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ABSTRACT

The Child Quantity–Quality Trade-off

This chapter reviews the growing literature on the child quantity–quality (QQ) trade-off. During the transition from the traditional agricultural economy to modern economic growth, household real income increases, fertility decreases, and human capital investment per child increases. Motivated by this observation, economists started to develop theoretical models of the child QQ trade-off in the 1970s. Macroeconomic models that theoretically incorporate the QQ trade-off flourish. As a parallel development, empirical studies exploit multiple sources of exogenous variations in family size, such as twin births, child sex composition, and family planning policies, to identify the causal effect of fertility on child quality. Dialogues between theoretical and empirical analyses should empower future research on the child QQ trade-off.

JEL Classification: D10, J13

Keywords: demographic transition, fertility, child human capital investment, child quantity-quality trade-off

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1. Introduction

The idea of the child quantity–quality (QQ) trade-off can be at least dated back to Malthus (1798), who observed that the "constant effort" to increase the number of children trapped disadvantaged people in a subsistence level of living.[1] Although Malthus was correct in explaining a large part of human history (Ashraf and Galor 2011), he did not foresee the demographic transition. In western Europe, after a prolonged period of mortality decline, fertility started to decline at the end of the 19th century (Lee 2003). Advanced countries have largely "escaped" from the "Malthusian trap." However, many parts of the world are still in the high-fertility–low-growth regime, and are yet to complete the demographic transition.

Figure 1 depicts the demographic transition in the last half century. For a sample of 99 countries, the total fertility rate (TFR) is almost halved. The TFR declines from an average of 5.5 children in 1960 to less than 2.8 children in 2015 (sub-figure a). By contrast, with 2017 as the base year of measurement, the real GDP per capita more than triples, rising from an average of 6,019 USD in 1960 to 20,748 USD in 2015 (sub-figure b). At the same time, schooling years rises from an average of 3.5 years in 1960 to 9.0 years in 2015 (sub-figure c). Overall, the world has witnessed declining fertility, growing GDP per capita, and rising educational attainment from 1960 to 2015.

Evolving cross-sectional associations between TFR and GDP per capita also

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[1] We interchangeably use fertility, family size, sibling size, child number, and child quantity to refer to the number of children.

reflect the ongoing demographic transition (Figure 2).[2] In 1960–1970, the TFR stays at six children per women for countries with a GDP per capita below 5000 dollars; the TFR then declines with the GDP per capita, except for countries with very high income levels. By contrast, in the 21st century, the TFR shows a monotonic decline with GDP per capita, and stays at roughly two children per women for high-income countries. The changing cross-sectional associations between TFR and GDP per capita results from a substantial over-year decline of TFR for middle-income countries, especially for countries with GDP per capita at around 8000 dollars. The associations between TFR and average schooling years display a similar pattern (Figure 3). For most years, the TFR stays at approximately two children for countries with average schooling years above nine.

The ongoing demographic transition motivates generations of theoretical and empirical investigations of the child QQ trade-off. This chapter first reviews the seminal contributions by Gary Becker and his co-authors, followed by macroeconomic studies on dynastic models and theories of differential fertility. Then, the chapter discusses empirical studies on the effect of family size on child quality (the QQ effect), with particular attention to the causal inference of the QQ effect, using twin, child gender, and public policies as instrumental variables for the number of children. The QQ trade-off has profound policy implications for the demographic future of the society. Problematically, theoretical and empirical investigations of the QQ trade-off appear to have taken divergent paths, and only recently start to

[2] Similar figures have been drawn in other studies (Myrskylä et a. 2009; de Silva and Tenreyro 2017, 2020)

re-connect. A reunion of theoretical and empirical analyses should empower the next generation of research on the child QQ trade-off.

2. Economic theory on the child quantity–quality trade-off

2.1. Seminal contributions

Becker (1960) was the first to present an influential economic analysis of fertility. Becker's original analysis has several key ingredients. First, modern contraceptives enlarge the scope of human decision-making on pregnancy and birth giving. Second, children are treated as durable consumption goods that can only be produced at home; just like other durable goods, a rise in household income tends to increase the demand for both the quantity and quality of children. Third, children are normal goods, that is, the income effect on fertility is positive. Fourth, fertility declines because of the decline in child mortality, the adoption of contraceptives, and a rising cost of child rearing. Along with these provocative discussions, Becker (1960) makes an ad hoc assumption that child quantity and quality are close substitutions. Then, if the income elasticity of child quality is higher than that of child quantity, a rise of income would eventually reduce fertility, substituting child quantity with quality.[3]

Becker and Lewis (1973) relax the ad hoc assumption on the close substitutability between child quantity and quality in their child QQ trade-off model. Parents take children as durable consumption goods, choosing over child quantity (n) and quality (q):

[3] Becker's (1960) seminar paper attracts a lot of criticisms. Heckman (2015) provides an excellent account of how Becker absorbed useful criticisms to advance the theory of the child QQ trade-off.

$$\max_{n,q,s} \quad U(n,q,s),$$
$$\text{subject to} \quad \pi_n n + \pi_q q + \pi_{nq} nq + p_s s = y,$$

where s is parents' own consumption, and y is household income. The most salient feature of the model is the interaction of n and q in the household budget constraint.

The interactive budget constraint gives the price of an additional child,

$$p_n = \pi_n + \pi_{nq} q,$$

where π_n represents the "fixed" cost of an additional child, such as the cost of birth giving, subsistence-level child consumption, and the minimal time cost of child rearing; $\pi_{nq} q$ represents the costs of private goods, such as tuition fees and health expenditures, which increase in child quality. A higher-quality child costs more. The price of children is higher for rich households, as long as the rich demands higher-quality children, who are more expensive to raise.

Similarly, the price of child quality is

$$p_q = \pi_q + \pi_{nq} n,$$

where π_q represents the costs of child-related public goods within a household, which may include the economy of scale in household tutoring or the sharing of clothes among children; $\pi_{nq} n$ represents the costs of private goods, which increase in the quantity of children.

The model generates a trade-off between child quantity and quality without assuming a close substitutability between quantity and quality in the preference or household production function. Instead, the model directly incorporates the trade-off in the budget constraint. Child quality enters the price of child quantity, and child quantity enters the price of child quality. In the case of external changes, child quantity and quality tend to be negatively correlated. For instance, when income increases, the demand for both *q* and *n* increases; if the income elasticity of *q* is higher than that of *n*, *q* tends to rise more than *n*, raising the price of *n* relative to *q*. As a result, the increase in income initially raises both child quantity and quality; as income continues to rise, rising *q* induces declining *n*. Thus, the model generates the demographic transition: as income rises, average human capital keeps increasing, while fertility follows a hump-shaped path, and eventually declines. The model also predicts a negative correlation between *q* and *n* after the demographic transition.

Becker and Tomes (1976) further develop the QQ model by incorporating Becker's (1974) own insights on social interactions. Becker and Tomes (1976) motivate several strands of literature. First, by assuming that each child has an endowment in child quality, they derive the demographic transition even when the income elasticity of child quantity is the same as that of quality. The endowment assumption has been adopted by many subsequent studies, especially the macroeconomic studies on the demographic transition, which we will discuss in detail in the next section.

Second, when child endowment differs within a household, altruistic parents will conduct efficient compensatory or reinforcing investments according to the endowment of each child.[4] This insight leads to generations of studies on intra-household allocation (Behrman et al. 1982; Behrman et al. 1994; Rosenzweig and Zhang 2009; Yi et al. 2015; Yi 2019).

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[4] When child endowment differs, child quality can also differ within a household. Becker and Tomes (1976) open the door for the relaxation of the "equal quality" assumption in Becker and Lewis (1973).

Third, public education may fail, as it crowds out parental investment on child education, increases the number of children for disadvantaged families, and consequently lowers social mobility. Along this line, Becker and Tomes (1979, 1986) further study the effects of endowment inheritance and human capital investment on intergenerational mobility and social inequality, laying down a theoretical foundation for subsequent studies on mobility and inequality (Solon 2004; Black and Devereux 2011; Chetty et al. 2014; Becker et al 2018; Fan et al 2021; Zhang 2021).

In sum, seminal contributions by Gary Becker, Gregg Lewis, and Nigel Tomes have explained a large variety of empirical regularities by incorporating the child QQ trade-off into standard models of utility maximization. This endeavor motivated an important line of macroeconomic research, some conducted by Becker himself, on the demographic transition and its consequences for long-term economic growth and income inequality. Doepke (2015) provides an excellent account of Gary Becker's contributions to the child QQ trade-off literature.

2.2. Macroeconomic studies on fertility, growth, and inequality

The intellectual exchange between Gary Becker and Robert Barro has paved the way for the macroeconomics of the demographic transition. Becker (1974) owes the name of the "Rotten-kid Theorem" to the Barro family, while Barro's (1974) formalization of the "Ricardian equivalence" is based on an altruistically linked family lineage.

Becker and Barro (1986, 1988) first incorporate fertility choices in a family lineage linked by parental altruism and transfers toward children. Parents derive utility from their own consumption, the number of children, and children's utility. Because children care about the utility of grandchildren, altruism transmit across generations: parents actually care about the utility of all descendants of their family lineage. In this dynastic model, parents act as if they optimize utility for the entire family lineage, under the discounted resource constraint of the entire family lineage. If the cost of child rearing increases, parents tend to have fewer children, and allocate more money (either in the form of physical or human capital) to each child. Even though the dynastic model does not explicitly model human capital investment, it does generate a negative association between fertility and average child consumption. Becker and Barro then use the model to explain the baby bust during the Great Depression and World War II, and the baby boom in the post-war period in the US. They also predict that, in their small open economy model, a rise of international interest rate would raise fertility. Barro and Becker (1989) formally model the production side of the economy, which enables an explicit consideration of capital accumulation and technological progress. They show that rapid technological progress, which raises per capita income, tends to reduce fertility and population growth.

Becker, Murphy, and Tamura (1990) extend the dynastic model to incorporate human capital production, and explicitly consider the child QQ trade-off. As the production of human capital intensively uses the stock of human capital, the return to human capital investment increases with the stock of human capital for a wide range of the stock. When the initial human capital stock is low, the model reaches a steady state with high fertility and low per capita income (Malthusian stagnation). By contrast, when the initial human capital shock is high, the model converges to a steady state with low fertility and high per capita income (sustained growth). Becker, Murphy, and Tamura successfully generate the two regimes of Malthusian stagnation and sustained growth as separate steady states in one model. The transition from the Malthusian stagnation to sustained growth, as emphasized by Becker, Murphy, and Tamura, requires "accidents and good fortune."

Galor and Weil (2000) endogenize the transition process from the regime of Malthusian stagnation to the regime of sustained growth. Galor and Moav (2004) further model the transition process as the replacement of physical capital accumulation by human capital accumulation. Galor (2005, 2012) provides detailed reviews of this class of unified growth theories. In particular, religions, culture, and social norms are important determinants of the path and pace of the demographic transition (de la Croix and Delavallade, 2018; de Silva and Tenreyro 2020; Myong et al. 2021). Macro-economists also study efficiency properties under endogenous fertility (Golosov et al. 2007; De La Croix and Doepke 2021; Córdoba and Liu 2022), develop the Becker-Barro model without an explicit consideration of human capital investment (Jones and Schoonbroodt 2010; Córdoba et al. 2016; Córdoba and Ripoll 2019), and examine the interaction between female empowerment and fertility (Tertilt 2005, 2006; Doepke and Tertilt 2009, 2018; Doepke et al. 2012; Doepke and Kindermann 2019). Jones et al. (2010) and Doepke and Tertilt (2016) provide excellent reviews of the macroeconomics of family and fertility.

An important strand of macroeconomic research focuses on the link between differential fertility on inequality and growth. Lam (1986) and Chu (1990) point out that income-specific fertility rates have a large compositional effect on income inequality. The tendency for the poor to have more children, combined with limited intergenerational mobility, enlarges income equality. De la Croix and Doepke (2003, 2004) build models of differential fertility along the line of Becker and Barro (1988). They endogenize fertility and human capital investment for a population with unequal initial distribution of human capital. The QQ trade-off induces the poor to have more children and invest little in child education. The differential fertility between the rich and the poor, coupled with the differential human capital investment, enlarges inequality and slows down economic growth. Doepke (2004) is a pioneering study on the speed and timing of the demographic transition. He finds that the provision of public education and strict regulations on child labor accelerate the fertility decline, and diminish income inequality throughout the demographic transition. Vogl (2016) extends the differential-fertility model to explain simultaneously the positive association between child quantity and quality before the demographic transition and the negative association after the demographic transition. Vogl (2020) uses a differential-fertility model to explain the changing intergenerational association of fertility, which feeds back and explains aggregate fertility changes. Zhou (2021) calibrates a differential-fertility model to quantify the effects of monetary and in-kind pro-natal policies on fertility, mobility, and social welfare in the US.

The macro-economic studies have greatly expanded the theoretical implications of the child QQ trade-off on fertility, growth, and inequality. The plentiful theoretical constructs, however, do not necessarily imply explanatory power to real-world changes. Careful calibrations, which adjust deep parameters of macro models to fit empirical moments, can deliver sensible theoretical predictions. But without well-crafted causal inference, economists still ponder on the quantitative importance of each theoretical construct. Complementary to the "macro literature" that incorporates the child QQ trade-off, a "micro literature" uses quasi-experimental variations to identify the causal effect of fertility on child quality.

3. Empirical studies on the child quantity–quality trade-off

3.1. Early attempts

The increasing availability of micro data has empowered economists to investigate the child QQ trade-off at the household level. Willis (1973) uses the 1960 US census to study the association between paternal lifetime income and maternal education on completed fertility. Although child quality does not directly appear in the estimation equation, the empirical analysis in Willis (1973) is derived from a QQ model that incorporates maternal time allocation (Becker, 1965) into the QQ theory. A more direct analysis is Leibowitz (1974), who analyzes the Terman sample of gifted children with top-one-percent IQ scores in the US, and finds that children with more siblings attain less schooling. Hanushek (1992), using a sample of children from poor families (the sample of the Gary Income Maintenance Experiment), separates the effects of family size and birth order on child quality. He finds that, conditional on child birth order, a larger family size negatively correlates with a child's reading and vocabulary test scores at the sixth grade; by contrast, conditional on family size, birth order does not show a monotonic relationship with child test scores.[5]

In the midst of descriptive studies using micro data, Rosenzweig and Wolpin (1980) pioneer the use of the natural experiment of twins to identify the causal effect of fertility on child quality. First, they build on the QQ model of Becker and Lewis (1973) to derive the comparative statics of an exogenous fertility increase on child quality. Surprisingly, even though an exogenous fertility increase raises the price of child quality, the fertility increase does not necessarily reduce child quality, because both child quantity and quality directly enter parental utility. If child quantity and quality are close complements in the utility function, then an exogenous increase in child quantity may increase child quality. When theoretical restrictions are imposed on the substitutability between child quantity and quality in the utility function, the QQ theory can deliver the refutable implication that an exogenous increase of child quantity reduces child quality. Second, they use a sample of farm households in India to conduct the empirical analysis. Exploiting twin births as the instrumental variable for child quantity, they find that a twinning-induced fertility increase reduces children's school attainment. Rosenzweig and Wolpin (1980) provide the first quasi-experimental evidence for the QQ theory.

At the end of the 20th century, few studies had adopted the quasi-experimental approach to examine the QQ trade-off. Empirical economists have been fascinated by

[5] One strand of literature studies the QQ trade-off in historical settings (e.g., Becker et al. 2010; Shiue 2017; Klemp and Weisdorf 2019).

multiple sources of natural experiments, such as variations in child gender composition and comparisons within genetically identical twins, to answer a large variety of important research questions (Rosenzweig and Wolpin 2000). It is not until the twenty-first century that economists again tread on the path of Rosenzweig and Wolpin (1980) to analyze the causal effect of fertility on child quality.

3.2. Identifying QQ effects using twin and sex composition instruments

Black et al. (2005) appear to be a triggering contribution in the new wave of studies on the causal effect of fertility on child quality. Using administrative records in Norway, they find that, conditional on child birth order, twinning-induced fertility increases do not reduce children's educational attainment. By contrast, children born in higher birth orders consistently show lower educational attainment. Their empirical specification has been followed by many studies: when exploiting twinning at the *n*th birth, they restrict the sample to families with at least *n* children, and study the outcomes of children born before the *n*th birth. For example, when using twinning at the third birth as the IV for family size, they restrict the sample to families with at least three children, and examine the education outcomes of the first- and second-born children. This sample restriction avoids the problem that families with a larger number of births are more likely to have at least one birth of twins, as noted by Rosenzweig and Wolpin (1980).

A handful of studies use the empirical strategy of Black et al. (2005), and find comparable results. Åslund and Grönqvist (2010), using Swedish administrative data, do not detect significant effects of twinning-induced fertility increases on children's grades, school enrollment, schooling years, employment, earnings, and social welfare dependence. De Haan (2010), using a longitudinal survey of US high-school graduates, similarly detect no effects of twinning-induced fertility increases on children's completed education. Similar to Black et al. (2005), Åslund and Grönqvist (2010) and de Haan (2010) detect negative birth order effects on child outcomes.

Besides twinning, the sex composition of the first two children is another widely used IV for family size. As parents prefer a mixed sex composition of children, parents with two girls or two boys are more likely to proceed to a third birth (Angrist and Evans 1998). Black et al. (2005) and De Haan (2010), two studies we discussed above, also use the sex composition instrument, and find robust non-negative QQ effects. Using Israeli administrative data, Angrist et al. (2010) exploit multiple natural experiments, combining twin births, sex composition, and ethnic differences, to generate plausibly exogenous variations in family size. They examine the family size and birth order effects on children's educational and labor market outcomes. They find neither evidence for the QQ effect, nor evidence for the birth order effect on child quality. Millimet and Wang (2011) also use sex composition to generate variations in family size, and detect no QQ effects on child height and BMI. Taken together, these studies seem to cast doubt on the child QQ trade-off.

In contrast, several studies using similar empirical strategies do detect negative QQ effects in the US. Caceres-Delpiano (2006) find that twining-induced fertility increases reduce the likelihood of private school attendance for first-born children in the 1980 US census. Conley and Glauber (2006) exploit sex composition as the IV for family size, and detect a negative QQ effect in the 1990 US census. Fletcher and Kim (2019), using the US National Longitudinal Study of Adolescent to Adult Health, find that twinning-induced increases in family size lead to deficiency in children's personality traits. Diaz and Fiel (2021) combine multiple sources of US survey data, and detect negative QQ effects at high birth parities.

Studies in less developed countries generally detect negative QQ effects. Li et al. (2008) use the 1990 China census, and find that twinning-induced increases in family size negatively affect children's schooling outcomes. Ponczek and Souza (2012) use the 1991 Brazilian census, and find that twinning-induced increases in family size raise the incidence of child labor and reduces child schooling attainment. Lee (2008) exploits son preference in Asia to generate variations in family size: under son preference, parents with a firstborn daughter tend to have more children. Using Korean household surveys, Lee detects a negative effect of family size on children's educational investment. Similarly, using Indian household surveys, Kugler and Kumar (2017) exploit the gender of the firstborn child as the IV for family size, and find a negative QQ effect on child education outcomes. Chen (2021) also adopts the indicator on firstborn daughter as an instrumental variable for family size, and detect a negative QQ effect on child health in Vietnam.

In sum, negative QQ effects tend to emerge when the household budget constraint becomes binding for the specific quality measure and the sub-population. In developed countries, negative QQ effects have been detected when examining private school attendance in the US (Caceres-Delpiano, 2006; Conley and Glauber, 2006) and educational expenses in Korea (Lee, 2008). In addition, negative QQ effects are more likely detected in less developed countries than in developed countries. A common pattern of treatment effect heterogeneity has been found in China, India, and Brazil: the magnitude of the estimated negative QQ effects are larger for the more disadvantaged sub-population (Li et al. 2008; Ponczek and Souza 2012; Kugler and Kumar 2017).

3.3. Concerns on twin and sex composition instruments

The empirical studies discussed in the previous section use either twin births or children's sex composition, or both, as instrumental variables for family size. The validity of both types of instruments can be questionable.[6]

The sex composition of children can directly affect child outcomes, possibly through sibling competition. Using multiple sources of US surveys, Butcher and Case (1994) have shown that, conditional on family size, the presence of a female sibling would reduce girls' education. By contrast, also using US survey data, Kaestner (1997) and Hauser and Kuo (1998) do not detect significant effects of sibling gender composition on child education. Garg and Morduch (1998) find that having more sisters improves children's health outcomes in Ghana. Morduch (2000) finds that having more sisters improves children's educational outcomes in Tanzania, but detects no effect in South Africa. Using survey data from the region of Taiwan, Parish

[6] Öberg (2019, 2021) offers comprehensive discussions on the validity of the twin instrument and other identification strategies. He thinks that both the twin and sex composition instruments do not generate policy-relevant estimates of the QQ effects.

and Willis (1993) find that older sisters tend to help out younger siblings; hence, child sex composition directly affects child outcomes. Guo and Zhang (2020), exploiting exogenous variations in twins' gender composition, do not detect significant effects of sibling sex composition on child's health and educational outcomes in an underdeveloped province in China. Despite the controversies, some recent studies tend to take sex composition as a valid instrument for family size (Brinch et al. 2017; Lin et al. 2019).

The twin instrument is believed to generate upward-biased, i.e., less negative, estimates of the QQ effects. As Rosenzweig and Zhang (2009) point out, the widely adopted empirical specification in Black et al. (2005) does not provide a direct test on the Becker-Lewis model. Becker and Lewis (1973) have assumed equal quality for all children within the same household; their QQ theory implies a negative association between child quantity and *average* child quality. As discussed at the start of Section 3.2, the specification used in Black et al. (2005) only includes low-parity children in the estimation sample. Rosenzweig and Zhang (2009) further show that, as twins have inferior birth endowments, parents tend to reinforce the endowment difference, and invest more in low-parity singleton children in families with high-parity twins. Therefore, the use of the twin instrument in the specification of Black et al. (2005) would provide upward-biased estimates of the QQ effects. Using information on children's birthweight, Rosenzweig and Zhang (2009) then develop a a method to bind the effects of family size on the average child quality; subsequently, they find modestly negative QQ effects for children's health and educational outcomes in

China.

Guo et al. (2017) provide an alternative reason for the upward bias. Guo, Yi, and Zhang argue that outcomes of low-parity children can be non-sensitive to high-parity fertility increases, simply because low-parity children more exclusively share parental time when their younger siblings are yet to be born (Price, 2008). When the effect of family size on child quality is less negative for low-parity children, examining child outcomes for low-parity children would provide an upper bound for the effect of family size on *average* child quality.

Bhalotra and Clarke (2019, 2020), using data from the US and 68 developing countries, find that twin births positively correlate with maternal health. As twins consume more maternal resources at pregnancy, healthier mothers are more likely to successfully deliver twins. Hence, the estimated QQ effects using the twin instrument would be biased upward. Maternal health is multi-dimensional and difficult to be fully controlled for in most empirical studies. Bhalotra and Clarke (2020) further suggest methods to bind the estimated QQ effects when using the twin instrument. Similarly, Farbmacher et al. (2018) detect the non-randomness of twin births using administrative data from Sweden; they then assume that monozygotic twins are exogenous, and construct a new instrument to correct the upward bias.

3.4. Identifying QQ effects using family planning and abortion policies

Besides the twin and sex composition instruments, economists have also exploited family planning and abortion policies to obtain plausibly exogenous variations in fertility. Access to contraceptives and abortion helps prevent unwanted or mistimed births. Exploiting an abortion ban in Romania in 1966, Pop-Eleches (2006) find that the subsequent increase in unwanted births has a negative QQ effect on child educational and labor market outcomes. Similarly, Dumas and Lefranc (2019) study a ban on modern contraceptives in Manila city of the Philippines in the late 1990s, and also detects a negative QQ effect on educational attainment. Dang and Halsey Rogers (2016) exploit access to family planning centers in Vietnam as an instrumental variable for family size, and detect a negative QQ effect. Bailey et al. (2019) find that the county-level roll-out of family planning programs in the US induces fertility reductions that boost children's adulthood income, suggesting a negative QQ effect. Sun (2019), using the county-level roll-out of abortion clinics in the US, also detect a negative QQ effect.

China's "One-child" policy (OCP) is also widely studied in the literature of the QQ effects. Unlike most family planning programs, the OCP is coercive. Forced sterilization was not uncommon. Unauthorized births lead to heavy penalties, such as job dismissal for employees in the public sector. As such, the relaxation of the OCP leads to desired increases in fertility. Qian (2009) finds that the fertility increase induced by the relaxation of the OCP raises children's school enrollment. Liu (2014) also exploits the relaxation of the OCP, and detects a modestly negative QQ effect on child health, but zero effect on child education.[7]

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[7] Wang and Zhang (2018) show that the OCP, by imposing stricter birth control on the richer population, actually lowers the average human capital of the descendants. Cameron et al. (2013) and Li and Qiu (2021) find that the OCP-induced "only child" suffers from deficits in personality traits. Qin et al. (2017) use a regression-discontinuity design to study the effect of the OCP on family size and child education. Weng et al. (2019) exploit multiple stages of China's birth-control policies, including the less coercive "Later, Longer, and Fewer" campaign, and find

Overall, the literature document that unwanted births, as induced by the lack of access to contraceptives or abortion, consistently lead to negative QQ effects. By contrast, desired births, as induced by the relaxation of China's coercive birth control, lead to ambiguous QQ effects.

3.5. Understanding treatment effect heterogeneity

The "reduced-form" studies on the causal effect of fertility on child quality, as discussed in Sections 3.2–3.4, provide an important insight on treatment effect heterogeneity: the QQ effects tend to be more negative for families with more stringent resource constraints (Åslund and Grönqvist 2010; Li et al. 2008; Ponczek and Souza 2012; Kugler and Kumar 2017). The pronounced QQ trade-off in resource-constrained families is consistent with the initial conceptualization of the QQ model in Becker and Lewis (1973). These reduced-form studies, though excelling in the inference of causal effects, do not directly speak to the QQ theory of Becker and Lewis (1973). Macro economists, such as Vogl (2016), even take reduced-form studies on the QQ effects as "a separate literature" (footnote 10 on p. 369 in Vogl 2016). The empirical studies are in danger of "measurement without theory" (p. 873 in Rosenzweig and Wolpin 2000); p. 74 in Heckman 2015), which may impede the scientific progress (Deaton 2010).

A recent line of research explicitly connects the estimation of treatment effects to economic theory. Mogstad and Wiswall (2016) emphasize that the QQ model does

a negative QQ effect on child education.

not imply a negative effect of family size on child quality, as first shown by Rosenzweig and Wolpin (1980). However, most reduced-form studies often neglect this aspect. Using Norwegian data, Mogstad and Wiswall (2016) estimate the QQ effects for fertility increases at different fertility levels. They find a positive QQ effect for a an increase in fertility from two to three, but negative QQ effects for increases in fertility from three to four, four to five, and five to six. They attribute the non-linearity to the declining complementarity between child quantity and quality as mothers proceed to higher fertility levels. Brinch et al. (2017) develop an econometric method to estimate the marginal treatment effect using binary instrumental variables. As an application, they use the sex composition and twin instruments to recover the marginal treatment effects of family size on child quality, and find that the effect of family size on child quality is correlated with the idiosyncratic parental returns of fertility changes.

Bagger et al. (2021) extend the QQ model to consider the family size and birth order effects simultaneously. While their theory does not restrict the signs of the birth order effects, they derive a set of sufficient conditions for a negative family size effect on average child quality. They then develop a two-step estimation strategy to identify birth order effects using within family variations, and recover family size effects using the twin instrument. Using Danish administrative data, they discover negative birth order and family size effects on children’s schooling years.

Guo et al. (2022) derive a generalized theory of rationed fertility to analyze heterogeneous QQ effects for desired and undesired fertility increases. Fertility rationing corresponds to the general scenario when people can not achieve the desired fertility level: infertility, unintended births, coercive birth control, and the incidence of twin births all impose fertility rationing. They discover a new rationing income effect: a desired fertility increase induces a positive rationing income effect on child quality, while an undesired fertility increase induces a negative rationing income effect. Building on the econometric analysis of multivalued treatment, they then combine the natural experiment of twin births with China's coercive birth-control policy to design an empirical test of the rationing income effect. They find that the QQ effect induced by an undesired fertility increase is more negative than that induced by a desired fertility increase.

The theory of rationed fertility reconciles findings in three strands of empirical studies. First, using IQ to measure child quality in Norway, Black et al. (2010) find negative QQ effects for "unexpected" fertility increases induced by the twin instrument, and zero QQ effects for "expected" fertility increases induced by the sex composition instrument. Second, Lin et al. (2019) identify the QQ effects for "planned" versus "unplanned" fertility increases, combining variations in children's sex composition and parental fertility intentions to estimate a dynamic structural model of human capital investment. Third, as summarized in Section 3.4, unwanted births consistently lead to negative QQ effects; by contrast, desired births lead to ambiguous QQ effects. The above three strands of empirical studies are consistent with more negative QQ effects for undesired fertility increases than for desired increases.

3.6. Measures of child quality

The phrase "child quality," initially used in Gary Becker's seminal contributions, refers to child human capital. The most widely used measures of child quality or human capital are children's educational outcomes. Leibowitz (1974) pioneers the use of completed schooling years to measure child quality, using a longitudinal survey that tracks gifted children across adolescence and adulthood. Subsequent studies using survey or administrative data generally adopt the measure of completed schooling years (Black et al. 2005; Åslund and Grönqvist 2010; Angrist et al. 2010; de Haan 2010; Mogstad and Wiswall 2016; Brinch et al. 2017; Kugler and Kumar 2017; Lin et al. 2019; Weng et al. 2019; Bhalotra and Clarke 2020; Bagger et al. 2021).

For young children in census and survey data, completed schooling years is not available. Hence, researchers employ age-standardized indices of school attainment (Rosenzweig and Wolpin 1980; Liu 2014), school enrollment and attendance (Caceres-Delpiano 2006; Conley and Glauber 2006; Li et al. 2008; Qian 2009; Ponczek and Souza 2012; Kugler and Kumar 2017; Guo et al. 2022), and school performance such as test scores and grade retention (Hanushek 1992; Caceres-Delpiano 2006; Rosenzweig and Zhang 2009). Some studies also examine children's educational investment (Lee 2008; Rosenzweig and Zhang 2009; Dang and Halsey Rogers 2016), IQ scores (Black et al. 2010), and adulthood income and labor market outcomes (Black et al. 2005; Åslund and Grönqvist 2010; Bailey et al. 2019), depending on data availability.

Another commonly used measure of child quality is child health, especially for young children in less developed countries. Researchers examine health inputs (Joshi and Schultz 2013), and age-standardized height, weight, and body mass index (Rosenzweig and Zhang 2009; Millimet and Wang 2011; Liu 2014). Recent studies extend the measure of child quality to mental health (Park and Wu, 2017), as well as behavioral and personality traits (Cameron et al. 2013; Fletcher and Kim 2019; Li and Qiu 2021). The examination of multiple measures of child quality is important. Various dimensions of human capital can respond differently to an exogenous change in family size (Liu 2014).

4. Policy implications and concluding remarks

In fear of an explosion of population and the subsequent Malthusian stagnation, many countries launched population control policies after the 1970s (de Silva and Tenreyro 2017). A main objective of population policies is “The Less The Merrier,” for which the child QQ trade-off provides a theoretical basis. Policy instruments mainly include the dissemination of effective contraceptives and information campaigns to advocate small families, which have substantially accelerated the global fertility decline, and contributed to the demographic transition (de Silva and Tenreyro 2020).[8] Besides voluntary population policies in most countries, coercive population

[8] As Galor (2012) points out, economists have overemphasized the child QQ trade-off as a mechanism behind the demographic transition. By Figure 1, TFR decreases by 2.7 children per women between 1960 and 2015, while average schooling years increase by 5.5 years. The causal effect of child quantity on quality is much smaller than the over-year correlation. For example, Rosenzweig and Zhang (2009), using data in China, suggest that one exogenous birth reduces average schooling progress by 0.23–0.65 years, and reduces the expected likelihood of college attendance by 14–27%. Bhalotra and Clarke (2020) find that one exogenous birth reduces schooling years by 0.12–0.15 in developing countries, and reduces schooling progress by 0.3–0.36 years in the US. The estimated QQ effects are far from explaining the over-year association between TFR and schooling years. Other economic

control once prevailed in China and India (Schultz 2007). Specifically, following a prolonged "Later, Longer, and Fewer" population campaign in the 1970s, China launched the coercive One-child policy that is unprecedented in human history (Chen and Fang 2021; Chen and Huang 2020; Zhang 2017).

Nowadays, fertility rates have declined to below-replacement level in many parts of the world, especially in East Asia and Europe. Small family now becomes a social norm (de Silva and Tenreyro 2020). Fertility rates are the lowest in East Asian societies, where the unequal gender division of childcare suppresses fertility, especially for highly-educated women (Myong et al. 2021). The policy challenge has reversed: how to boost fertility and prevent a rapidly aging society?

Most OECD countries have adopted pro-natal policies (Olivetti and Petrongolo 2017). In 2021, China have completely abandoned its birth-control policy, and encouraged each family to have three or more children. However, pro-natal policies seem to have limited effect on fertility. If any, as shown in studies using cross-country data, a combination of subsidized childcare and cash transfers appears to raise fertility (Luci-Greulich and Thévenon 2013; Olivetti and Petrongolo 2017).

In light of the QQ theory, it is not surprising that pro-natal policies hardly boost fertility. When fertility is low, the cost per child is high. Pro-natal policies can increase fertility only if the policies substantially reduce the high cost of child rearing. Furthermore, the effects of pro-natal policies should be heterogeneous. The same amount of subsidy, in-kind or in-cash, offers larger incentives for the economically

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incentives contribute greatly to the demographic transition (Fernihough 2017; de la Croix and Perrin 2018).

disadvantaged groups (Zhou 2021). Differential fertility, coupled with the child QQ trade-off, implies that pro-natal policies may lower intergenerational mobility and widen income inequality.

To understand the demographic future of our society, a clear connection between theory and estimation is imperative. Most of the micro literature on the QQ effects, as reviewed in Section 3, do not directly speak to the QQ theory. While the macro literature, which incorporates the child QQ trade-off, could also pay more attention to the identification issue that is the hallmark of the micro literature. As a bottom line, micro studies should target clearly specified theoretical constructs, while macro studies should reconcile with micro evidence.

Low and Meghir (2017) point out that a promising research agenda is to exploit quasi-experimental variations in the inference of structural economic relations, as pioneered by Rosenzweig and Wolpin (1980) in the QQ literature. Future research can further use quasi-experimental variations in the prices of child quantity and quality, exploit household income shocks, or combine different sources of quasi-experimental variations through the lens of economic theory. One challenge is to model discrete fertility decisions in the presence of random child gender, son preference, and sex selection. A revival of the dialog between theory and evidence should deepen our understanding of the child QQ trade-off and its implications for demography and development.

Cross references

Analysis of Twins

Fertility and Female Labor Force Participation

Fertility and Wellbeing

Gender and Income Inequality

Gender, Time Allocation, and Birth Controls

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Figures

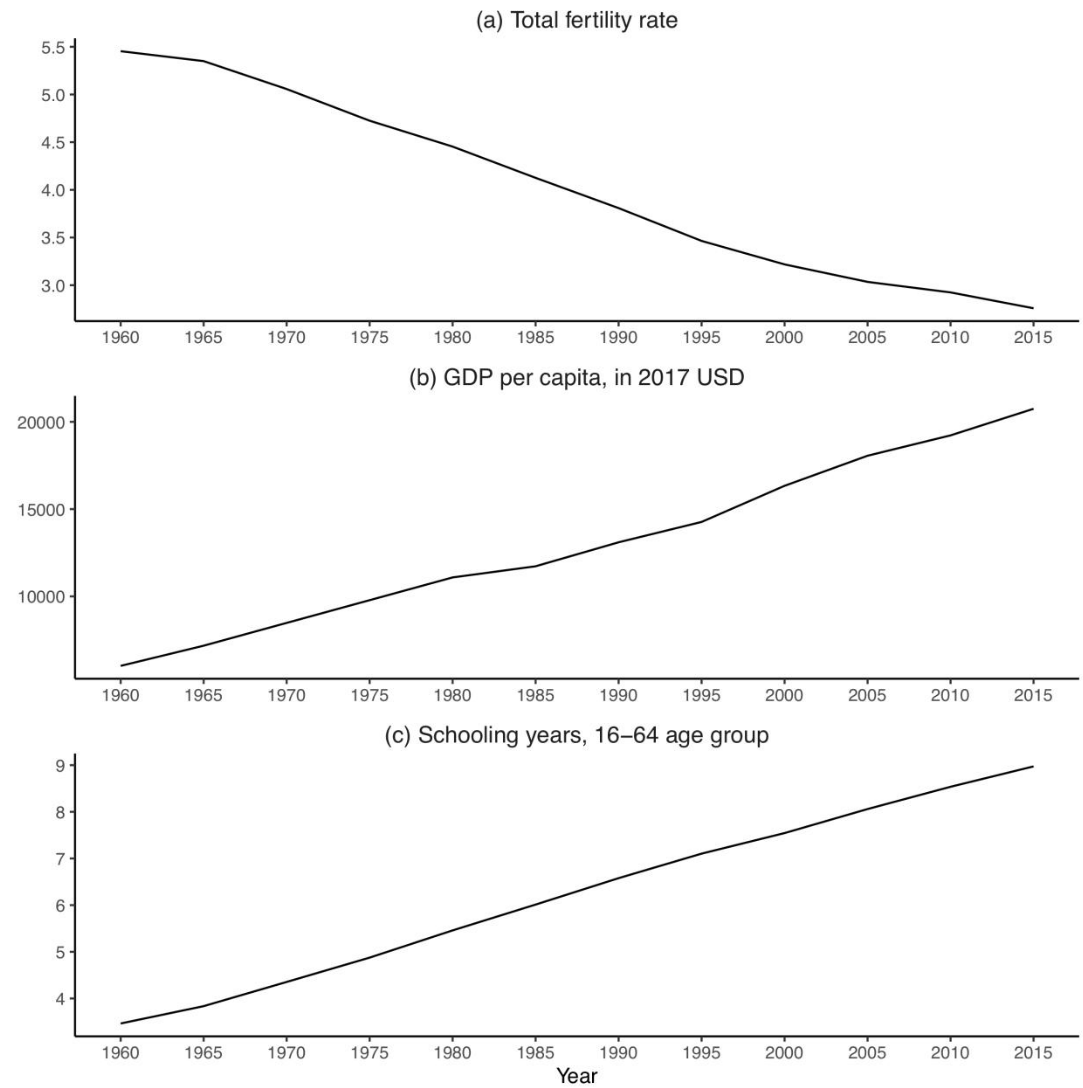

Figure 1. Trends for fertility, development, and education

Notes: The data sources are the World Development Indicators, the Penn World Table (Feenstra et al. 2015), and the Barro-Lee education data set (Barro and Lee 2013). The merged data set contains 99 countries or regions with complete data for 1960–2015 in the interval of five years. We use population weights when aggregating total fertility rate, GDP per capita, and schooling years over countries or regions.

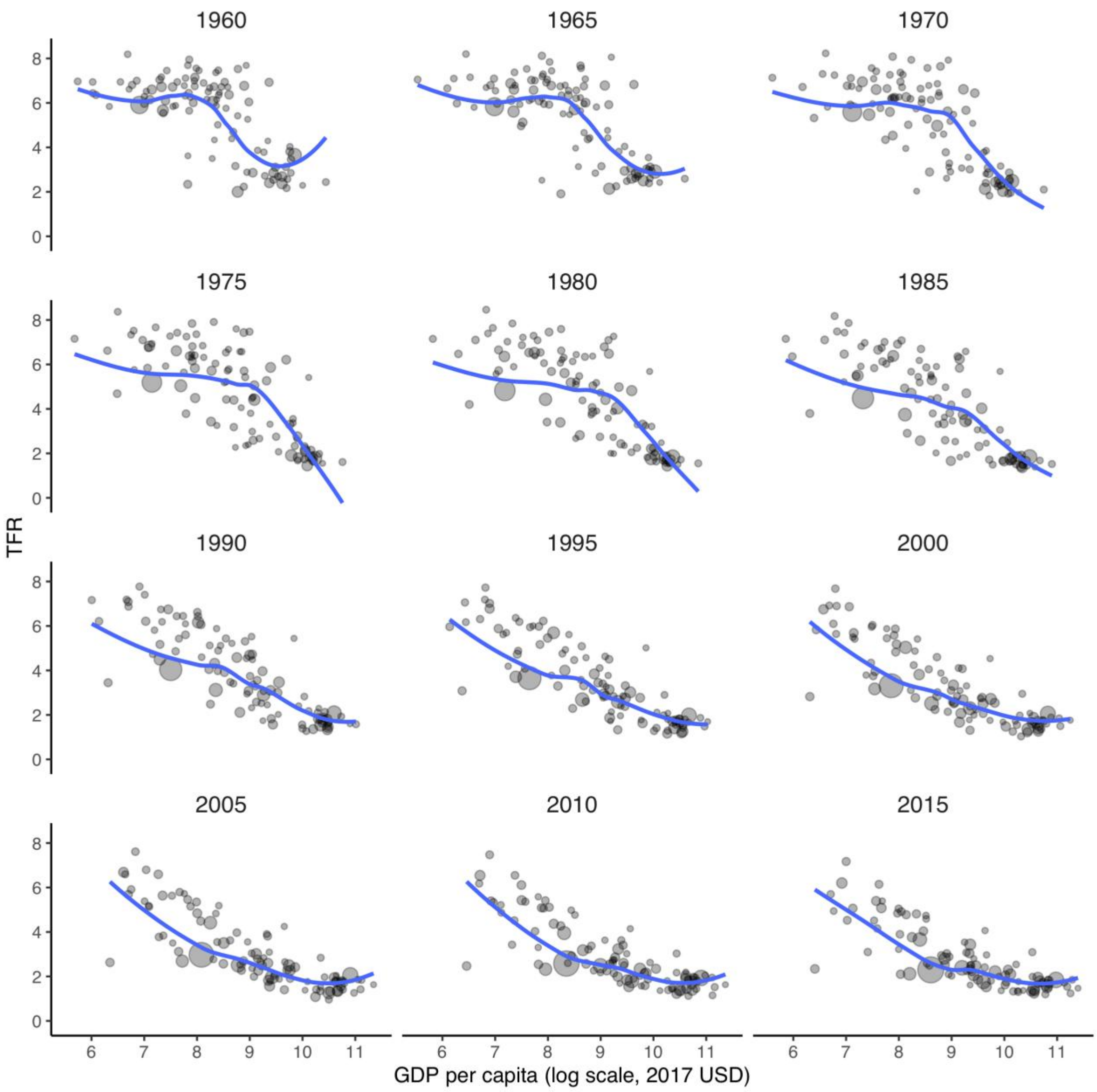

Figure 2. Snapshots of fertility and development

Notes: The x-axis is the log GDP per capita in millions 2017 USD obtained from the Penn World Table. The y-axis is the total fertility rate obtained from the World Development Indicators. The data sources are the same as those used in Figure 1. The size of points represents the population size of the country or region. We estimate fitted lines weighted by population size using the loess method. We exclude China, a clear outlier that would have banned the fitted lines downward for the middle years.

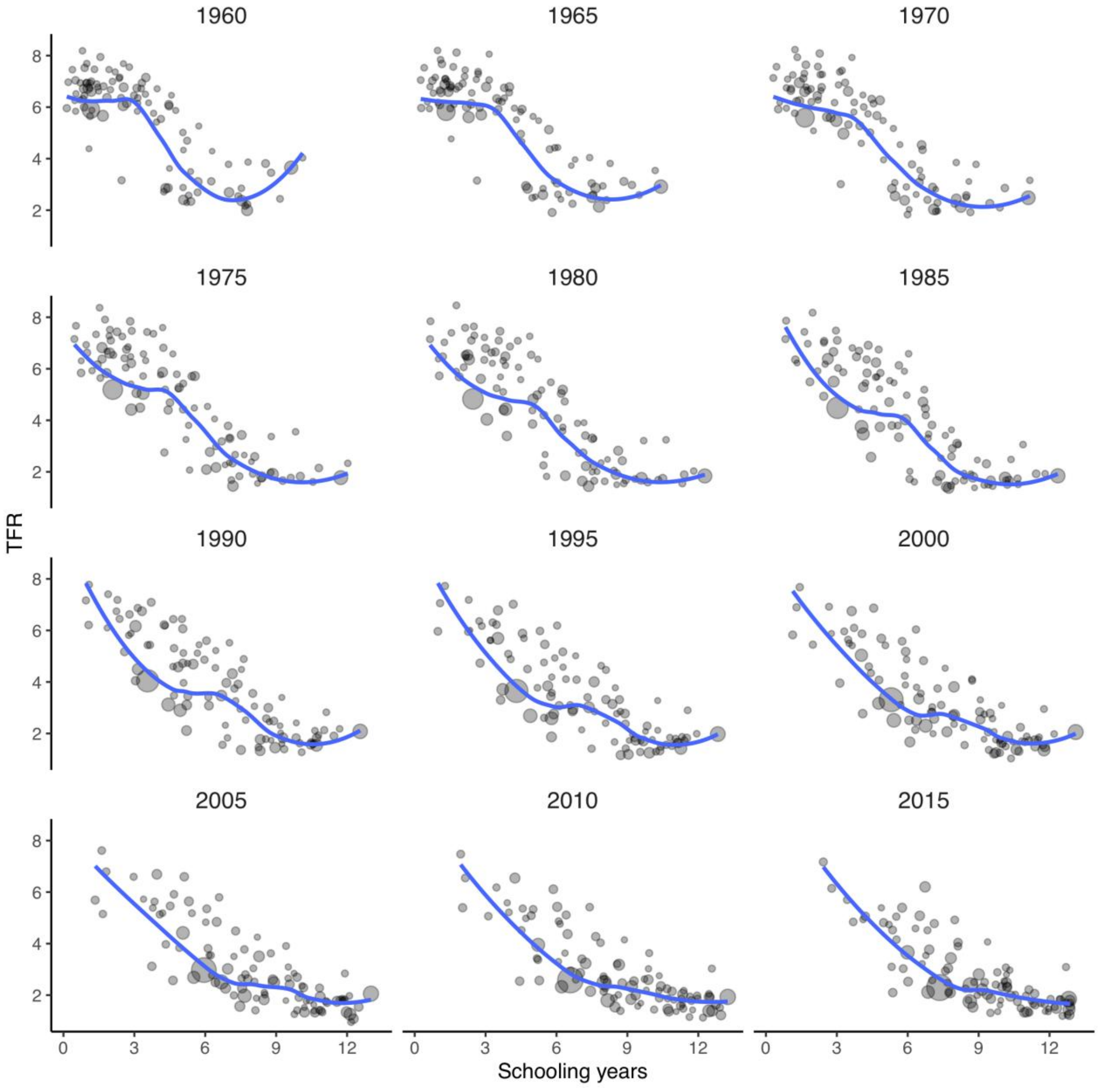

Figure 3. Snapshots of fertility and education

Notes: The x-axis is the schooling years for the 16-64 age group, as obtained from the Barro-Lee education data set. The y-axis is the total fertility rate obtained from the World Development Indicators. The data sources are the same as those used in Figure 1. The size of points represents the population size of the country or region. We estimate fitted lines weighted by population size using the loess method. We also exclude China to maintain consistency with Figure 2.