by 'α'). The second effect is the 'transfer channel', and captures the need to save more with a reduction in expected old-age support —again, despite higher human capital per child (the third term multiplied by '$1/\beta$'). Indeed, incorporating the response of human capital h_{t_0+1}, we get:

$$n_{t_0-1}^{\omega} - n_{\max}^{\omega} \left(\frac{h_{t_0+1}}{h_{t_0}} \right)^{\alpha} = n_{t_0-1}^{\omega} \left(1 - \left(\frac{n_{\max}}{n_{t_0-1}} \right)^{\frac{\omega-\alpha}{1-\alpha}} \right) \geq 0$$

The response of human capital does not offset the fall in fertility such that total discretionary education expenditures and expected transfers fall with fewer children, leading to an unambiguous rise in middle-aged savings.[17] However, the size of the response of human capital of only child is essential to assess quantitatively the response of aggregate savings. With a stronger response of human capital ($\alpha \to \omega$), the transfer channel disappears and the fall in expenditures is limited to the 'mouths to feed' term. To the opposite, with constant (exogenous) human capital, one might overstate the response of savings as shown in Eq. 8.

[16] In period $t_0 + 1$, the reduction in fertility has not yet fed into an increase in the proportion of the dependent elderly (relative to the middle-aged). Thus, the negative effect of the rising share of the elderly on the aggregate saving rate materializes only once the generation of only child reaches middle-age (at $t_0 + 2$).

[17] On the top of the rising share of elderly to middle-aged, another effect that is absent in the transition is that fewer siblings among whom the burden of supporting parents can be shared lowers middle-aged savings. However, this effect only shows up when the only child generation turns middle age and does not apply to middle-aged parents in $t_0 + 1$.

3.3.2 Identification Through 'Twins'

We next show theoretically how one can identify the microeconomic channel (over time) through a *cross-sectional* comparison between only-child households and twin-households. Proofs of these results are relegated to Appendix C.1. Consider the scenario in which some middle-aged individuals exogenously deviate from the one-child policy by having twins. Two main testable implications regarding human capital and savings can be derived.

Quantity-Quality Trade-Off. Parents of twins devote less resources for education *per-child* but their *overall* discretionary education expenditures are higher:

$$\frac{1}{2} \leq \left(\frac{h_{t_0+1}^{twin}}{h_{t_0+1}} \right) = \left(\frac{1}{2} \right)^{\frac{1-\omega}{1-\alpha}} < 1. \tag{9}$$

The quantity-quality trade-off driving human capital accumulation can be identified by comparing twins and an only-child. This ratio as measured by the data also provides some guidance on the relative strength of ω and α. Despite the trade-off, the fall in human capital per capita is less than the increase in the number of children, so that total discretionary education costs are higher for twins (and are the same when $\alpha \to \omega$).

Identifying the micro-channel on savings. The micro-economic impact of having twins on the middle-age parent's saving rate comprise the same 'expenditure channel' and 'transfer channel'. Parents of twins save less and the difference in the saving rate between parents of an only-child and parents of twins in $t_0 + 1$ satisfies:

$$s_{m,t_0+1} - s_{m,t_0+1}^{twin} = \frac{\beta}{1+\beta} \left[n_{\max} \phi_0 + \left(\alpha + \frac{1}{\beta} \right) \frac{\psi \mu}{\omega} n_{\max}^{\omega} \left(\frac{h_{t_0+1}}{h_{t_0}} \right)^{\alpha} \left(2^{\frac{\omega-\alpha}{1-\alpha}} - 1 \right) \right] > 0.$$

A Lower Bound for the Micro-Channel. Let $\Delta s_m = s_{m,t_0+1} - s_{m,t_0}$, the policy implied change in the saving rate of middle-aged parents, one generation after the policy implementation (second-term above bracket in Eq. 8). Δs_m reflects the micro-economic impact on savings of moving from unconstrained fertility n_{t_0-1} to n_{max}. One can estimate the micro-channel of the policy by comparing, in the cross-section, the savings behaviour of parents of twins versus parents of only child:

Lemma 2 If the fertility rate in absence of fertility controls is two children per household ($n_{t_0-1} = 2n_{\max}$), then

$$\Delta s_m = s_{m,t_0+1} - s_{m,t_0+1}^{twin}.$$

Proof: See Appendix C.1.

If the unconstrained fertility is 2 children per household, we can identify precisely the micro-economic impact of the policy—by comparing the saving rate of a middle-aged individuals with an only child to the one of parents having twins. We can also deduce a *lower-bound* estimate for the overall impact of the policy on the middle-aged's saving rate—if the unconstrained fertility is greater than 2 (as in China prior to the policy change). That is, if $n_{t_0-1} > 2n_{\max}$, then

$$\Delta s_m > s_{m,t_0+1} - s_{m,t_0+1}^{twin}.$$

These theoretical results demonstrate that cross-sectional observations from twin-households can inform us of the impact of the one-child policy on savings behavior over time.

Caveats. The identification strategy based on twins coming out of our model relies on a set of important assumptions. Due to the timing and the presence of binding credit constraints, having two children that are expected or (non-expected) twins leads to identical savings and education decisions. There are also no inherent differences in the behavior of twin-households from other households prior to the policy implementation. Finally, if in China, some households can avoid the policy by manipulating fertility (having twins) and these households make different savings and education decisions than the average household, any empirical strategy based on twins would be biased. The validity of these assumptions is discussed in the empirical section (Section 5).

4 A Quantitative OLG Model

We develop a multi-period quantitative version of our model, calibrated to household-level data. A reasonably parameterized model can assess the quantitative impact of the one-child policy on aggregate savings and human capital over the period 1982-2012. In addition, it is able to deliver finer age saving profiles—their evolution, a distinct implication of the model, can be confronted with the data.

4.1 Set-up and model dynamics

Timing. Agents now live for 8 periods, so that eight generations $\gamma = \{1, 2..., 8\}$ coexist in the economy in each period. The timing of the events that take place over the lifecycle is similar to before: the agent is a child for the first two periods, accumulating human capital in the second period; a young worker in the third period, he makes fertility decisions at the end of this period. The agent becomes middle-aged during periods 4-6, rearing and educating children while making transfers to his elderly parents. Upon becoming old in periods 7 and 8, he finances consumption from previous savings and support from his children, and dies with certainty at the end of period 8, without leaving any bequests.

Preferences. Let $c^i_{\gamma,t}$ denote the consumption of of an individual aged γ in period t, with $\gamma \in \{3, 4, ..., 8\}$. The lifetime utility of an agent born at $t-2$ entering the labor market at date t is

$$U_t = v \log(n_t) + \sum_{\gamma=3}^{8} \beta^{\gamma-3} \log(c_{\gamma,t+\gamma-3}),$$

with $0 < \beta < 1$ and $v > 0$.

Transfers and life income profile. The functional form of transfers and the costs of rearing and educating children are retained from before, although the timing of expenditure outlays is more elaborate. Data reveals the timing and scale of these expenditures and transfers. We assume that compulsory education costs paid at age $\gamma = \{4, 5\}$ are a fraction $\phi_\gamma n_t$ of the agent's wage income. The discretionary education costs are borne only at age $\gamma = 5$ and are a fraction $\phi_h h_{t+1} n_t$ of wages—corresponding to the fact that the bulk of 'non-compulsory' education costs is paid when the child is above 15—just before entering the labor market. Transfers to parents are made at age $\gamma = \{5, 6\}$.

Transfers to children and parents of a middle-age individual of age $\gamma = \{4, 5, 6\}$ entering the labor force at t are thus:
$T_{4,t+1} = \phi_4 n_t w_{4,t+1}$; $T_{5,t+2} = \left[(\phi_5 + \phi_h h_{t+1}) n_t + \psi \frac{n_{t-1}^{\omega-1}}{\omega}\right] w_{5,t+2}$; $T_{6,t+3} = \psi \frac{n_{t-1}^{\omega-1}}{\omega} w_{6,t+3}$.
When old, he receives transfers from his children: $T_{7,t+4} = \psi \frac{n_t^{\omega}}{\omega} w_{5,t+4}$; $T_{8,t+5} = \psi \frac{n_t^{\omega}}{\omega} w_{6,t+5}$.
An individual entering the labor market at date t with human capital h_{t-2} earns, for $\gamma = \{3, ..., 8\}$: $w_{\gamma,t+\gamma-3} = e_{\gamma,t+\gamma-3} z_{t+\gamma-3} h_{t-2}^{\alpha}$; $e_{\gamma,t}$, the experience aspect of the life income profile is potentially time-varying if growth is biased towards certain age-groups; z_t represents aggregate productivity and is assumed to be growing at a constant rate of $z_{t+1}/z_t = 1 + g_z$. Figure B.1 in Appendix B summarises the timing and patterns of income flows, costs and transfers, at each age of the agent's life.

Consumption decisions. The assumption of credit constraints dictates that

$$a_{\gamma,t+\gamma-3} \geq -\theta \frac{w_{\gamma+1,t+\gamma-2}}{R} \text{ for } \gamma = \{3, ..., 8\},$$

where $a_{\gamma,t}$ denotes asset holdings by the end of period t at age γ. Parameters chosen for the age-income profile $e_{\gamma,t}$, productivity growth g_z, interest rate and discount factor (R and β) make the constraint binding only in the first period of working age $\gamma = 3$.[18] Combining a sequence of budget constraints of middle-aged and old similar to Eq. 1 together with a binding credit constraint at young age $\gamma = 3$, we obtain the intertemporal budget constraint for an agent born at $t-2$, entering middle-age at $t+1$:

$$\sum_{\gamma=4}^{8} \frac{c_{\gamma,t+\gamma-3}}{R^{\gamma-4}} + \theta w_{4,t+1} = \sum_{\gamma=4}^{6} \frac{w_{\gamma,t+\gamma-3} - T_{\gamma,t+\gamma-3}}{R^{\gamma-4}} + \sum_{\gamma=7}^{8} \frac{T_{\gamma,t+\gamma-3}}{R^{\gamma-4}}, \tag{10}$$

Eq. 10, along with the credit constraint for $\gamma = 3$ and the Euler equations for $\gamma \geq 4$:

$$c_{\gamma+1,t+\gamma-2} = \beta R c_{\gamma,t+\gamma-3}, \tag{11}$$

yields optimal consumption and savings decisions in each period, given state variables $\{n_t; h_{t+1}\}$.

Fertility and human capital. The quantitative model, despite being more complex, yields a similar set of equations capturing the dynamics of fertility and human capital accumulation as in the simple model (see Appendix C.2 for a detailed derivation):

$$n_t = \left(\frac{v}{\beta(1 + \beta + ... + \beta^4) + v}\right) \left(\frac{1 - \theta + \varkappa_t (1 - \psi \frac{n_{t-1}^{\omega-1}}{\omega})}{\phi_{0,t} + \phi_{h,t}(1 - \lambda) h_{t+1}}\right) \tag{12}$$

$$h_{t+1} = \left[\frac{\psi}{\phi_h \omega} \frac{\alpha \xi_{t+1}}{h_t^{\alpha} n_t^{1-\omega}}\right]^{\frac{1}{1-\alpha}}, \tag{13}$$

where $\lambda = \frac{v + \omega\beta(1+\beta+...+\beta^4)}{\alpha v + \alpha\beta(1+\beta+...+\beta^4)}$. The transformation of the education costs $\phi_{0,t}$ and $\phi_{h,t}$, and the parameters $\varkappa_t$ and ξ_{t+1} are defined in Appendix C.2 as a function of $\mu = (1 + g_z)/R$ and the experience parameters $e_{\gamma,t}$. The unique steady state $\{n_{ss}; h_{ss}\}$ can be characterized analytically, and is analogous to that of the four-period model—as are comparative statics.[19]

[18] We verify that the condition for the parameters is satisfied at every point along the equilibrium path in the simulations.
[19] One important difference is that optimal fertility also depends on the *shape of the income profile*, originally assumed to

4.2 Data and Calibration

Parameter values. In an 8-period OLG model, a period corresponds to 10 years. Endogenous variables prior to 1971 are assumed to be at a steady-state characterized by optimal fertility and human capital $\{n_{ss}; h_{ss}\}$. Data used in the calibration are described in Appendix A. Table 3 summarizes the calibration.

Table 3: Calibration of Model Parameters

Parameter	Value	Target (Data source)
β (annual basis)	0.99	/
R (annual basis)	5.55%	Agg. household saving rate in 1981-1983
g_z (annual basis)	7%	Output growth per worker over 1980-2010 (PWT)
v	0.18	Fertility in 1966-1970; $n_{ss} = 3/2$ (Census)
θ	2%	Saving rate of under 25 in 1986 (UHS)
α	0.37	Mankiw, Romer and Weil (1992)
ω	0.65	Transfer to elderly w.r.t the number of siblings (CHARLS)
$\{\phi_4, \phi_5, \phi_h\}$	$\{0.14, 0.06, 0.35\}$	Educ. exp. at age 30-50 in 2006-08 (UHS/RUMiCI)
ψ	12%	Saving rate of age 50-60 in 1986 (UHS)
$(e_\gamma/e_5)_{\gamma=\{3,4,6\}}$	$\{65\%, 90\%, 57\%\}$	Wage income profile in 1992 (UHS)
Alternative calibrations		
Low transfers		
ψ	4%	Observed transfers to elderly (CHARLS)
R (annual basis)	3.75%	Agg. household saving rate in 1981-1983
v	0.25	Fertility in 1966-1970; $n_{ss} = 3/2$ (Census)
Time-varying income profile		
$(e_{\gamma,t}/e_5)_{\gamma=\{3,4,6\}}$ for $t \leq 1998$	$\{65\%, 90\%, 57\%\}$	Wage income profile in 1992 (UHS)
for $1998 < t \leq 2004$	$\{65\%, 94\%, 57\%\}$	Wage income profile in 2000 (UHS)
for $t > 2004$	$\{65\%, 101\%, 56\%\}$	Wage income profile in 2009 (UHS)

Preferences and Technology. We set $\beta = 0.99$ on an annual basis. The real growth rate of output per worker averages at a high rate of 8.2% over the period 1980-2010 in China (Penn World Tables). This rate of growth is an upper-bound for g_z, as growth occurs partly endogenously through human capital accumulation. To generate a real average output growth per worker of about 8% in the model requires a constant exogenous growth rate g_z of 7%. The technological parameter α is set to 0.37—in line with estimates of production functions in the empirical growth literature (Mankiw, Romer and Weil (1992) and Sianesi and van Reenen (2000)).[20]

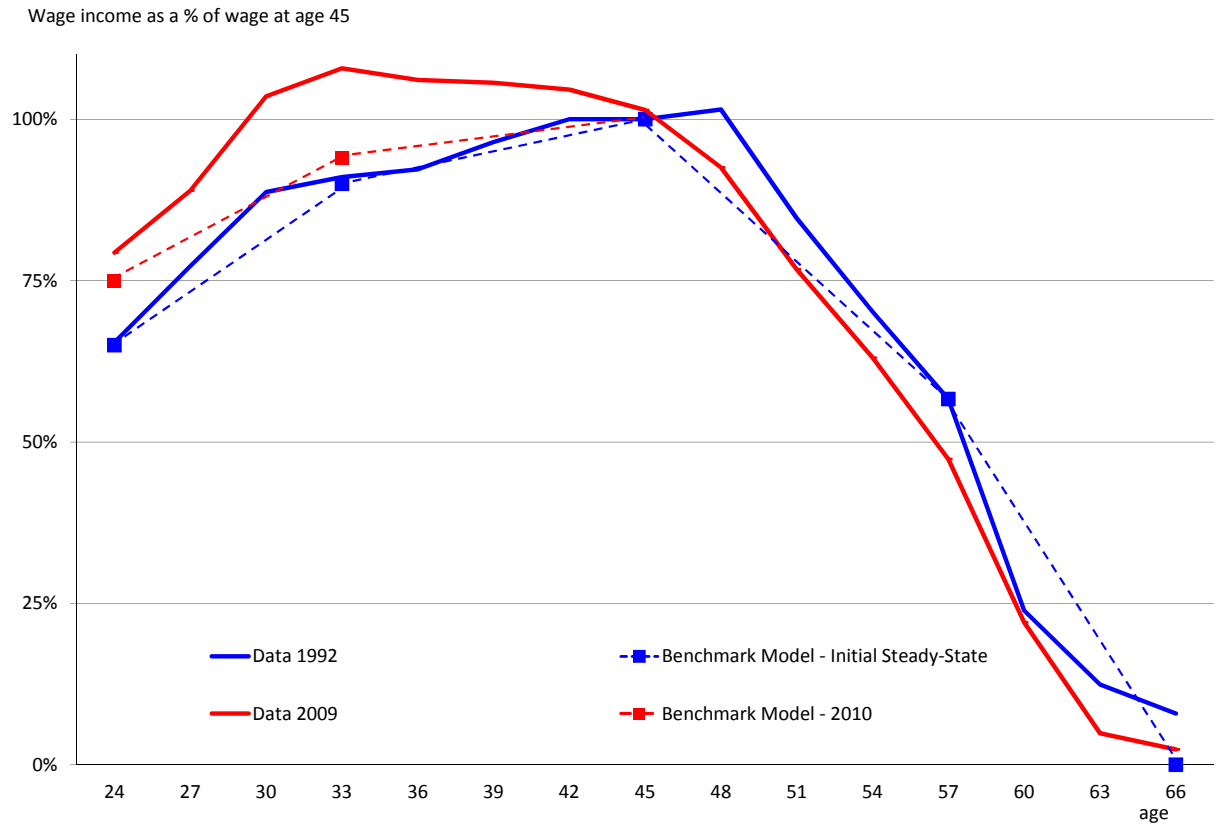
Age-Income Profile. We calibrate the experience parameters $\{e_\gamma\}_{3\leq\gamma\leq6}$ to labour income by age group, provided by UHS data. The first available year for which individual labour income information is available is 1992. Calibrating the (pre-policy) initial income profile to 1992 data is still sensible as

be flat across the middle-age in the four-period model. In particular, the case in which growth is biased towards younger individuals (of age $\gamma = 4$) features a *falling* natural rate of fertility—the costs of raising children in terms of foregone wages rise without an equivalent increase in future benefits in terms of received transfers.

[20] Using Eq. 9, one can also compute α for a given ω by looking at the ratio of education expenditures per child of twins versus only child (above 15). This method leads to an estimate of 0.39, very close to our calibrated value.

human capital levels of the working-age population have not been affected by fertility controls (chosen by 'non-treated' parents). The age-income profile in 1992 is displayed in Figure 6. The benchmark case considers time-invariant experience parameters in order to zero-in on the impact of the one-child policy. An extension allows for a *time-varying income profile*, in order to replicate the flattening of the profile for adults between 30 and 45 over the period 1992-2009 (Fig. 6). It is important to recognize that part of this flattening arises *endogenously* from the model: the quantity-quality trade-off induces rising income for the young only children due to human capital accumulation.

Figure 6: Age-income profiles (1992 and 2009)



Notes: Data source: UHS, 1992 and 2009. Wages includes wages plus self-business incomes. The model counterpart in 2010 (Benchmark Model 2010) is obtained under the benchmark calibration.

Fertility, demographic structure and policy implementation. The targeted initial fertility rate n_{ss} is the one of urban households prior to 1971—when families were entirely unconstrained. Census data gives a fertility rate slightly above 3 in urban areas in 1965-1970. We therefore select the preference parameter for children, v, to target $n_{ss} = n_{t<1971} = \frac{3}{2}$.[21] The initial population distribution—the share of each age group (0-10, 10-20, ..., 60-70 and above 70) in 1966—is calibrated to its empirical counterpart provided in the United Nations data (in 1965). While the one-child policy appeared to be nearly binding in 1980 and fully-binding after 1982, earlier endeavors to curb

[21]The Census data provides information on the number of siblings associated with each observed adult born between 1966-1970. The result is slightly above 3 children per couple. Since the number of children under the one-child policy is also slightly above 1, we take 3 to obtain the appropriate change in fertility. Note that it is possible that the natural rate of fertility may have changed after 1971 in China owing to changing preferences; we discuss this possibility in Section 5.

population growth were already under way, and most likely account for the fall in fertility over the period 1972-1980 (see Fig. 1). The policy is thus assumed to be implemented progressively during the 1970s, such that, taking cohorts to be born every 4 years, fertility varies (exogenously) according to $n_{1974} = \frac{2.6}{2}$, $n_{1978} = \frac{1.8}{2}$. For any date after 1982, fertility is constrained by the one-child policy: $n_{\max} = \frac{1}{2}$.

Education expenditures. We calibrate education costs based on the evidence shown in Section 2 (Fig. 3). Data from UHS (2006) show that for children below 15, education costs (as a fraction of total household expenditures) are between 2% and 15% for an only child. Thus, we select $\phi_4 = 0.14$ so that 7% of household income are devoted to compulsory education of a young child. For children between 15-21, education expenditures constitute an average of $15\% - 25\%$ of total expenditures. A reasonable target is setting $\phi_5 + \phi_h h$ to be on the order of 20% of total expenditures. Compulsory education costs for this age group, given in CHIP (2002), constitutes about 5% of total household expenditures. We match this target by setting $\phi_5 = 0.06$, which corresponds to about 3% of household income devoted to a child's compulsory education. In equilibrium, the remaining discretionary education costs as a share of household income ($\phi_h h$) are in line with the data for $\phi_h = 0.35$.[22]

Old age support. Two parameters govern transfers to parents, ψ and ω. The first captures the degree of altruism towards parents in the economy; the latter captures the propensity to free-ride on the transfers provided by one's siblings. We first estimate ω empirically.

Estimation of ω and validation of the transfer function. CHARLS provides data on transfers from a given child to his/her parents for the year 2008.[23] Using this cross-sectional data, the transfer function can be estimated performing the following regression:

$$\log(T_{i,f,p}) = \alpha_p + \beta_n \log(n_f) + \beta_x \log(x_i) + \gamma Z_{i,f} + \varepsilon_{i,f,p}, \tag{14}$$

where $T_{i,f,p}$ denotes transfers per child i belonging to family f and living in province p to his/her parents. n_f denotes the number of children of a given family f, x_i a numerical indicator of quality of child i (education or imputed individual income),[24] $Z_{f,i}$ a vector of control variables (child's age and gender, child's and parents' age, dummy for the co-residence of parents) and α_p a province fixed-effect. The Poisson Pseudo-Maximum-Likelihood (PPML) estimator is employed to treat the zero values in our dependent variable (see Gourieroux, Monfort, and Trognon (1984) and Santos and Tenreyro (2006)).

Results are displayed in Table 4. The amount of transfers (per offspring) received by the parents is decreasing in the number of siblings the offspring has, and increasing in the offspring's quality — using

[22] These estimates based on education expenditures only represent a lower bound of the total cost associated with a child since other transfers (food, co-residence,...) are largely omitted. Unlike education costs, other types of expenditures are difficult to break down into amounts solely related to children.

[23] CHARLS include both rural and urban. We focus on urban households. When performing robustness checks on the whole sample of urban and rural, we find very similar results. We also perform robustness checks using the 'Three cities survey' for the year 1999 based only on urban households and the recent version of CHARLS (2011) with similar findings. See Appendix A for data description.

[24] There is no direct income information for the children in CHARLS (2008). Therefore, we measure an offspring's quality x_i either by his/her education level (Columns 1-2), or, in Column 3, use information on individual income and observable characteristics of the offspring (duly observed in UHS data) to assign to each child the income of an individual with the same set of characteristics in UHS data (see Appendix A).

Table 4: Transfers from a given child to his/her parents

Dependent Variable	Transfers per child to parents		
	(1)	(2)	(3)
Log nbr children	-0.349**	-0.344**	-0.336**
	(0.167)	(0.172)	(0.168)
Log educ. level	1.302***	1.199***	
	(0.205)	(0.191)	
Log income (predicted using UHS)			0.987***
			(0.143)
Observations	1,489	1,489	1,475
Other controls	NO	YES	YES

Notes: Data source: CHARLS (2008). Sample restricted to children whose parents are above the age of 60. We take one observation per child. Estimation using Poisson Pseudo-Maximum-Likelihood (PPML). Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Other controls included in all regression includes: age of child, average parents' age, a dummy for co-residence of the child with his parents and the child's gender.

either education or income-based measures of quality. The regression estimates for the elasticity of transfers to an offspring's income and to the number of his/her siblings correspond to our theoretical formulation of the transfer function, $\psi \frac{n^{\omega-1}}{\omega} w$ (in logs), with $\beta_n = \omega - 1$ and $\beta_x = 1$. The elasticity with respect to (imputed) income is very close to unity (Column 3), while the elasticity β_n of transfers to the number of children is equal to -0.35. Thus, we set $\omega = 0.65$.[25]

Measuring ψ. The second parameter ψ measures the degree of altruism towards parents, linked to the overall level of transfers towards the elderly. Direct measurement of ψ based solely on measured transfers from CHARLS gives a very low value for ψ, around $4-5\%$ for $\omega = 0.65$.[26] Such a low value does not square with the Census evidence where family support is reported to be the main source of income of elderly (Fig. 2). Transfers measured in the data are likely to be underestimated. It does not include many forms of 'non-pecuniary transfers'—in-kind benefits such as coresidence and health care—and CHARLS does not report most pecuniary transfers *within* a household in the case of coresidence. Section 2 documents how coresidence with children is a primary form of living arrangement for the elderly. Any sort of transfers that provide insurance benefits to the elderly should in principle be taken into account—as they determine savings decisions for middle-aged adults. Importantly, if one takes only pecuniary transfers towards parents living in another city from CHARLS (2011), ψ is significantly closer to our calibrated value, about $9-10\%$. These transfers are arguably a better proxy since in-kind benefits and mis-measured pecuniary transfers within households become less of an issue when parents live far away. However, given the difficulty in accurately measuring ψ from the data, our preferred strategy is to calibrate it to match the initial age-saving profile in the early 1980's.[27]

[25] In a non-reported regression using preliminary data from CHARLS (2011), we find a very similar estimate for ω (= 0.61) and a unitary elasticity w.r.t. income (CHARLS 2011 provides income data for the children). Using 'Three cities survey' data, we find a smaller estimate of ω (=0.52) but not statistically different.

[26] Wages of children, not observed in CHARLS (2008) can be imputed based on children's characteristics. Transfers range from 4% (4 or more siblings) to 10% (only child) of the wages of individuals $42-54$ years old, yielding a value of $\psi = 4-5\%$.

[27] The mismeasurement of transfers is less of an issue when estimating ω, unless non-reported transfers have a different elasticity w.r.t the number of children.

Parameters $\{\psi, \theta, R\}$: matching initial age-saving profile and aggregate savings. Our calibration strategy jointly determines the remaining parameters, θ, R, ψ, to match the initial age-saving profile— its level and shape—and in turn, the aggregate saving rate in 1982. Replicating the initial saving profile is important for accurately assessing the ability of the model to explain the *change* in aggregate and micro-level savings over time. We construct the initial age-saving profile based on year 1986, the first year available in UHS (Figure B.2 in Appendix B).[28] The profile estimated at this point in time is a valid proxy for the initial steady-state profile—prior to the policy change. The validity rests on the fact that the sole cohorts (of adults) affected by the policy at that time are those in their 20's to early 30's.[29] The parameter θ largely determines the first point on the age-saving profile—the level of saving rate of under 25 in 1986—resulting in a value of $\theta = 2\%$.[30] The rate of return R is set to match the average aggregate saving rate of 10.4% between 1981-1983 for a given value of ψ. Calibrated values of the interest rate are of reasonable order of magnitude of $4-5\%$. The value for ψ is essential for matching the saving rate of those in their 50s, about 25% in 1986, and for determining the overall shape of the profile. The resulting value in our benchmark calibration is $\psi = 12\%$—a choice in line with Banerjee et al. (2014) and Curtis et al. (2011). A unique combination of the parameters $\{\psi, \theta, R\}$ gives a very close fit of the model-implied initial age-saving profile with that of the data in 1986—matching the saving rate of young, middle-aged and old.[31]

4.3 The Impact of the One-Child Policy

We next study the dynamics of the model following the (progressive) implementation of fertility constraints at date $t_0 > 1970$, starting from an unconstrained steady state characterized by $\{n_{ss}; h_{ss}\} = \{n_{t_0-1}; h_{t_0}\}$. After 1982, fertility is restricted to one child per family. The policy is assumed to be binding (with the exception of twin births) for all $t \geq t_0$. Parents of twins born under the one-child policy only differ ex-ante in the number of children. Since analytical solutions are cumbersome, we resort to a numerical simulation of the model's dynamics following the policy.

[28] Estimating the individual age-saving profile in the presence of multigenerational households (more than 50% of the observations) is a complex task, and the standard approach based on using household head information is flawed—as demonstrated in Coeurdacier, Guibaud and Jin (2013). Technical Appendix D.1 shows how individual age-saving profiles can be recovered from household-level data following a method proposed by Chesher (1998). The method relies on estimating individual consumption from household level consumption data using variations in the family composition as an identification strategy. Individual savings are then calculated using these individual consumption estimates in conjunction to the observed individual income data (see Appendix D.1 and Coeurdacier et al. (2013) for details).

[29] The youngest age group (age $20-25$) is subject to the credit constraint and their savings decisions are therefore unaffected by fertility policies in the model. Even within the group of individuals in their early 30s, there is likely a sizeable fraction that had children before 1980, in which case they would have been less affected by the policy.

[30] The lack of consumer credit and mortgage markets, and the very low levels of household debt in China (less than 10% of GDP in 2008) warrants a choice of a low θ to strongly limit the ability of young households to borrow against future income. The choice of $\theta = 2\%$ allows the model to match the young's saving rate in 1986, and similar estimates would have been obtained using the subsequent years of the survey. Results are not sensitive to θ as long as it is fairly close to zero.

[31] As Figure B.2 in Appendix B shows, taking $\psi = 4\%$ from direct estimates from CHARLS significantly distorts the profile. Lower transfers to the elderly tends to underestimate the saving rate of the young in their 30s and overestimate that of the middle-aged—as lower receipts of transfers from children bid the middle-aged to save more, and the young to save less due to mitigated parental obligations. This larger wealth accumulation also leads to significantly larger dissavings of the old. Note also that with $\psi = 12\%$, the saving rate of those between 25-30 falls slightly short of data estimates. This discrepancy is, if anything, consistent with the theory, since these individuals are the first to be affected by the policy change and therefore, should see a higher saving rate than their counterparts before the policy change.

Transitory dynamics. The maximization problem is the same as with unconstrained fertility, except that fertility is subject to the binding constraint $n_t \leq n_{\max,t}$. After t_0, the equation governing the evolution of human capital is described by Eq. 13, except that $n_{\max,t}$ replaces n_t. Given initial human capital h_{t_0} and the dynamics of human capital h_t for $t \geq t_0 + 1$, the consumption/saving decisions at $t \geq t_0 + 1$ can be readily backed out for each age group, using the appropriate intertemporal budget constraint (Eq. 10) and the Euler equation (Eq. 11). Aggregate savings and age-saving profiles for $t \geq t_0 + 1$ immediately follow. In our simulations, we consider cohorts that are born every 4 years—the oldest of which is born in the year 1938. While individuals optimize every 10 years, we assume that they have the same saving rate over the following age brackets: [20-26], [30-38], [42-50], [54-60], [64-70] and above 70 (corresponding to $\gamma = 3, .., 8$). In between those ages, saving rates are interpolated in order to generate a smoother age-saving profile.

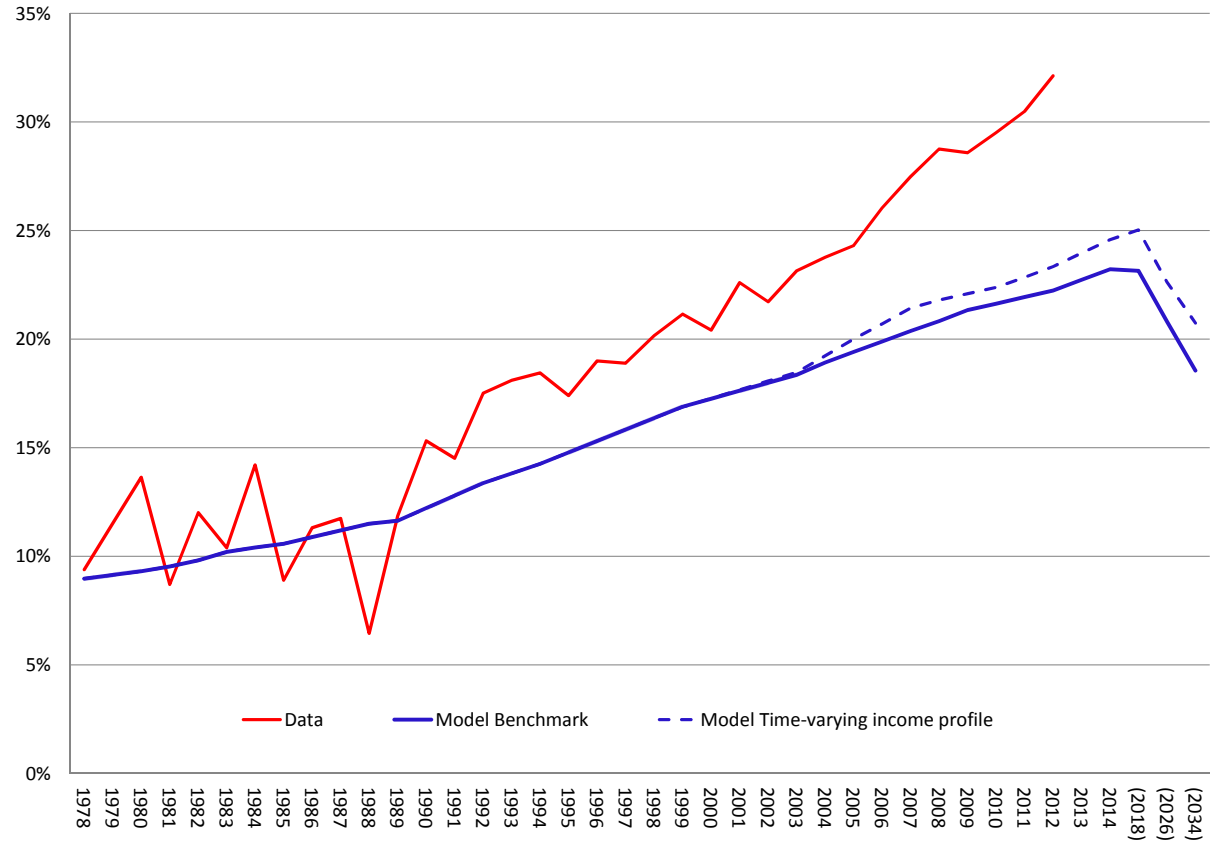
4.3.1 Aggregate savings and human capital accumulation

Aggregate savings. Figure 7 displays the aggregate saving rate in the years following the policy change in the model and in the data. Model estimates are linearly interpolated at the various dates starting in 1970. Our benchmark simulation delivers almost 60% of the total increase in aggregate savings over the last thirty years. However, this number is most likely an *upper-bound* of what can be attributed to the policy change—if the (endogenous) natural fertility rate had fallen since 1982, and had thus raised savings independently of the policy. Section 5.2 discusses more precisely counterfactual fertility and savings in the absence of the policy. Our model also predicts a fall in aggregate savings in about 15 years, driven by composition effects (macro-channel), as the generation of only child ages and old dissavers account for a larger share of the population. The experiment with a *time-varying income profile* brings the model predictions even closer to the data. The larger savings increase derives from a stronger incentive to save for individuals in their thirties as they face lower expected wage growth—due to the flattening of the income profile in the recent years (Fig. 6).

It is somewhat reassuring that aggregate savings dynamics are quite insensitive to different values of ψ — a 12.4% rise over the period 1982-2012 in the benchmark calibration ($\psi = 12\%$) compared to a 11.0% rise in the case of low transfers ($\psi = 4\%$). The predicted aggregate saving rate is similar because the two main channels governing aggregate savings turn out to be more or less offsetting: a high value of ψ makes the 'micro-channel' stronger owing to a greater importance of transfers (and their decline ensuing the policy); the 'macro-channel', however, is dampened as a result of a flatter age-saving profiles (Fig. B.2 in Appendix B): composition effects on savings are weaker when differences in saving rates among age groups are less pronounced. Conversely, a lower value of ψ implies a stronger 'macro-economic channel' and a weaker 'micro-economic channel'. The predicted rise in aggregate savings is thus comparable— even though the age-saving profiles are markedly different across calibrations.

Human capital accumulation. Due to the quantity-quality trade-off, our model predicts an increase in the level of human capital in the economy following the policy. Quantitatively, the level of human capital for an only child is 47% higher than the level of his/her parents (with two siblings)—translating into a wage increase of about 15% for the only-child generation compared to their parents (benchmark calibration). This has to be compared to a 49% increase in the number of years of schooling of the

Figure 7: Aggregate Household Saving Rate: Model vs. Data



Notes: Data source: CEIC Data (using Urban household Survey, UHS). The Model Benchmark (resp. Time-varying income profile) simulates the one-child-policy under the Benchmark (resp. Time-varying income profile) calibration of Table 3.

only-child generation compared to their parents—even though comparison between model and data is not straightforward.[32] As a consequence, the model generates *endogenously* a portion of the flattening of the age income profile observed in the data. While economically significant, the increase in human capital of the only-child generation explains only a fraction of the faster wage increase of young adults (see Fig. 6).

Using cross-sectional comparison between twins and only child in the model, the model predicts 22% less human capital investment in twins in the later years—corresponding to lower education spending per child of about 2% of parental income. The human capital difference between an only child and a twin is likely to constitute a lower bound of the overall effect of the policy—as the natural fertility rate is likely to be above 2. Cross-sectional differences in education investment between twins and only child are testable implications that motivate our subsequent empirical strategy.

The policy response of human capital is also critical for assessing the quantitative impact of a fertility change on aggregate savings. As shown in Section 3.3, the degree of substitution between quantity and quality determines the extent of the fall in expected transfers—and thus the strength

[32] According to Barro and Lee (2010), for China as a whole, the generation of only child aged 25-34 in 2010 has on average 8.7 years of schooling compared to 5.8 for their parents. The number of children achieving secondary education being multiplied by almost 3 over 1980-2010. See Li et al. (2013) for similar numbers on urban households only.

of the savings-response through the transfer channel.[33] Human capital accumulation also shifts the distribution of income across age groups, and in turn impacts aggregate savings (income composition channel). This channel will rise in magnitude in the next ten years when the generation of only children—of at most 30 years old in 2010—exerts a greater impact in the economy in terms of their higher income and savings.

4.3.2 Micro-implications: age-saving profiles

Time-Series Implications. Figure 8 plots the change in the saving rate between the initial steady state and 2010 at a given age, as implied by the model and as in the data: $(s_{\gamma,2010} - s_{\gamma,ss})_{\gamma=\{3,...,7\}}$.[34] The data reveals a marked evolution in the age-saving profile between 1986 to 2009. There has been an upward *shift* in the age-saving profile for all age groups but the youngest, as well as a change in the *shape* of the profile. The latter is characterized by a flattening of the saving profile for the middle aged (30-50), which contrasts with the typical hump-shaped profile in 1986.[35] One can mark that the model can generate the upward *shift* of the profile over the period except for the oldest above 60. The rise in saving rates results from both a fall in expenditures on children and a fall in expected future receipts of transfers. The magnitude of the rise is quantitatively in line with the data, particularly so once we allow for a *time-varying income profile*.

The model also captures part of the change in the shape of the profile. It predicts a particularly fast growth of savings of those in their early 30s: in 2009, they are the most impacted by the policy—because they are only child themselves and therefore take on the brunt of the burden of supporting their parents later, and *also* because they are subject to the one-child policy themselves and expect to receive less transfers from their only child. Both effects raise substantially their saving rate. The calibration under a time-varying income profile further increases their savings as their expected wage growth falls. Older middle-age individuals, in their late 30s-50s are only partially affected by the policy: although they are allowed only one child, they have more siblings. The eldest (above 65) were unaffected by the policy and our model alone cannot explain the rise of their savings.

Comparison with a standard OLG Model. Figure 8 also displays the change in saving rates across ages in a standard OLG model without old-age support. In this case, only the *expenditure channel* is operative.[36] In the absence of old-age support, the standard OLG model falls significantly short of predicting the change in saving rates across all ages. Thus, the transfer channel appears to be necessary for matching quantitatively the evoluation of the profile. Another important discrepancy between the two models concerns individuals in their 50s. Due to consumption smoothing over the

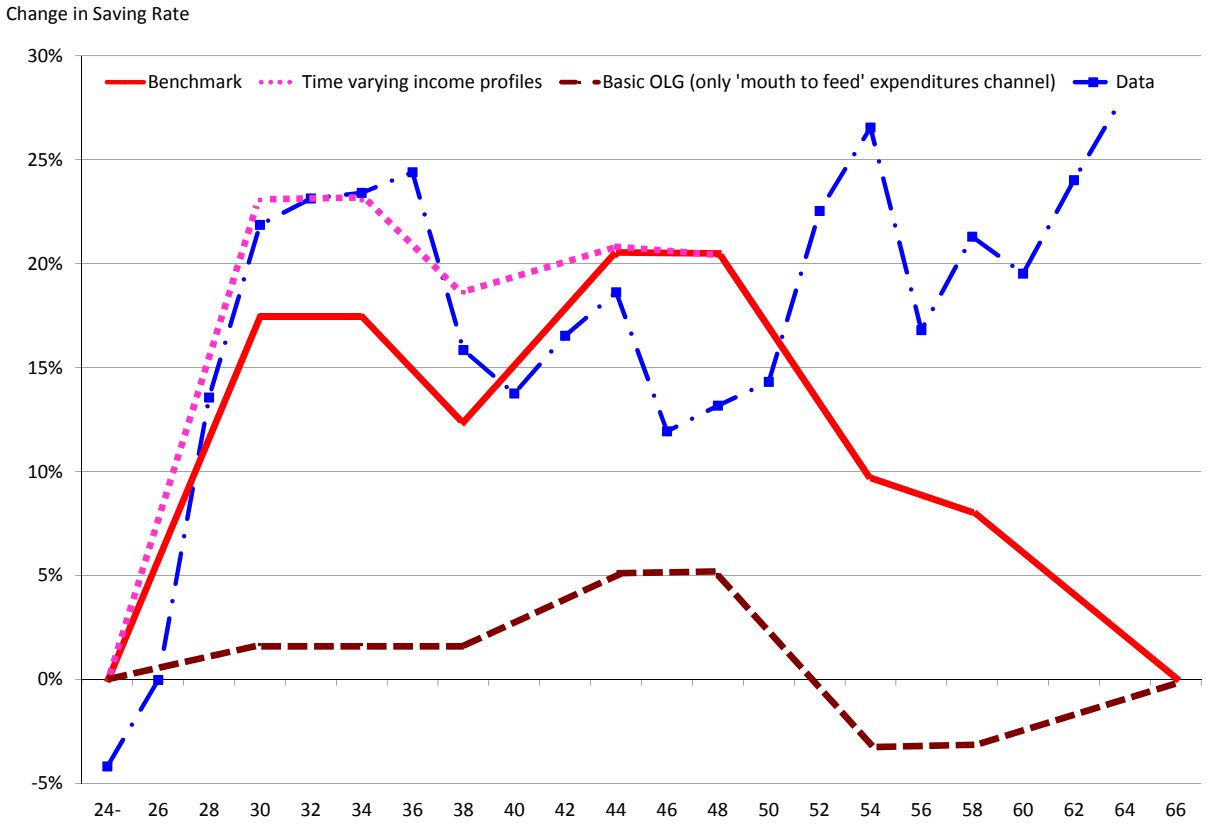
[33] Alternative calibrations (of decreasing returns to transfers and/or education for instance) can generate a much stronger human capital response to the policy and thus a very low savings response—micro-channels being limited to the 'mouth to feed' expenditure channel.

[34] For sake of space, we plot only the changes in age-saving profiles; see Appendix B for age-saving profiles in levels at the initial period and in 2009-2010.

[35] In the 30-50 age bracket, the saving rate increased more for those in their early 30s (see Chamon and Prasad (2010) and Song and Yang (2010) for similar findings). An important difference between our saving profiles as estimated from the data and those of Chamon and Prasad (2010) and Song and Yang (2010) is that young (childless) adults did not see a rise in saving rates. The difference comes from our correction for the biases associated with multi-generational households (see Coeurdacier, Guibaud and Jin (2013)).

[36] Education costs per child ϕ_γ are kept constant but human capital is fixed and transfers to elderly are set to zero. Similar patterns emerge if old-age support is independent of the number of children.

Figure 8: Change in saving rates between the initial steady-state and 2010. Model Predictions.



Notes: This figure plots the model-implied change in saving rates between the initial (steady-state) period and 2010 at different ages. Three cases considered: benchmark calibration, *time-varying income profile* calibration and standard OLG model in which old-age support and human capital accumulation are absent. Cohorts born every four years starting from 1938. Parameter values provided in Table 3. The data counterpart corresponds to the change of saving rate for a given age between 1986 and 2009.

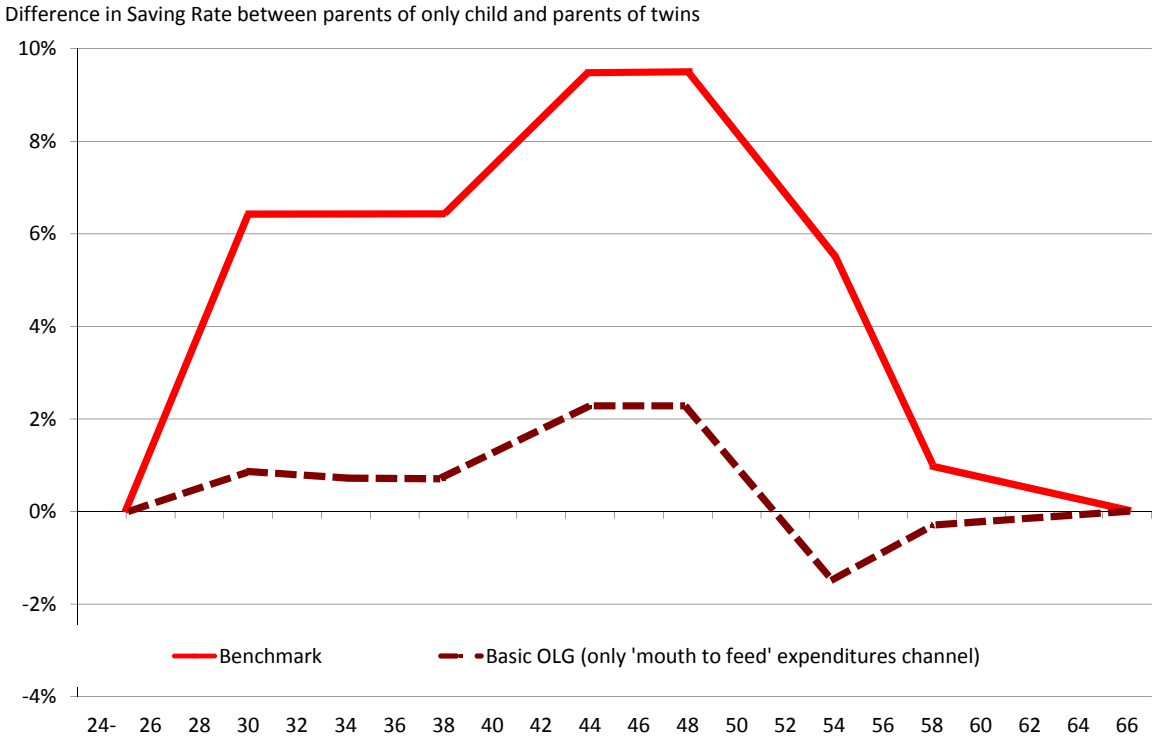
life cycle, lower expenditures on children release more resources for consumption when children are no longer living in the household. The standard OLG model predicts a fall in saving rate for this age group, while our model predicts a rise due to the *transfer channel*. This channel can thus be identified by investigating the savings behaviour of parents in their 50s once children have left the household—as done in Banerjee et al. (2010, 2014). Importantly, the magnitude of the transfer channel predicted by our model is very close to their empirical evidence. Using the partial implementation of fertility restrictions in the 1970s as an identification strategy, their double-difference estimation compares the savings behavior of individuals in their mid-50s to individuals in their early 60s in 2008: in line with our quantitative estimates, they find that the latter save on average about 10% less than the former.[37]

Cross-Sectional Implications. As shown in our theoretical analysis, one can relate the time-series change in saving rates to the cross-sectional difference in saving rates between a twin-household and an only-child household. Figure 9 plots the difference in savings rates at a given age between parents

[37] One can mark that our benchmark model falls short of explaining the sharp increase in saving rates of older workers and retirees over this period. Banerjee et al. (2010, 2014) suggests that our model predicts the appropriate variations between treated and non-treated households. Yet, saving rates increased for both groups beyond what can be explained by fertility planning.

of an only child and parents of twins as predicted by the (benchmark) model for a 2006 cross-section of individuals: $\left(s_{\gamma,2006} - s^{twin}_{\gamma,2006}\right)_{\gamma=\{3,...,7\}}$. As stated by Lemma 2, this difference is likely a lower bound of the overall time-series change in savings rates implied by the policy—if the natural fertility rate stays above 2. Compared to Figure 8 (time-series), the same patterns hold in the cross-section: only child households save more across all age groups, even after children have departed from the household—when the expenditure channel is no longer in operation. To the opposite, in a standard OLG model, parents of an only child in their fifties, should save less than parents of twins. The savings behaviour of parents in their 50s is again a distinct prediction of our model and constitutes a basis to test the relevance of the transfer channel. The cross-sectional difference in savings behaviour between parents of an only child and parents of twins constitutes our main empirical motivation to assess the quantitative properties of our model.

Figure 9: Difference in saving rates between parents of an only child and parents of twins. Model Predictions.



Notes: This figure plots the model-implied difference in saving rates between parents of an only child and parents of twins in 2006 at different ages. Two cases considered: benchmark calibration and standard OLG model in which old age support and human capital accumulation are absent. Parameter values provided in Table 3.

5 'Twin' Tests and Counterfactuals: Model vs. Data

Section 3.3.2 showed how one can identify theoretically the time-series micro-channel by comparing two-children (twin) households to only-child households. Using this theoretical analysis as guidance, we estimate a 'twin effect' from the data and, using the 'twin' experiment in the quantitative model, we compare various outcomes between model and data. One may query the validity of using twins

as exogenous deviation of fertility—for instance, in the event that twinning is fostered by 'artificial' fertility methods whose adoption may be correlated with the propensity to save. We endeavor to address this concern. The important thing to note is that identification based on twins born *under* the one child policy is of independent value—particularly for providing a good out-of-sample check to our model predictions—and this is precisely how it should be viewed.

5.1 Estimates of the 'Twin Effect'

A detailed description of the data used is provided in Appendix A. One data limitation is that one observes children (twins or only child) only when (1) residing in a household, (2) when residing outside but remaining financially dependent, or (3) in the years following their departure from the household using the panel dimension of UHS.[38] Ideally, one would have like to additionally observe the savings behaviour of parents in their late fifties, many years after the children have departed. This limitation means that the 'transfer channel' can only be inferred using fewer observations of older parents still living with their children or parents whose children just had left the household—rather than using the whole set of observations of parents in their fifties living alone.

Household Savings. The first set of regressions estimates the impact of twins on household saving rate. It uses the whole sample in UHS (1986 and 1992-2009), which includes households that had children both before and after the implementation of the one-child policy. We consider only households with resident children below the age of 18 (or 21 as a robustness check), as otherwise consumption, income and savings of the household include those of the potentially employed children. The following regression is performed for a household h living in province p at a date $t = \{1986, 1992, ..., 2009\}$:

$$s_{h,p,t} = \alpha_t + \alpha_p + \beta_1 D_{h,t}^{\text{Twins}} + \beta_2 D_{h,t}^{\text{Twins born} \geq 1982} + \gamma Z_{h,t} + \varepsilon_{p,h,t}, \tag{R1}$$

where $s_{h,p,t}$ denotes the household saving rate of household h (defined as the household disposable income less expenditures over disposable income); α_t and α_p are respectively time and province fixed-effects, $D_{h,t}^{\text{Twins}}$ is a dummy that equals one if twins are observed in a household, $D_{h,t}^{\text{Twins born} \geq 1982}$ is a dummy that equals 1 if the twins are born after the full implementation of the one-child policy (post 1982), $Z_{h,t}$ is a set of household level control variables and $\varepsilon_{p,h,t}$ is the residual. While β_1 measures the overall effect of giving birth to twins on the household saving rate over all years, β_2 measures the effect of having twins *after* the policy implementation.

Columns 1-3 in Table 5 display the coefficient estimates of the impact of twins on household saving rate before and after the policy implementation. Importantly, the twin effect (*Twins*) is insignificant (or not robustly so) when the one-child policy was not binding in the earlier years, but is significant and negative in the later years when it was enforced (*Twins born* ≥ 1982). In other words, households who had twins were not saving at systematically different rates from households without twins in the absence of fertility controls. The estimated coefficients on $D_{h,t}^{\text{Twin born} \geq 1982}$ show that under the one-child policy, households with twins saved (as a share of disposable income) on average 6.5 to 7.4

[38] Family composition and the number of children are in general unobserved in UHS when children are financially independent and living outside the household. The panel dimension (households observed for 3 consecutive years) provides some observations of households where children have departed.

Table 5: Household Saving Rate: Twin Identification

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Sav. rate	Sav. rate	Sav. rate	Sav. rate	Sav. rate inc. educ. transfers	
Oldest child	Up to 18y	Up to 18y	Up to 21y	Up to 18y	Up to 18y	Up to 21y
Sample UHS	1986 and 92-09	1986 and 92-09	1986 and 92-09	2002-2009	2002-2009	2002-2009
Type of household	All	All	All	Nuclear only	Nuclear only	Nuclear only
Twins born $\geq$ 1982	-0.0692***	-0.0653***	-0.0747***	-0.0540***	-0.0691***	-0.0662***
	(0.0170)	(0.0164)	(0.0154)	(0.0118)	(0.0123)	(0.0120)
Twins	0.0227	0.0196	0.0242*			
	(0.0139)	(0.0136)	(0.0125)			
Benchmark Controls	YES	YES	YES	YES	YES	YES
Additional Control (1)	NO	YES	YES	YES	YES	YES
Additional Control (2)	YES	YES	YES	NO	NO	NO
Observations	85,643	85,643	101,815	41,899	41,867	50,668
R-squared	0.088	0.180	0.170	0.158	0.159	0.161
Years Dummies	YES	YES	YES	YES	YES	YES
Province Dummies	NO	YES	YES	NO	NO	NO
Prefecture Dummies	NO	NO	NO	YES	YES	YES

Notes: Data source: UHS (1986, 1992-2009). We take one observation per household. Outliers with saving rate over (below) 85% (-85%) of income are excluded. Controls include average age of parents, mother's age at first birth, and child's age. Additional control (1) includes household income in addition to the benchmark controls, and additional controls (2) includes a dummy for the multigenerational structure of the family. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Columns (5) and (6) include education transfers to children living in another city as part of consumption expenditures when computing household savings.

percentage points less than household with an only child. The magnitude is similar under different specifications and across samples.[39] Columns 4-6 report regression results for a restricted sample of nuclear households (unigenerational). These households had only one incidence of births—either bearing an only child or twins. The advantage of pooling all households that are unigenerational is that the same demographic composition (up to the presence of twins) applies to all households —making this exercise the closest to our theoretical framework. Unlike the full sample in regression (R1), all households here are treated by the policy.[40] Households with twins have on average a 5.4 percentage-points lower saving rate than those with an only child. The simple-difference in the cross-section of treated households gives estimates similar in magnitude to the double-difference estimates of Columns 1-3. The result is perhaps unsurprising since no significant difference in the savings behavior of households with twins was detected before the policy. Finally, in Columns 5-6, we compute an alternative and more accurate measure of the saving rate by incorporating education transfers to children residing outside of the household as part of household expenditures (only available in the sample starting in 2002). The more precise measure of saving rate gives a larger twin effect: households

[39] In Column 1, household income is excluded as it could be an outcome variable—household members may decide to work more to meet higher expenditures with a larger number of children, or, lower the labor supply of mothers. Column 2 controls for household income. Column 3 includes all children up to the age of 21 years old.

[40] The regression performed is for a household h living in prefecture p at date $t = \{2002, ..., 2009\}$: $s_{h,p,t} = \alpha_t + \alpha_p + \beta D_{h,t}^{\text{Twins}} + \gamma Z_{h,t} + \varepsilon_{p,h,t}$.

with twins save on average 6.9 percentage-points less than those with an only child. In a nutshell, our results show that having (exogenously) one more child under the one-child policy reduces saving rates by at least 5 percentage-points and up to 7 percentage-points.

Identifying the transfer channel. One could argue that our results on savings are entirely driven by the extra costs of having twins compared to an only-child as one cannot disentangle the 'expenditure channel' from the 'transfer channel' in the previous regressions. We use two different strategies to provide evidence of the relevance of the 'transfer channel', one based on parental age and one that identifies a specific 'twin effect' on savings after their departure from the household.

Table 6: Savings and expenditures for different age groups: Twin identification

VARIABLES (in % of household income)	(1) Savings rate	(2) Savings rate	(3) Non-education exp.	(4) Non-education exp.
Twins	-0.0691***	-0.0521***	0.0237*	0.0115
	(0.0123)	(0.0131)	(0.0127)	(0.0137)
Twins with parents > 45		-0.122***		0.0688**
		(0.0350)		(0.0346)
Controls	YES	YES	YES	YES
Observations	41,867	41,867	25,833	25,833
R-squared	0.159	0.160	0.154	0.154
Years Dummies	YES	YES	YES	YES
Prefecture Dummies	YES	YES	YES	YES

Notes: Data source: UHS (2002-2009) for columns 1-2 and UHS (2002-2006) for columns 3-4 (decomposition of expenditures across different sectors including education is only available for the years 2002-2006). Restricted sample of nuclear households are those with either an only child or twins up to the age of 18 years old. Outliers with saving rate over (below) 85% (-85%) of income are excluded. In columns 3-4 outliers with non-education expenditures above 150 % of income are also excluded. Controls include average age of parents, mother's age at first birth, child's age, and household income. In columns (2) and (4) dummy for parents above the age of 45. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The 'transfer channel' becomes more relevant in one's older age as shown in Section 4.3.2. At the same time, it should mostly affect non-education related expenditures. We test whether there is a differential twin effect for older parents (above 45), and particularly so for expenditures excluding education. Results are shown in Table 6 using the sample of nuclear households (unigenerational). The first observation is that savings of twin-households compared to only-child households are smaller but even more so when parents are above 45 (Columns 1-2). Furthermore, expenditures excluding education are higher for twin households—again even more so when parents are older (Columns 3-4). An interpretation is that the 'transfer channel' is in operation.

To identify the 'transfer channel' as *the* source of variation of saving rates across households with different numbers of children, one would prefer to observe savings after the children have departed from the household and have become financially independent.[41] Using the panel dimension of UHS, our data partially allows to do so, identifying a specific effect on parental savings on 'movers'—households for which twins (or singleton) have left the household in between two surveys. Unfortunately, this is

[41]The 'expenditure channel', if anything, would tend to *raise* the saving rates of families with more children, once they have left—owing to consumption smoothing (see Fig. 9).

Table 7: Savings difference between twins and only child: identification on 'movers'

VARIABLES Oldest child	(1) Sav. rate Up to 30y birth $\geq$ 1980	(2) Sav. rate Up to 30y birth $\geq$ 1980	(3) Sav. rate Up to 30y birth $\geq$ 1972	(4) Sav. rate Up to 30y birth $\geq$ 1980	(5) Sav. rate Up to 30y birth $\geq$ 1972
Adult twins left the household	-0.0998*	-0.0950*	-0.0574	-0.00704	0.0230
	(0.0539)	(0.0539)	(0.0490)	(0.0454)	(0.0448)
Adult singleton left the household	0.0805***	0.0850***	0.0586***	0.0943***	0.0746***
	(0.0107)	(0.0109)	(0.00831)	(0.0111)	(0.00908)
Twins	-0.0534***	-0.0544***	-0.0379***		
	(0.00944)	(0.0104)	(0.00778)		
Twins 18 to 30y		0.0112			
		(0.0230)			
Singleton 18 to 30y		0.00666**			
		(0.00277)			
Observations	87,031	87,031	106,672	51,989	67,668
R-squared	0.170	0.170	0.174	0.068	0.070
Additional controls	YES	YES	YES	YES	YES
Years Dummies	YES	YES	YES	YES	YES
Province Dummies	YES	YES	YES	NO	NO
Household FE	NO	NO	NO	YES	YES

Notes: Data source: UHS (1992-2009). We take one observation per household. Outliers with saving rate over (below) 85% (-85%) of income are excluded. The sample is restricted to households with either a singleton or twins in at least one of the survey waves. Columns (4) and (5) include only households present in more than one survey year. Controls include, in logs, the average age of parents, mother's age at first birth, average child's age and household income. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

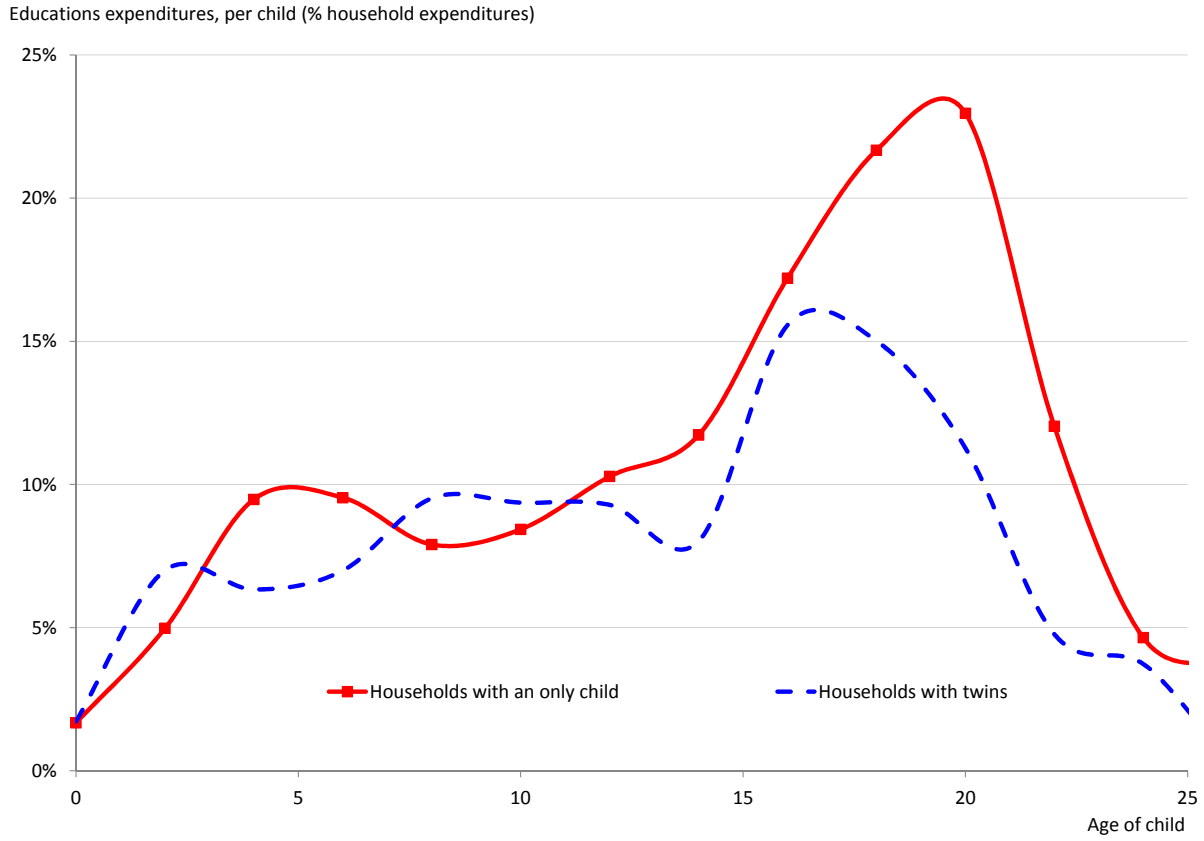
at the expense of the number of observations for identification as 'movers' constitute a small fraction of our sample of twins (about 20 observations and up to 30 in an extended sample).[42] Results are shown in Table 7 using the sample of households with children. Columns 1-3 show how savings of parents of twins and only child are affected once one (or two) child has left the household (the reference group being households with an only child residing in the household). For households with an only child, savings are higher once the child has left—whereas it falls, if anything, for twins (although the difference is not statistically different at 5%). Most importantly, households with an only child still save more than twin households once a child has left. Column 2 checks that our findings are not driven by the older age of 'movers'. Column 3 provides similar findings on an extended sample of 'movers'—considering all children born after the beginning of fertility restrictions (1972). Columns 4-5 fully use the panel dimension of the survey by adding *households fixed-effects* in the regression. This confirms our results: savings are higher in households where the only child left but not in twin households where one (or two) child left. Column 5 provides similar findings on the extended sample of 'movers'. These results confirm the importance of the 'transfer channel' in driving household savings.

'Artificial Twins'. There is a concern that twins born after the one-child policy could potentially be 'artificial'. If true, this becomes a concern when families with 'artificial twins' have a different

[42] Due to the lack of 'movers' in the twins sample, we have to consider households in which one or two children left instead of households where both left.

propensity to save/educate—after controlling for observable factors such as differences in household income, education, parents' age, etc. We conduct a series of robustness checks on income and savings differences between only-child and twin households (by first child birth) over time. If artificial twin households were partly driving our empirical results, the difference between the two type of households would increase over time as artificial twinning technologies improve and become more accessible. Our first-hand investigation suggests that this is not the case. While there was a clear discontinuity between twin and non-twin household's saving behavior around 1982 (echoing our regression results), the difference between their saving rate has not risen over time since 1982. Also, no such discontinuity occurred for the average household income level—which has been similar between twin and non-twin households (by first child birth) since 1970—nor for the number of observations of twin vs. non-twin households (per first child birth) since 1970: the proportion over this period has stayed roughly constant. Regression analysis also confirms that the incidence of twinning is not correlated with observables other than a weak association with parental age.[43]

Figure 10: Education Expenditures per child: Only Child vs. Twins



Notes: UHS (2002-2006), restricted sample of nuclear households. This figure displays the average education expenditure per child (as a share of total household expenditure) by age of the child, over the period 2002-2006.

Quantity-Quality Trade-Off. A quantity-quality trade-off is immediately visible from the evidence in Figure 10: the per-capita education expenditure on a twin is significantly lower than on an only child—for children above the age of 15. The difference reaches almost 50% at age 20. One can confirm

[43]Results based on UHS data (1986, 1992-2009). Figures and regressions are available upon request.

this finding by running the regression

$$\frac{\exp_{h,p,t}^{Educ.}}{n_{h,t}} = \alpha_t + \alpha_p + \beta D_{h,t}^{\text{Twin}} + \gamma Z_{h,t} + \varepsilon_{p,h,t}, \tag{R3}$$

for a household h at date $t = \{2002, ..., 2006\}$, where $\frac{\exp_{h,p,t}^{Educ.}}{n_{h,t}}$ denotes the education expenditure household h spends on each child (as a share of household income) at date $t = \{2002, ..., 2006\}$.[44]

Table 8: Education Expenditures per Child: Twin identification.

VARIABLES (in % of household income)	(1) Education exp. total	(2) Education exp. per child	(3) Education exp. total	(4) Education exp. per child
Twins	0.0605***	-0.0239***	0.0482***	-0.0121***
	(0.0105)	(0.00526)	(0.00952)	(0.00467)
Twins $\geq$ 15			0.0292	-0.0240**
			(0.0221)	(0.0111)
Controls	YES	YES	YES	YES
Observations	31,648	31,648	31,648	31,648
R-squared	0.122	0.120	0.136	0.134
Years Dummies	YES	YES	YES	YES
Prefecture Dummies	YES	YES	YES	YES

Notes: UHS (2002-2006), restricted sample of nuclear households are those with either an only child or twins up to 21 years of age. Other controls include average age of parents, mother's age at first birth, child's age and household income. Outliers with saving rate over (below) 85% (-85%) of income are excluded. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Education Attainment: Twin Identification (LOGIT)

VARIABLE	Higher education		Academic high school		Technical high school	
(logistic regression)	(1)	(2)	(3)	(4)	(5)	(6)
	estimate	odds ratio	estimate	odds ratio	estimate	odds ratio
Twins	-0.538***	0.584***	-0.520***	0.595***	0.316**	1.372**
	(0.168)	(0.0982)	(0.140)	(0.0834)	(0.161)	(0.220)
Controls	YES	YES	YES	YES	YES	YES
Observations	15,336	15,336	15,336	15,336	15,336	15,336
Years dummies	YES	YES	YES	YES	YES	YES
Province dummies	YES	YES	YES	YES	YES	YES

Notes: UHS (2002-2009), restricted sample of nuclear households are those with either an only child or twins of ages 18-22 years old. Controls include child's age, average age of parents, mother's age at first birth, average parents' education level, and household income. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Results of regression (R3) are shown in Columns 2 and 4 of Table 8. For the sake of comparison, the impact of twins on overall education expenditures of the household is also shown (Columns 1 and

[44] Education expenditures are only available for the years 2002-2006 in UHS.

3). We find that education investment (*per* child) in twins is significantly lower than in an only child: while having twins significantly raise total education expenditures (as a share of household income) (Column 1), it reduces education expenditures spent on each child—by an average of 2.4 percentage points (Column 2). As conjectured, this trade-off mostly applies to older children (above 15), whose education attainment becomes discretionary (Column 4).

The quantity-quality trade-off is also visible when looking at differences in education attainment. LOGIT regression results on dummies that measure the level of school enrollment (academic high school, technical high school and higher education) are displayed in Table 9. Comparing education attainment of twins versus only children (of age 18-22) over the period 2002-2009 indicates that twins are on average 40% less likely to pursue higher education than their only-child peers (Column 2), a quantitatively large effect. The reason is that twins are 40% less likely to pursue an academic secondary education which prepares to university (Columns 4) and instead 40% more likely to attend a technical high school (Column 6).[45]

Table 10: Twin Experiment: Model and Data

		Model			**Data**
Saving rate		Only child	Twins	Difference	Difference
$\gamma = 4$	(30–40)	25.9%	19.5%	6.4%	5.4 – 6.9%
$\gamma = 5$	(40–50)	36.2%	26.7%	9.5%	7.0 – 9.6%
$\gamma = 6$	(50–60)	36.2%	31.0%	5.2%	11.5 – 17.9%[a]
Education expenditures					
(% of wage income)					
$\gamma = 4$	(30–40)	7.0%	14%	7.0%	6.1%
$\gamma = 5$	(40–50)	12.5%	20.9%	8.4%	7.5%[a]
Non compulsory educ. exp. per child					
(% of wage income)					
$\gamma = 5$	(40–50)	9.5%	7.4%	−2.1%	−2.4%
Human capital		Only child	Twins	% Difference	
$(h_{2010} - h_{ss})/h_{ss}$		47%	15%	$\left(\frac{h_{only} - h_{twin}}{h_{only}}\right) = 22\%$	

[a]Estimates of the impact on household saving rates and education expenditures of having twins for the age brackets [30-40] and [40-50] are available on request. Non reported in our benchmark regressions as coefficients were not significantly different across age brackets in most specifications. For the age bracket [50-60], we use the savings estimation based on 'movers'.
Notes: This table compares the saving rate, expenditures devoted to children and children's human capital attainment for households with twins and those with an only child in 2009-2010, under the benchmark calibration, and in the data (where relevant).

Predictions of the 'Twin Effect': Model vs. Data. We turn to the simulated results of a twin experiment as predicted by our model (and discussed in Sections 4.3.1 and 4.3.2), and juxtapose these results with our empirical estimates. Table 10 reports model outcomes for an individual with twins and an individual with an only child at various ages under the benchmark calibration (in 2009). The model predicts very close estimates on the differences between these individuals compared to data

[45]It is possible that twins are of lower quality compared to singletons–for example, by having lower weights at birth (net of family-size effects)—and parents may in turn invest less in their education and substitute investment towards their singleton offspring. The problem is less serious, however, when households are allowed only one birth as in China. Oliveira (2012) finds no systematic differences between singletons and twins.

estimates. The predicted saving rate at $\gamma = 4$ and $\gamma = 5$ are respectively 6.4% (5.4 − 6.9% in the data) and 9.5% (7.0 − 9.6% in the data) lower in households with twins than in households with an only child. At $\gamma = 6$, once children have left, estimates from the data based on movers are less in line with our predictions, but arguably less precisely estimated (a 5.2% difference in the model against more than 10% in the data, even though for the latter, standard errors are large). When examining education expenditure differences (as a share of wage income), we observe that households with twins have 7% (6.1% in the data) higher total expenditures for $\gamma = 4$ and 8.4% (7.5% in the data) higher expenditures at $\gamma = 5$. Parents of twins tend to reduce their children's quality as compared to their counterparts with an only child— spending (as a % of wages) about 2.1 percentage points less on non-compulsory education per child (2.4 percentage points in the data). Our calibrated model suggests a 22% difference in human capital attainment between a twin and an only child to be compared to a 40% less chance to access higher education. The proximity of model and data estimates are reassuring since the model is not calibrated on results from twin households.

5.2 Counterfactuals

5.2.1 Data Counterfactual

Using the empirical estimates of the twin-effect on savings and human capital, one can back out the counterfactual aggregate saving rate if instead a 'two-children policy' had been implemented since 1977. In other words, given the difficulty in knowing what the natural fertility rate in China would have been over this period, we can estimate empirically a *lower-bound* of the overall impact of the one-child policy on the aggregate saving rate—assuming that the natural rate of fertility would not have fallen below 2. The procedure to compute the counterfactual involves estimating the age-saving profile and aggregate saving rate that would have prevailed in 2009 if all households were assumed to have two children after 1977, and to behave like parents of twins (using regression results based on twins). Details of the procedure are provided in Appendix D.2.[46]

Results are displayed in Table 11, which shows the decomposition of the overall effect of the policy on aggregate savings into contributions from the various channels. The counterfactual exercise indicates that aggregate saving rate would have been between 6.4% to 7.3% lower if China had implemented a (binding) 'two-children' policy—or, alternatively if the natural rate of fertility after 1977 had simply been two children per household. These empirical estimates attribute roughly a third of the 20% increase in aggregate savings rate in China to the one child policy since its implementation. Importantly, the micro-channels explain about two-thirds of the overall effect, and are significantly more important than the macro-channel conventionally emphasized.

Twins versus two-children. One should be cautious with our empirical counterfactual as it assumes that having twins is similar to having two children sequentially. In what ways are twins different from two singleton children? One is that their arrival together may have been unanticipated, and the second is that there may be a difference in the degree of scale economies when having twins compared to having two children sequentially. With regard to the first issue, we mainly focus on older parents,

[46] Note that the full impact of the policy on aggregate saving rate is not yet realized, as the generation of only-children has yet to grow old and exert a greater impact on the economy, both in terms of their demographic weight and in terms of their income weight via their higher human capital.

Table 11: Empirical counterfactuals using estimates from twins regressions: aggregate effect under a two children scenario.

	Aggregate savings rate	Additional effect
Aggregate savings rate 2009 (Census corrected)	29.74%	
Macro channels		
Age composition	28.28%	-1.45%
Education and income composition (22 to 33y)	28.06%	-0.23%
Micro channels		
Education (child below/over 15y)	25.68%	-2.37%
Non-education (parents below/above 45)	24.22%	-1.46%
Additional transfer channel[a]		
(More conservative) 3.4% scenario	23.32%	-0.90%
(Less conservative) 6.8% scenario	22.42%	-1.80%
Total effect (3.4% scenario)	-6.42%	
Total effect (6.8% scenario)	-7.31%	
Total effect (Model)	-6.45%	

[a]Our empirical counterfactual does not disentangle the expenditure channel from the transfer channel (labeled Micro channels). For observations of older parents whose children have left the household, we impute some additional savings (transfer channel) according to two scenarios (more or less conservative) based on the savings behaviour of older parents still residing with their child.

Notes: Counterfactuals are run using estimates from the twins regressions. Macro (composition) channels are computed by multiplying the number of individuals born after 1982 by 2 (and 1.5 between 1978-1981), at the same time imputing them lower incomes/education attainment as predicted by Table 9. Micro-channels are calculated using the response of expenditures of households at various ages of the children (for educ. exp.) and various ages of the parents (for non-educ. exp.) from Tables 6 and 8. See details in Appendix D.2. Model estimates are based on running a 'two-children' policy in the quantitative model (benchmark calibration).

so that the unanticipated dimension to the arrival of twins is less relevant—particularly since most of the expenditures relates to education at a later stage. Regarding economies of scale, there is evidence that they are larger for short birth spacing (of less than two years), particularly in childcare, and when children are of the same gender (see Newman (1983), Browning (1992), Rosenzweig and Wolpin (2000) for references; see also Rosenzweig and Zhang (2009)). For instance, apparel and room-sharing is found to be more likely when siblings are of the same gender. Thus, if anything, we tend to underestimate the expenditure channel when focusing on twins even though scale economies should not significantly differ between twins and two children households for most part of education costs.

5.2.2 Model Counterfactuals

The quantitative model can perform the same 'two-children' policy counterfactual as conducted in the data. One can also potentially use it to assess the quantitative contribution of the one-child policy on national savings by simulating the case under unconstrained (and optimal) fertility.

'Two-children' policy. If commencing 1976, all Chinese households were constrained to having 2 children, then the quantitative model (retaining all calibrated parameters) predicts a 6.5% lower aggregate saving rate in 2009 than that under a one-child policy—about a third of the increase in aggregate saving rate over the last thirty years. This falls in the ballpark of our (conservative) empirical estimates (Table 11).

Natural fertility rate. The empirical and model-based counterfactual of an alternative (two-children) policy demonstrates the quantitative relevance of the model given its proximity to empirical estimates. It is important to note that as long as fertility is constrained (under a one/two-children policy), our estimates are fairly accurate since the model is mostly calibrated to data in the constrained regime. Ideally, one would also like to see how much of the rise in aggregate savings and human capital can be *tied* to the one-child policy by letting fertility be optimally chosen. The challenge, though, is that any attempted estimate risks being crude and speculative as one cannot observe variations in the data that would enable us to deduce the natural fertility rate.[47] At this stage, the benchmark simulation implicitly assumes that the natural fertility remains at 3 children per household. Under this scenario which provides an upper-bound of the effect, the policy would explain almost 60% of the increase in aggregate savings.

The alternative calibration with *time-varying income profiles* implies a falling natural rate of fertility. Since growth is biased towards younger workers, the cost of educating children in terms of foregone wages is rising relative to its expected benefits. In a simulation without fertility constraints, the predicted natural fertility rate falls to 2.75 children per household in 2010, leading to a 3.5% increase of the aggregate saving rate since 1982. In this scenario, the one-child policy would thus explain about 45% of the increase in aggregate savings. If one conjectures that the natural fertility had been closer to 2 in the early 1980s and remained as such until 2009—then a third of the increase can then be tied to the policy (similar to a 'two-children' policy experiment). In a nutshell, if the natural fertility rate of China hovered between 2 and 3 over this period—a reasonable scenario—[48] one can argue that the one-child policy may have contributed to at least a third (and at most 60%) of the 20% increase in the aggregate household saving rate over the last three decades. For capital accumulation, with similar bounds for the natural fertility rate, one can attribute to the policy at least a 22% increase in human capital of the only child generation compared to their parents and at most a 47% increase.

6 Conclusion

We show in this paper that exogenous fertility restrictions in China may have led to a rise in human capital and in household saving rate—by altering saving decisions at the household level, and demographic and income compositions at the aggregate level. We explore the quantitative implications of

[47] One would also need to solve for the transition path post-1970—with data prior to the early 90s being very scarce. In particular, we have access neither to survey based data to estimate costs/returns to education nor aggregate data to gauge the relative benefits of investing in children over that period (mostly pinned-down by μ). Reliable estimates of the real interest rate is absent prior to the late-1980's. Data post 1990 shows that μ has been fairly constant—consistent with our simulations.

[48] For comparison purposes, the overall fertility rate in South Asia is 2.7 in 2011 (United Nations).

these channels in a model linking fertility, human capital and savings through intergenerational transfers that depend on the quantity and quality of offspring. Savings predictions across ages also become distinct from that of the standard lifecycle model—where human capital investment and intergenerational transfers towards the elderly are absent. We show that where our quantitative framework can generate both a micro and macro effect on savings that is close to the data, the standard OLG model falls short on both fronts.

The impact of twins estimated from the data provides an out-of-sample check to our model predictions, based on a similar twin experiment. The impact on household savings, expenditures and the degree of the quantity-quality trade-off is very close between model and data estimates. We find that the 'one-child policy' can account for at least a third (and up to 60%) of the rise in the aggregate household saving rate since its enforcement in the early 1980s. Importantly, the micro-channel accounts for the majority of the effect. This contrasts with the standard lifecycle hypothesis which conventionally focuses only on the macro channel of shifting demographic compositions. The policy also significantly fostered human capital accumulation of the only child generation.

This paper demonstrates that shifts in demographics as understood through the lens of a lifecycle model remain to be a powerful factor in accounting for the high and rising national saving rate in China—when augmented with important features capturing the realities of its households. The tacit implication—on a broader scale—is that the one-child policy provides a natural experiment for understanding the link between fertility and savings behavior in many developing economies. The quantitative impact of the policy is still evolving as the generation of more-educated only children become older and exert a greater impact on the economy—both in human capital and demographic weight. We may therefore expect a larger impact of the policy on aggregate outcomes in years to come, before the ageing of the generation of only child and the progressive relaxation of fertility constraints in China eventually reverse the effects.

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A Data

Common Definitions.

Nuclear household: a household with two parents (head of household and spouse) and either a singleton or twins.

Individual disposable income: annual total income net of tax payments: including salary, private business and property income, as well as private and public transfers income.

Household disposable income: sum of the individual disposable income of all the individuals living in the household.

Household consumption expenditures: the sum of consumption expenditures in the household, including food, clothing, health, transportation and communication, education, housing (ie. rent or estimated rent of owned house), and miscellaneous goods and services. Education transfers to children living in another city are available only for UHS 2002 to 2009. Our definition of consumption expenditure does not include interest and loan repayments, transfers and social security spending.

Individual consumption expenditures: individual expenditures are not directly observable. The estimation strategy explicated in Appendix D.1 gives age-specific individual expenditures from household aggregates.

Household saving rate: household disposable income less household expenditures as a share of household disposable income.

Individual savings rate: individual disposable income less individual expenditure as a share of disposable income.

A.1 Data Sources and Description

1. Urban Household Survey (UHS)

We use annual data from the Urban Household Survey (UHS), conducted by the National Bureau of Statistics, for 1986 and 1992 to 2009. Households are expected to stay in the survey for 3 years and are chosen randomly based on several stratifications at the provincial, city, county, township, and neighborhood levels. Both income and expenditures data are collected based on daily records of all items purchased and income received for each day during a full year. No country other than China uses such comprehensive 12-month expenditure records. Households are required by Chinese law to participate in the survey and to respond truthfully, and the Chinese survey privacy law protects illegal rural residents in urban locations (Gruber (2012) ; Banerjee et al. (2010)).

The 1986 survey covers 47,221 individuals in 12,185 households across 31 provinces. Hunan province observations in 1986 are treated as outliers and excluded because of the excessive share of twin households (46 out of 356). For the 1992 to 2009 surveys the sample covers 112 prefectures across 9 representative provinces (Beijing, Liaoning, Zhejiang, Anhui, Hubei, Guangdong, Sichuan, Shaanxi and Gansu). The coverage has been extended over time from roughly 5,500 households in the 1992 to 2001 surveys to nearly 16,000 households in the 2002 to 2009 surveys.

We generally limit the sample of households to those with children of 18 and below (or 21 and below) because older children who still remain in their parents' household most likely are income earners and make independent decisions on consumption (rather than being made by their parents).

Children who have departed from their parents' household are no longer observed (unless they remain financially dependent). As less than 0.5% of surveyed individuals aged 18 to 21 years old are living in uni-generational household (i.e. children studying in another city are still recorded as members of their parents' household), we believe that potential selection biases are rather limited.

Definitions

Young dependents: all individuals aged below 18 years of age as well as those aged 18 to 25 who are still full-time students. We assume that those individuals, being financially dependent, do not make their own saving and investment decisions.

Twins: we identify a pair of twins as two children under the same household head who are born in the same year, and when available, in the same month. When comparing twins identified using year of birth data as opposed to using both year and month of birth data (available for 2007 to 2009), only 8 households out of 206 with children below 18 years were misidentified as having twins and only 1 nuclear household out of 154 was misidentified. Overall, twin household make up for roughly 1% of all households with young children, which is consistent with the biological rate of twins occurrence.

In Table 9 the following definitions apply:

Higher education: dummy is equal to one if the child has reached post-secondary education.

Academic high school: dummy is equal to one if the child's highest level of education is either an academic high school or an undergraduate/postgraduate degree.

Technical high school: dummy is equal to one if the child's highest level of education is either a technical or vocational high school or a professional school (i.e. junior college).

2. CHARLS

The China Health and Retirement Longitudinal Study (CHARLS) pilot survey was conducted in 2008 in two provinces—Zhejiang and Gansu. Subsequently, CHARLS conducted in 2011 the first wave of its national baseline survey covering 28 provinces. Data for 2011 are now partially available. The main respondents are from a random sample of people over the age of 45, and their spouses. Detailed information are provided on their transfer received/given to each of their children. The urban sample in 2008 (2011) covers 670 households (4,224 households) of which 321 (1,699) have at least one parent above 60 and at least one adult children above 25.

Definitions

Gross transfers: sum of regular financial transfer, non-regular financial transfer and non-monetary transfer (i.e. the monetary value of gifts, in-kind etc.) from adult children to elderly parents. In 2008, of the 359 urban households in which transfers occur between children and parents: regular monetary transfers represent 14% of the total value of transfer from children, non-regular monetary transfers represent 42%, and 44% takes in the form of non-monetary support.

Net transfers: gross transfers less the sum of all transfers from parents to children.

Used in Table 4 (CHARLS 2008): *Transfers:* the sum of all financial and non-monetary transfers from an individual child to his elderly parents. We focus only on gross transfers because the Poisson estimation does not allow for negative values in the dependent variable. This restriction does not bias the results since negative net transfers between elderly parents and adult children occur in only 4% of the households in CHARLS 2008.

Individual income: CHARLS 2008 does not provide data on children's individual income. Therefore,

in order to approximate the share of transfers in children's income we need to use UHS (2008) income data. We compute the average individual income level by province, gender and education level (four groups) for each 3-year age group, in UHS. Then the incomes of these individuals with a certain set of characteristics are taken to be proxies for the incomes of children with the same set of characteristics in CHARLS. In CHARLS 2011 parents are asked to estimate each of their children household annual income. Regression estimates CHARLS 2011 using this measure are very similar.
Education level: categorical variable with 10 groups ranging from "no formal education" to "PhD level".

3. RUMiCI

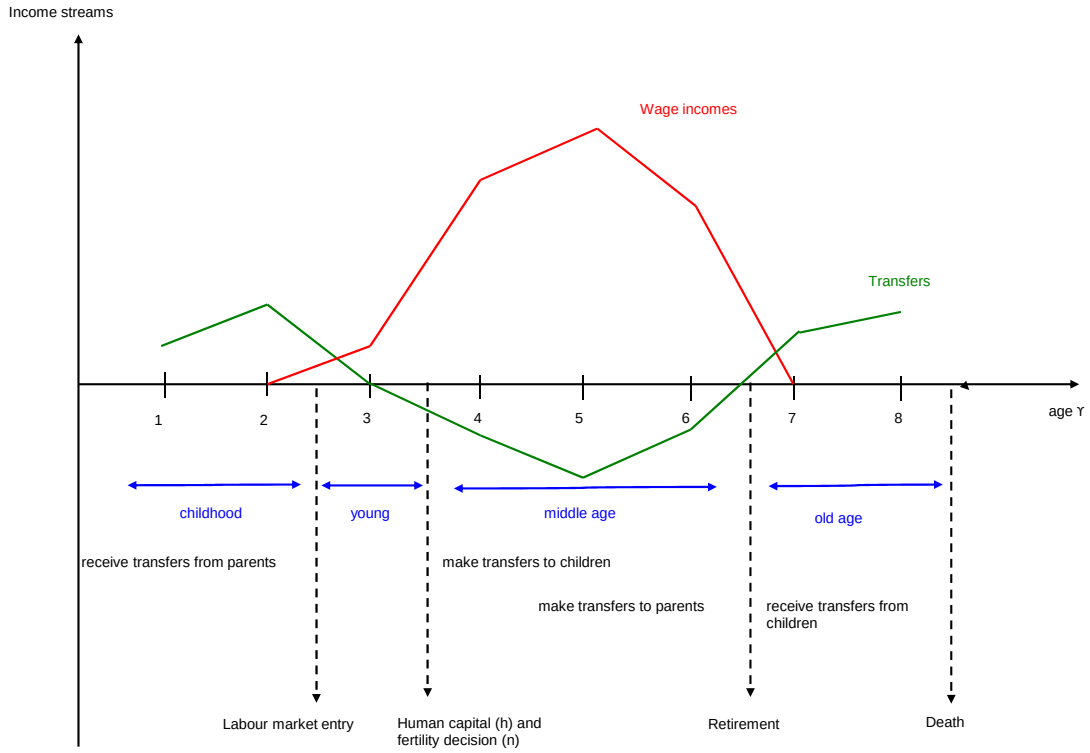
We use the China sample of the 2008 Rural-Urban Migration in China and Indonesia (RUMiCI) survey. The urban sample covers 4,998 households (of which 2,654 are nuclear households) across 19 cities in 10 provinces. RUMiCI provides data on all children born to the household head (as opposed to UHS where only children registered in the household are reported). Thus we can use RUMiCI as a robustness check on the saving and expenditures profiles, which are in line with those estimated from UHS data (Figure 3).

4. Census

The 1990 Chinese census surveyed 1% of the Chinese population across 31 provinces. The urban sample includes nearly 3 million individual observations. Figure 1 plots the number of surviving children associated with the responding head of household (or spouse) against the average birth cohort of children living in the household. For the calibration and counterfactual analysis we use the 1990 Census age distribution of urban individuals, assuming a zero mortality to compute the aggregate savings rate in different years.

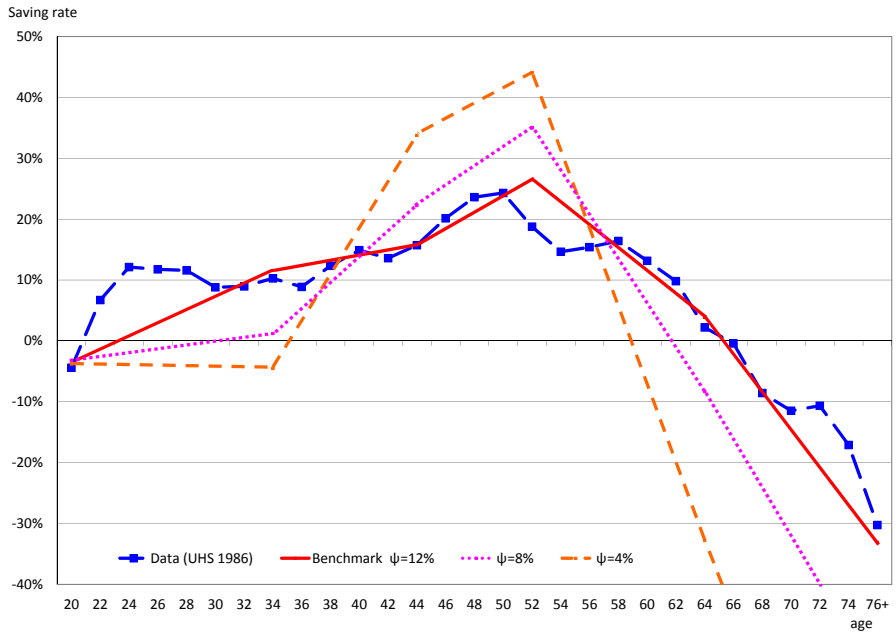
B Quantitative Model: Additional Tables and Figures

Figure B.1: Timing of Lifetime Events: Quantitative OLG Model



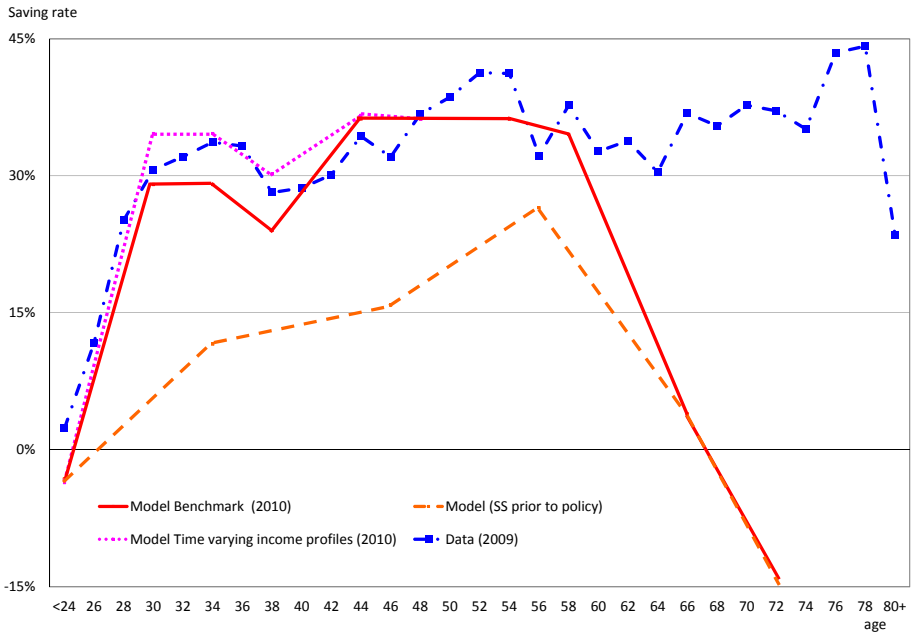
Model implied age savings profiles. We consider cohorts that are born every 4 years—the oldest of which is born in the year 1938. The age at which individuals have their first child (end of age $\gamma = 3$) corresponds to the average age of first-births in the data (age 28, average over 1975-2005 from UHS). While individuals optimize every 10 years, we assume that they have the same saving rate over the following age brackets: [20-26], [30-38], [42-50], [54-60] (corresponding to $\gamma = 3, .., 6$)—older individuals being unaffected by the policy. In between those ages, saving rates are interpolated in order to generate a smoother age-saving profile. It is important to note that individuals from different age groups coexisting in 1986 and 2009 may be differently affected by fertility control policies (see Table B.1 for detailed information of coexisting cohorts in terms of the number of children and siblings they have in 1986 and 2009). For instance, parents subject to the one-child policy (born after 1954) contrast with those subject to partial fertility policies (born between 1944-1953), as well as with those altogether unaffected (born before 1943). There are also differences within age brackets: a 30 year old in 2009, for example, is different from a 38 year old: the former is only allowed one child and was born during a period in which the policy was almost fully-implemented (in 1979). Those who were 38 were also subject to the one-child policy but potentially have siblings (born in 1971 before the policy implementation).

Figure B.2: Initial Age-Saving Profile: Model vs. Data



Notes: Data source: UHS (1986), to construct individual profiles according to the methodology in Chesher (1998) (see Appendix A and technical appendix in Coeurdacier et al. (2013)). Steady-state age-saving profiles as implied by the model take $n_{ss} = \frac{3}{2}$. For different values of ψ, the real interest rate R such that aggregate saving equals the 1981-1983 average.

Figure B.3: Age-Saving Profiles (2009): Model vs. Data



Notes: Data source: UHS (2009), to construct individual age-saving profile following Chesher (1998) (see Appendix A and technical appendix in Coeurdacier et al. (2013)). Cohorts in the quantitative model are born every four years starting from 1938. Parameter values are provided in Table 3.

Table B.1: Number of Siblings/Children by Cohort (1986 and 2009)

	1986			**2009**	
Age	No. Sibling (Birth Year)	No. Children (Fertility Year)	Age	No. Sibling (Birth Year)	No. Children (Fertility Year)
30	3 (1956)	1 (1984)	30	1.3 (1979)	1 (2007)
35	3 (1951)	1.3 (1979)	35	$2.25 - 2.7$ (1974)	1 (2002)
45	3 (1941)	3 (1969)	45	3 (1964)	1 (1992)
55	3 (1931)	3 (1959)	55	3 (1954)	1 (1982)
65	3 (1921)	3 (1949)	65	3 (1944)	2.7 (1972)
75	3 (1911)	3 (1939)	75	3 (1934)	3 (1962)

Notes: The number of children and siblings (including the individual) attributed to an individual belonging to a particular cohort in the year 1986 and 2009—by year in which they and their children were, respectively, born. This shows that contemporaneous cohorts in each of these two years were differentially affected by fertility control policies.

C Technical Appendix: Theory

C.1 Four-period model

Proof of Proposition 1:

Proof of existence and uniqueness: if $\{n_{ss}; h_{ss}\}$ exists, then it must satisfy the steady-state system of equations:

$$\begin{aligned} \frac{n_{ss}}{1-\theta-\psi\frac{n_{ss}^{\omega-1}}{\omega}} &= \left(\frac{v}{\beta(1+\beta)+v}\right)\left(\frac{1}{\phi_0+\phi_h\left(1-\lambda\right)h_{ss}}\right) \\ h_{ss} &= \left(\frac{\alpha\psi\mu}{\phi_h}\right)\frac{n_{ss}^{\omega-1}}{\omega}, \end{aligned}$$

which, combined, yields:

$$\frac{n_{ss}}{1-\theta-\psi\frac{n_{ss}^{\omega-1}}{\omega}} = \left(\frac{v}{\beta(1+\beta)+v}\right)\left(\frac{1}{\phi_0+\frac{\alpha}{\omega}\left(1-\lambda\right)\left(\psi\mu\right)n_{ss}^{\omega-1}}\right).$$

Let $N_{ss} = n_{ss}^{\omega-1}$, and rewriting the above equation yields

$$N_{ss}^{-1/(1-\omega)} - \left(\frac{v}{\beta(1+\beta)+v}\right)\left(\frac{1-\theta-\frac{\psi}{\omega}N_{ss}}{\phi_0+\left(1-\lambda\right)\mu\frac{\alpha\psi}{\omega}N_{ss}}\right) = 0$$

Define the function $G(x) = x^{-1/(1-\omega)} - \left(\frac{v}{\beta(1+\beta)+v}\right)\left(\frac{1-\theta-\frac{\psi}{\omega}x}{\phi_0+(1-\lambda)\mu\frac{\alpha\psi}{\omega}x}\right)$ for $x > 0$. Then,

$\lim_{x\to+\infty} G(x) = \left(\frac{v}{\beta(1+\beta)+v}\right)\frac{\psi/\omega}{(1-\lambda)\left(\mu\frac{\psi\alpha}{\omega}\right)} < 0$ if $\lambda > 1$, and $\lim_{x\to 0^+} G(x) = +\infty$

We have:

$$G'(x) = -\frac{x^{-\omega/(1-\omega)}}{1-\omega} + \frac{v\psi/\omega}{\beta(1+\beta)+v}\frac{\phi_0+\left(1-\theta\right)\left(1-\lambda\right)\alpha\mu}{\left(\phi_0+\left(\left(1-\lambda\right)\mu\frac{\alpha\psi}{\omega}x\right)^2\right.}.$$

Two cases are:

- Case (1): if $\phi_0 + \left(1-\theta\right)\left(1-\lambda\right)\alpha\mu \leq 0$ then $G(x)$ is monotonically decreasing over $[0; +\infty]$.
- Case (2): $G(x)$ is first decreasing— to a minimum value strictly negative attained at $x_{\min} > 0$— and then increasing for $x > x_{\min}$.

In both cases, the intermediate value theorem applies, and there is a unique $N_{ss} > 0$ such that $G(N_{ss}) = 0$—-thus pinning down a unique $\{n_{ss}; h_{ss}\}$ such that both are greater than 0. Moreover, if we define a unique n_0 implicitly by

$$\frac{n_0}{1-\theta-\psi\frac{n_0^{\omega-1}}{\omega}} = \left(\frac{v}{\beta(1+\beta)+v}\right)\left(\frac{1}{\phi_0}\right),$$

then it immediately follows that $n \geq n_0$ if $\omega \geq \alpha$ (and $\lambda > 1$).

Aggregate Savings.

Definition of Saving Rates. The aggregate savings of the economy in period t, S_t, is the sum of the aggregate savings of each generation $\gamma = \{y, m, o\}$ coexisting in period t. Thus, $S_t \equiv \sum_\gamma S_{\gamma,t}$, where the overall savings of each generation $S_{\gamma,t}$ are by definition the change in asset holdings over a period with optimal asset holdings $a_{\gamma,t}$ given by Eq. 1 and Eq. 4: $S_{y,t} \equiv N_t^y a_{y,t}$, $S_{m,t} \equiv N_t^m (a_{m,t} - a_{y,t-1})$, and $S_{o,t} \equiv -N_t^o a_{m,t-1}$.

The individual saving rate $s_{\gamma,t}$ of cohort γ is the change in asset holdings over a period divided by the cohort's corresponding labor income (for the young and middle-aged) or capital income (for the old):[49]

$$s_{y,t} \equiv \frac{a_{y,t}}{w_{y,t}} \; ; \quad s_{m,t} \equiv \frac{a_{m,t} - a_{y,t-1}}{w_{m,t}}; \quad s_{o,t} \equiv -\frac{a_{m,t-1}}{(R-1)a_{m,t-1}} = -\left(\frac{1}{R-1}\right).$$

The aggregate saving rate, defined as $s_t \equiv S_t/Y_t$ (where Y_t denotes aggregate labor income), can thus be decomposed as follows:

$$s_t \;\; = \;\; s_{y,t}\left(\frac{n_t w_{y,t}}{y_t}\right) + s_{m,t}\left(\frac{w_{m,t}}{y_t}\right) + s_{o,t}\left(\frac{(R-1)\, a_{m,t-1}}{n_{t-1} y_t}\right), \tag{15}$$

where aggregate labor income per middle-aged household, $y_t = Y_t/N_{m,t}$, is introduced for convenience. The aggregate saving rate is thus a weighted average of the young, middle-aged and old's individual saving rates, where the weights depend on both the population and relative income of the contemporaneous generations coexisting in the economy—at a certain point in time. Changes in fertility can affect the aggregate saving rate through a *micro-economic channel*—changes in the individual saving behavior (change in $s_{m,t}$)—and a *macroeconomic channel*—changes to the composition of population and income.

Steady-State Aggregate Savings. Long-run analysis helps gain intuition on how exogenous changes in long-run fertility impacts the aggregate saving rate. These exogenous changes can be brought about by a change in the preference for children ν, since it alters the birth rate but does not exert any impact on savings other than through its effect on n_{ss}. The saving rate, decomposed into the contribution of contemporaneous generations, is, in the long-run version of Eq. 15:

$$s = \frac{n_{ss} e}{(1+n_{ss}e)} \underbrace{(-\theta\mu)}_{s_y} + \frac{1}{(1+n_{ss}e)} \underbrace{\left(\kappa(n_{ss}) + \frac{\theta}{R}\right)}_{s_m} - \frac{\kappa(n_{ss})(R-1)}{n_{ss}(1+n_{ss}e)(1+g_z)} \underbrace{\left(\frac{1}{R-1}\right)}_{s_o}, \tag{16}$$

where $\kappa(n_{ss}) \equiv a_{m,t}/w_{m,t}$ is given by the steady-state equivalent of Eq. 4:

$$\kappa(n_{ss}) = \frac{\beta}{1+\beta}\left[(1-\theta) - \underbrace{\left(\phi_0 n_{ss} + \alpha\psi\mu\frac{n_{ss}^\omega}{\omega}\right)}_{\substack{\text{cost of children} \\ =\text{'expenditure channel'}}} - \underbrace{\psi\frac{n_{ss}^{\omega-1}}{\omega}}_{\text{cost of parents}} - \underbrace{\frac{\psi\mu}{\beta}\frac{n_{ss}^\omega}{\omega}}_{\substack{\text{benefits from children} \\ =\text{'transfer channel'}}}\right]$$

using $n_{ss} h_{ss} = \alpha\psi\mu n_{ss}^\omega/\omega$ from Eq. 6.

[49] For analytical convenience, debt repayments for middle-aged and transfers are not included in the disposable income of the relevant generations. Results do not alter much except including more cumbersome expressions.

Proof of Lemma 1:

Substituting $n_{\max}$ for the choice variable n_t in Eq. 6, the dynamics of $\log(h_{t+1})$ becomes

$$\log(h_{t+1}) = \frac{1}{1-\alpha}\log\left(\frac{\alpha\psi}{\phi_h}\frac{n_{\max}^{\omega-1}}{\omega}\right) + \frac{1}{1-\alpha}\log(\mu_{t+1}) - \frac{\alpha}{1-\alpha}\log(h_t),$$

where $\log(h_{t+1})$ is mean-reverting due to $-\frac{\alpha}{1-\alpha} < 1$ for $\alpha < 1/2$. It follows from $n_{t_0-1} > n_{\max}$ that $h_{\max} > h_{t_0}$. To asses the increase in human capital for the first generation of only child, we use we first use Eq. 6 to determine the human capital level in periods t_0 (in steady-state) and t_0+1:

$$\begin{aligned} h_{t_0} &= \left(\frac{\alpha\psi}{\phi_h R}(1+g_z)\right)\frac{(n_{t_0-1})^{\omega-1}}{\omega} \\ (h_{t_0+1})^{1-\alpha}\, h_{t_0}^{\alpha} &= \left(\frac{\alpha\psi}{\phi_h R}(1+g_z)\right)\frac{(n_{\max})^{\omega-1}}{\omega} \\ \Rightarrow \left(\frac{h_{t_0+1}}{h_{t_0}}\right) &= \left(\frac{n_{t_0-1}}{n_{\max}}\right)^{\frac{1-\omega}{1-\alpha}} \end{aligned} \tag{17}$$

Proof of Proposition 2:

Define aggregate labor income in the economy to be the sum of income of the young and middle-aged workers $Y_{t+1} = (1+n_t e)\, N_{m,t+1} w_{m,t+1}$. Population evolves according to $N_{m,t+1} = N_{y,t} = n_{t-1} N_{o,t+1}$, and analogously, $N_{y,t+1} = n_t N_{y,t} = n_t N_{m,t+1}$. Cohort-level saving at date $t+1$ are respectively:

$$\begin{aligned} S_{y,t+1} &\equiv N_{y,t+1} a_{y,t+1} = -\theta n_t N_{t+1}^m \frac{w_{m,t+2}}{R} \\ S_{m,t+1} &\equiv N_{m,t+1}\left(a_{m,t+1} - a_{y,t}\right) \\ &= N_{m,t+1}\left[\frac{\beta w_{m,t+1}}{1+\beta}\left(1-\theta-n_t\phi(h_{t+1}) - \frac{\psi n_{t-1}^{\omega-1}}{\omega}\right) - \frac{w_{m,t+2}}{R(1+\beta)}\frac{\psi n_t^{\omega}}{\omega} + \theta\frac{w_{m,t+1}}{R}\right] \\ S_{o,t+1} &\equiv -N_{t+1}^o a_{m,t-1} = -\frac{N_{m,t+1}}{n_{t-1}}\left[\frac{\beta w_{m,t}}{1+\beta}\left(1-\theta-n_{t-1}\phi(h_t) - \frac{\psi n_{t-2}^{\omega-1}}{\omega}\right) - \frac{w_{m,t+1}}{R(1+\beta)}\frac{\psi n_{t-1}^{\omega}}{\omega}\right] \end{aligned} \tag{18}$$

Let $S_{t+1} = \sum_\gamma S_{\gamma,t+1}$ (where $\gamma \in \{y,m,o\}$) be aggregate saving at $t+1$, denoted, then the aggregate saving rate $s_{t+1} = S_{t+1}/Y_{t+1}$ can be written as

$$s_{t+1} = \frac{1}{(1+en_t)}\left[\begin{array}{c} -\frac{\theta}{R}n_t\left(\frac{w_{m,t+2}}{w_{m,t+1}}\right) + \frac{\beta}{1+\beta}\left(1-\theta-n_t\phi(h_{t+1}) - \frac{\psi n_{t-1}^{\omega-1}}{\omega}\right) - \frac{\psi}{R(1+\beta)}\frac{n_t^{\omega}}{\omega}\left(\frac{w_{m,t+2}}{w_{m,t+1}}\right) + \frac{\theta}{R} \\ -\frac{\beta}{(1+\beta)(1+g_z)n_{t-1}}\left(1-\theta-n_{t-1}\phi(h_t) - \frac{\psi n_{t-2}^{\omega-1}}{\omega}\right) + \frac{\psi}{R(1+\beta)}\frac{n_{t-1}^{\omega-1}}{\omega} \end{array}\right]. \tag{19}$$

The aggregate saving rate in t_0+1, after the policy implemented in t_0, is obtained by replacing $t+1$ by t_0+1 in Eq. 19 and n_t by n_{max}. Using the optimal relationship between fertility and human capital along the transition path: $\phi_h n_{\max} h_{t_0+1} = \left(\frac{\alpha\psi}{R}(1+g_z)\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha}\right)\frac{n_{\max}^{\omega}}{\omega} = \left(\frac{\alpha\psi}{R}\right)\frac{n_{\max}^{\omega}}{\omega}\left(\frac{w_{m,t+2}}{w_{m,t+1}}\right)$,

we have

$$s_{t_0+1} = \frac{1}{(1+n_{\max}e)} \left[\begin{array}{c} \frac{\theta}{R}\left(1 - n_{\max}\frac{w_{m,t+2}}{w_{m,t+1}}\right) + \frac{\beta}{1+\beta}(1-\theta)\left(1 - \frac{1}{n_{t_0-1}(1+g_z)}\right) \\ -\frac{\psi}{R(1+\beta)}\frac{n_{\max}^{\omega}}{\omega}\left(\frac{w_{m,t+2}}{w_{m,t+1}}\right)(1+\beta\alpha) - \frac{\beta}{1+\beta}\phi_0\left(n_{\max} - \frac{1}{1+g_z}\right) \\ +\frac{\psi}{R(1+\beta)}\frac{n_{t_0-1}^{\omega-1}}{\omega}(1+\beta\alpha) - \frac{\psi\beta}{1+\beta}\left(\frac{n_{t_0-1}^{\omega-1}}{\omega} - \frac{1}{n_{t_0-1}(1+g_z)}\frac{n_{t_0-2}^{\omega-1}}{\omega}\right) \end{array} \right]$$

The aggregate saving rate s_t in the initial period $t = t_0$ is the steady-state equivalent of the above equation. In order to find the difference $s_{t_0+1} - s_{t_0}$ we first obtain, with some algebraic manipulation:

$$\begin{aligned} s_{t_0+1} \quad - \quad & \left(1 + \frac{(n_{t_0-1} - n_{\max})\, e}{1+n_{\max}e}\right) s_{t_0} \\ = \quad & \frac{1}{1+n_{\max}e} \left[\begin{array}{c} -\frac{\theta}{R}\left(n_{\max}\left(\frac{w_{m,t+2}}{w_{m,t+1}}\right) - n_{t_0-1}\left(1+g_z\right)\right) \\ -\frac{(1+\beta\alpha)}{R(1+\beta)}\frac{\psi}{\omega}\left(n_{\max}^{\omega}\left(\frac{w_{m,t+2}}{w_{m,t+1}}\right) - (1+g_z)n_{t_0-1}^{\omega}\right) - \frac{\beta}{1+\beta}\phi_0\left(n_{\max} - n_{t_0-1}\right) \end{array} \right] \\ = \quad & \frac{1}{1+n_{\max}e} \left[\begin{array}{c} -\frac{\theta}{R}\left(1+g_z\right)\left(n_{\max}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha} - n_{t_0-1}\right) \\ -\frac{(1+\beta\alpha)}{R(1+\beta)}\frac{\psi}{\omega}(1+g_z)\left(n_{\max}^{\omega}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha} - n_{t_0-1}^{\omega}\right) - \frac{\beta}{1+\beta}\phi_0\left(n_{\max} - n_{t_0-1}\right) \end{array} \right]. \end{aligned}$$

Rearranging,

$$\begin{aligned} s_{t_0+1} - s_{t_0} \quad = \quad & \frac{(n_{t_0-1} - n_{\max})\, e}{1+n_{\max}e} s_{t_0} + \frac{\theta\mu}{1+n_{\max}e}\left(n_{t_0-1} - n_{\max}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha}\right) \\ + \quad & \frac{\beta}{(1+\beta)(1+n_{\max}e)}\left[\phi_0\left(n_{t_0-1} - n_{\max}\right) + \left(\alpha + \frac{1}{\beta}\right)\frac{\psi\mu}{\omega}\left(n_{t_0-1}^{\omega} - n_{\max}^{\omega}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha}\right)\right], \end{aligned}$$

where $\mu \equiv (1+g_z)/R$. To prove that $s_{t_0+1} - s_{t_0} > 0$, we first use Eq. 17. This implies that if $n_{t_0-1} > n_{\max}$, then

$$\begin{aligned} n_{t_0-1} - n_{\max}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha} \quad &= \quad n_{t_0-1}\left(1 - \left(\frac{n_{\max}}{n_{t_0-1}}\right)^{1-\frac{\alpha(1-\omega)}{1-\alpha}}\right) > 0 \\ n_{t_0-1}^{\omega} - n_{\max}^{\omega}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha} \quad &= \quad n_{t_0-1}^{\omega}\left(1 - \left(\frac{n_{\max}}{n_{t_0-1}}\right)^{\frac{\omega-\alpha}{1-\alpha}}\right) > 0 \end{aligned}$$

if $\omega > \alpha$.

Identification through twins.

From Eq. 6, the per-capita human capital of the twins (denoted $h_{t_0+1}^{twin}$) must satisfy:

$$\left(h_{t_0+1}^{twin}\right)^{1-\alpha} h_{t_0}^{\alpha} = \left(\frac{\alpha\psi}{\phi_h}\mu\right)\frac{(2n_{\max})^{\omega-1}}{\omega} < \left(\frac{\alpha\psi}{\phi_h}\mu\right)\frac{(n_{\max})^{\omega-1}}{\omega} = (h_{t_0+1})^{1-\alpha} h_{t_0}^{\alpha}.$$

This leads immediately to the first testable implication.

Proof of Lemma 2:
From 20, we have:

$$s_{m,t_0+1}-s_{m,t_0}=\Delta s_m=\frac{\beta}{(1+\beta)}\left[\phi_0\left(n_{t_0-1}-n_{\max}\right)+\frac{(1+\beta\alpha)}{R\beta}\frac{\psi\left(1+g_z\right)}{\omega}\left(n_{t_0-1}^{\omega}-n_{\max}^{\omega}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha}\right)\right]$$

The saving rate for a middle-aged agent in period $t+1$ is $s_{m,t+1}\equiv(a_{m,t+1}-a_{y,t})/w_{m,t+1}$. By Eq. 19, we have

$$s_{m,t_0+1}-s_{m,t_0+1}^{twin}=\frac{\beta}{1+\beta}\left[\phi_0 n_{\max}+\frac{(1+\alpha\beta)}{R\beta}\frac{\psi(1+g_z)}{\omega}n_{\max}^{\omega}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha}\left(2^{\frac{\omega-\alpha}{1-\alpha}}-1\right)\right].$$

The micro-channel on aggregate saving of moving from $n_{t_0-1}=2n_{max}$ to n_{max} in t_0 is, using Eq. 17:

$$\begin{aligned}\Delta s_m(2n_{\max}) &= \frac{\beta}{1+\beta}\left[\phi_0 n_{\max}+\frac{(1+\beta\alpha)}{R\beta}\frac{\psi(1+g_z)}{\omega}n_{\max}^{\omega}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha}\left(2^{\omega}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{-\alpha}-1\right)\right.\\ &= \frac{\beta}{1+\beta}\left[\phi_0 n_{\max}+\frac{(1+\beta\alpha)}{R\beta}\frac{\psi(1+g_z)}{\omega}n_{\max}^{\omega}\left(\frac{h_{t_0+1}}{h_{t_0}}\right)^{\alpha}\left(2^{\frac{\omega-\alpha}{1-\alpha}}-1\right)\right]\\ &= s_{m,t_0+1}-s_{m,t_0+1}^{twin}.\end{aligned}$$

C.2 Quantitative OLG model

Derivation of Fertility and Human Capital Relationships in the Quantitative Model. The intertemporal budget constraint satisfies

$$\begin{aligned}\left(\sum_{\gamma=4}^{8}\beta^{\gamma-4}\right)\left(\frac{c_{4,t+1}}{w_{4,t+1}}\right) &= (1-\theta-\phi_4 n_t)-\mu\left[(\phi_5+\phi_h h_{t+1})n_t+\psi\frac{n_{t-1}^{\omega-1}}{\omega}\right]\left(\frac{e_{5,t+2}}{e_{4,t+1}}\right)\\ &\quad -\mu^2\left(\psi\frac{n_{t-1}^{\omega-1}}{\omega}\right)\left(\frac{e_{6,t+3}}{e_{4,t+1}}\right)+\mu^3\left(\frac{\psi n_t^{\omega}}{\omega}\right)\left(\frac{h_{t+1}}{h_t}\right)^{\alpha}\left(\frac{e_{5,t+4}}{e_{4,t+1}}+\mu\frac{e_{6,t+5}}{e_{4,t+1}}\right)\\ &\quad +\mu\left(\frac{e_{5,t+2}}{e_{4,t+1}}+\mu\frac{e_{6,t+3}}{e_{4,t+1}}\right)\end{aligned}\tag{20}$$

First order condition on h_{t+1}:

$$h_t^{\alpha}h_{t+1}^{1-\alpha} = \left(\frac{\psi\alpha}{\omega}\frac{\mu^2}{\phi_h}\right)n_t^{\omega-1}\left[\mu\left(\frac{e_{6,t+5}}{e_{5,t+2}}\right)+\left(\frac{e_{5,t+4}}{e_{5,t+2}}\right)\right]$$

or,

$$\left(\frac{h_{t+1}}{h_t}\right)^{\alpha}=\frac{\phi_h h_{t+1}}{\xi_{t+1}n_t^{\omega-1}}\frac{\omega}{\alpha\psi}\tag{21}$$

where $\xi_{t+1}\equiv\mu^2\left[\mu\left(\frac{e_{6,t+5}}{e_{5,t+2}}\right)+\left(\frac{e_{5,t+4}}{e_{5,t+2}}\right)\right]$.
First order condition on fertility n_t:

$$\frac{v}{n_t}=\frac{\beta}{c_{4,t+1}}\left[\mu(\phi_5+\phi_h h_{t+1})\frac{e_{5,t+2}}{e_{4,t+1}}-\mu^3\left(\psi n_t^{\omega-1}\right)\left(\frac{h_{t+1}}{h_t}\right)^{\alpha}\left(\frac{e_{5,t+4}}{e_{4,t+1}}+\mu\frac{e_{6,t+5}}{e_{4,t+1}}\right)\right]w_{4,t+1}$$

$$\frac{v\Pi(\beta)}{n_t}\left\{1-\theta+\mu\left(\frac{e_{5,t+2}}{e_{4,t+1}}+\mu\frac{e_{6,t+3}}{e_{4,t+1}}\right)\left(1-\frac{\psi n_{t-1}^{\omega}}{\omega}\right)\right\}=$$
$$\mu^3\frac{\psi n^{\omega-1}}{\omega}\left(\frac{h_{t+1}}{h_t}\right)^{\alpha}\left(\frac{e_{5,t+4}}{e_{4,t+1}}+\mu\frac{e_{6,t+5}}{e_{4,t+1}}\right)\left[1+\frac{v\Pi(\beta)}{\omega}\right]+\mu\left(1+v\Pi(\beta)\right)\left(\phi_5+\phi_h h_{t+1}\right)\left(\frac{e_{5,t+2}}{e_{4,t+1}}\right),$$

where $\Pi(\beta)\equiv\beta\left(\sum_{g=4}^{8}\beta^{g-4}\right)$.

Using Eq. 20, and substituting in Eq. 21 we arrive at the optimal fertility equation:

$$\frac{n_t}{1-\theta+\varkappa_t(1-\varphi\frac{n_{t-1}^{\omega-1}}{\omega})} = \left(\frac{v}{v+\Pi(\beta)}\right)\left(\frac{1}{\phi_{0,t}+\phi_{h,t}h_{t+1}(1-\lambda)}\right), \tag{22}$$

where $\phi_{0,t}\equiv\phi_4+\phi_5\mu\left(\frac{e_{5,t+2}}{e_{4,t+1}}\right)$, $\phi_{h,t}\equiv\phi_h\mu\left(\frac{e_{5,t+2}}{e_{4,t+1}}\right)$,$\varkappa_t\equiv\mu\left(\frac{e_{5,t+2}}{e_{4,t+1}}\right)\left[1+\mu\left(e_{6,t+3}/e_{5,t+2}\right)\right]$, and $(1-\lambda)\equiv\frac{\Pi(\beta)}{v+\Pi(\beta)}\left(1-\frac{\omega}{\alpha}\right)+\frac{v}{v+\Pi(\beta)}(1-\frac{1}{\alpha})=1-\frac{v+\omega\Pi(\beta)}{\alpha v+\alpha\Pi(\beta)}$.

Steady-State Properties. If variables are assumed to be constant through time and $\lambda>1$, there exists a unique steady-state $\{n_{ss};h_{ss}\}$— characterized by $n_{ss}>\left(\frac{v}{v+\Pi(\beta)}\right)\left(\frac{(1-\theta)+\mu\varkappa_{ss}}{\phi_{0,ss}}\right)$ and $h_{ss}>0$— to which the dynamic model defined by Eq. 12 and 13 converges. The modified (NN) and (QQ) curves, describing the steady-state choice of fertility, given human capital accumulation and the quantity-quality trade-off, become:

$$\frac{n_{ss}}{(1-\theta)+\mu\varkappa_{ss}(1-\varphi\frac{n_{t-1}^{\omega-1}}{\omega})} = \left(\frac{v}{v+\Pi(\beta)}\right)\left(\frac{1}{\phi_{0,ss}+\phi_{h,ss}h_{ss}(1-\lambda)}\right) \tag{NN}$$

$$h_{ss} = \left(\frac{\psi\alpha}{\omega}\frac{\xi_{ss}}{\phi_h}\right)n_{ss}^{\omega-1}, \tag{QQ}$$

D Technical Appendix: Data Treatment

D.1 Individual consumption estimation

The estimation procedure for age-saving profiles in China is explained in details in the Technical Appendix of Coeurdacier, Guibaud and Jin (2013). Here, we briefly describe the main methodology employed to disaggregate household consumption into individual consumption, and thereby estimate individual saving by age. Following the projection method of Chesher (1997, 1998), the following model is estimated on the cross-section of households for every year:

$$C_h=\exp(\boldsymbol{\gamma}.\boldsymbol{Z}_h)\left(\sum_{j=19}^{99}c_j N_{h,j}\right)+\epsilon_h,$$

where C_h is the aggregate consumption of household h, $N_{h,j}$ is the number of members of age j in household h, and $\boldsymbol{Z}_h$ denotes a set of household-specific controls. Following Chesher (1997), multiplicative separability is assumed to limit the number of degrees of freedom, and control variables enter in an exponential term. The control variables include:

- Household composition: number of children aged 0-10, number of children 10-18, number of adults, and depending on the specification, the number of old and young dependents.

- Household income group: households are grouped into income quintile (a discrete variable 1-5).

In the estimation, a roughness penalization term is introduced to guarantee smoothness of the estimated function $c_j = c(j)$. This term is of the form:

$$P = \kappa^2 \int \left[c''(j)\right]^2 dj,$$

where κ is a constant that controls the amount of smoothing (no smoothing when $\kappa = 0$ and forced linearity as $\kappa \to \infty$). The discretized version of P, given that j is an integer in $[19; 99]$, can be written $\kappa^2(\boldsymbol{J}\boldsymbol{c}_j)'(\boldsymbol{J}\boldsymbol{c}_j)$, where the matrix $\boldsymbol{J}$ is the 79×81 band matrix

$$\boldsymbol{J} = \begin{bmatrix} 1 & -2 & 1 & 0 & \dots & 0 & 0 & 0 \\ 0 & 1 & -2 & 1 & \dots & 0 & 0 & 0 \\ 0 & 0 & 1 & -2 & \dots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \dots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & \dots & -2 & 1 & 0 \\ 0 & 0 & 0 & 0 & \dots & 1 & -2 & 1 \end{bmatrix},$$

and $\boldsymbol{c}_j = [c_j]_{j=19,\dots,99}$ is an 81×1 vector. Pre-multiplying $\boldsymbol{c}_j$ by $\boldsymbol{J}$ produces a vector of second differences. We set $\kappa = 10$.

As a robustness check, we use the projection method to estimate individual income distributions by age from household income data, and then confront the estimated distributions with the actual ones—which we observe for the period 1992-2009. The estimated income distributions are very close to the observed ones.[50]

D.2 Empirical Counterfactual

One would also need to identify all channels through which having two children rather than one affect household savings. Four different effects comprising the macro-economic and micro-economic channels include (i) composition of income and education; (ii) composition of population; (iii) expenditure channel; (iv) transfer channel. We decompose the quantitative contribution of each of these different channels in Table 11, noting however that (iii) and (iv) are difficult to disentangle empirically.

Macro-channels.

Composition of Population. First, one needs to account for the shifts in the demographic composition. This involves multiplying the number of observations of individuals born after 1982 by a factor of 2 and the number of individuals born in between 1978-1981 by a factor of 1.5, in the 2009 sample. Holding constant the age-saving profile, aggregate saving is now about 1.45 % lower under a 'two-child policy' due to the demographic composition effect.

Composition of Education and Income. Second, the incremental individual human capital that is attributed to the one-child policy alters household saving to the extent that those with higher edu-

[50] For the year 1986, information on income is available only at the household level. For that year, we therefore use the projection method to estimate both individual income and individual consumption.

cation tend to save more; it also alters the composition of income across age groups. Therefore, we need to 'purge' the additional human capital caused by the policy. Using estimates of the twin-effect on education attainment provided in Table 9, we give young cohorts a 40 percent less likelihood of attaining higher education under the two-children scenario. The overall impact on aggregate saving, holding everything else constant, is however very small—less that 0.3 %. The effect being small is not surprising since it concerns only a small fraction of households in the whole sample at present; also, the positive impact of higher education on savings comes through only in later stages of life rather than at young ages. We therefore expect a greater impact of the education and income channel in the future years.

Thus, when moving from one to two children per household, compositional effects account for a 1.7% difference in aggregate saving. Though this number may seem small at first glance, this effect will only rise in magnitude in the near future as the generation of only child ages and accounts for a larger share of aggregate income and saving at the age of 40—around 10 years time.

Micro-channels.

Expenditure and Transfers. Third, the imputed increase in expenditures associated with having an additional child is used to quantify the expenditure channel effect. Taking first education expenditures, we give all households with one child under 15 years of age in the sample now a 4.8% higher expenditure in education (as a share of household income) on compulsory education, relying on the estimates from Table 8 (Column 3). For households with a child above 15 years of age, we assign an additional non-compulsory education expenditure that is lower since the quantity-quality trade-off is at work: from the estimate in Column 3, we find a 2.7% increase for an additional child above 15 (ie. $= 4.8\%+2.9\%-5.0\%$ corresponding to 4.8% higher education expenditures for all twin households, 2.9 % higher education expenditures specific to households with twins above 15, minus 5% higher education expenditures which are common to all households with children above 15). The overall effect of higher education expenditures leads to an additional 2.37% fall in the aggregate saving rate.

One can proceed by the same methodology to calculate the additional non-education related expenditures, remarking though that these effects kick in mostly during later stages of adulthood (see Table 6 column 4). We impute to all parents with financially dependent children (i.e below 18 or below 25 and still students) a 1.2% higher non-education expenditure when under 45, and a 7.6% higher expenditures when above 45(ie. $= 1.2\% + 6.8\% - 0.4\%$ corresponding to 1.2% higher non-education expenditures for all twin households, 6.8% higher non-education specific to twins parents above 45, minus 0.4% higher expenditures common to all households with parents above 45).

Taken all together, the incremental education and non-education expenditures lead to an additional 3.83% ($= 2.37\% + 1.46\%$) drop in the aggregate saving rate (see Table 11). Note that apart from education expenditures that are clearly devoted to children, the change in other expenditures when moving from one to two children is partly driven by the 'expenditure channel' and partly by the 'transfer channel'. One cannot fully disentangle the two using this methodology, but we nevertheless believe that the impact on older parents' of 'other expenditures' is likely to operate through the transfer channel.

A caveat is that older parents (in their late 40s and 50s) that were subject to the policy should also

be affected by the 'transfer channel', even though their only child has left the household. This effect cannot be properly measured in the data since one can no longer observe whether parents had an only child or twins once the children have departed from the household (except in the 1 or 2 following years using the panel dimension). But if 'non-education expenditures' for parents above 45 (in Table 6) is used as a proxy for the increase in overall expenditures, (treated) households in their late 40s to 50s (before retirement) with two children should incur an additional 6.8%(of household income) higher expenditure. This channel is, however, less precisely estimated from the data and warrants a sensitivity analysis using more conservative estimates: assuming instead that additional expenditures are 3.4% higher (rather than 6.8%) for older parents (without children below 21 or below 25 but still studying in the household), aggregate saving rate falls by an additional 0.9% (resp. 1.8%).

The combined effect of these channels summarized in Table 11 indicates that aggregate saving rate would have been between 6.4% to 7.3% lower if China had implemented a (binding) 'two-children' policy—or, alternatively if the natural rate of fertility after 1977 had simply been two children per household. *These estimates impute roughly a third of the 20% increase in aggregate savings rate in China to the one child policy since its implementation.*