Nutritional Deficits and the Quantity-Quality Trade-off: Evidence from an Exogenous Fertility Shock in Low-Income Urban Settings in the Philippines

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This paper examines whether increased fertility affects early-life nutritional outcomes in low-income urban households. I exploit a natural experiment created by a 1990 policy in Manila, Philippines, which banned modern contraceptives from city-run health facilities. Using a difference-in-differences framework and nationally representative data from the Philippine Demographic and Health Surveys, I estimate the reduced-form impact of the policy on child height-for-age and weight-for-height. [Will add more after data analysis]

JEL: J13, I15, O15
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I. Introduction

The trade-off between child quantity and child quality is a foundational concept in the economics of the family. First articulated by Becker (1960) and extended in subsequent models of household behavior (Becker and Lewis, 1973; Becker and Tomes, 1976), this framework posits that parents allocate finite resources—both financial and non-financial—across children. An increase in fertility reduces the resources available per child and, under binding constraints, may lead to lower investments in health, education, and other forms of human capital. This mechanism has served as an explanatory model for changes in fertility behavior and the evolution of population structures in low- and middle-income countries.

Empirical investigations of the quantity–quality trade-off have focused primarily on educational outcomes. Studies in both high-income and low-income settings have examined the effects of fertility on school enrollment, grade progression, test scores, and completed years of schooling (Rosenzweig and Wolpin, 1980; Black, Devereux and Salvanes, 2005; Angrist, Lavy and Schlosser, 2010). These

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outcomes serve as accessible proxies for long-run human capital accumulation, but they represent only one dimension of child quality. Other outcomes, such as nutritional status, are early-onset or biologically constrained. They also tend to be less responsive to remediation later in life. A child who suffers from chronic malnutrition may exhibit permanently reduced cognitive capacity and face limits in physical development that affect long-run productivity regardless of subsequent educational access (Hoddinott et al., 2013*a*; Grantham-McGregor et al., 2007).

The exclusion of nutritional outcomes from much of the empirical literature leaves an important dimension of the trade-off untested. Nutritional investments in early childhood are essential to early childhood development and long-term outcomes (Victora et al., 2008; Hoddinott et al., 2013*a*). They shape brain development, immune system functioning, and physical stature, and they have been shown to predict later-life earnings and health outcomes across a wide range of settings (Grantham-McGregor et al., 2007; Alderman, Hoddinott and Kinsey, 2006). The biological irreversibility of early-life nutritional deficits further distinguishes them from other forms of investment. Educational deficits may be partially remediable; nutritional failures often are not. A credible estimate of the trade-off between fertility and child quality must account for nutrition if it aims to assess the full set of consequences associated with fertility shocks.

This study addresses this gap by examining the nutritional effects of a localized, exogenous increase in fertility in the Philippines. In 1990, the mayor of Manila implemented an executive policy that prohibited the provision of modern contraceptives in all city-run health facilities. The order removed access to pills, condoms, intrauterine devices, and related public health materials and instructed healthcare providers to offer only natural family planning methods. This policy remained in place for nearly a decade and affected only the jurisdiction of the Manila city government. The national government did not implement a comparable restriction, and surrounding cities within Metro Manila continued to provide access to modern contraceptives. The policy thus created a spatial and temporal discontinuity in contraceptive access that was uncorrelated with underlying fertility preferences or concurrent shifts in household income or governance. As a result, the Manila ban serves as a quasi-experimental source of variation in fertility exposure among poor urban households.

I use this natural experiment to estimate the causal effect of increased fertility on child nutrition. The analysis relies on nationally representative data from multiple waves of the Philippine Demographic and Health Survey (DHS), which provide data on household structure and maternal characteristics, as well as measurements of child anthropometry. The outcomes of interest are height-for-age and weight-for-height z-scores, which serve as standardized indicators of chronic and acute malnutrition, respectively. These outcomes are widely used in the global health and development literature and capture nutritional deprivation over both long and short time horizons (Victora et al., 2008). The empirical strategy follows a difference-in-differences design that compares child outcomes in Manila and comparable urban areas before and after the onset of the policy.

The identification strategy rests on two key assumptions. First, in the absence of the contraceptive ban, nutritional trends in Manila would have evolved in parallel with those in comparison cities. Second, any other policy or economic shocks affecting Manila during the study period must not coincide precisely with the timing and scope of the contraceptive policy. I test these assumptions using falsification checks, placebo comparisons, and robustness specifications that include city-specific time trends, maternal fixed effects, and controls for baseline demographic differences.

The analysis proceeds in three stages. I first replicate existing work (Dumas and Lefranc, 2019) to confirm that the contraceptive ban led to an increase in fertility among affected women. I then estimate reduced-form effects of policy exposure on nutritional outcomes for children under five years of age. Finally, I examine heterogeneity in effects across subsamples defined by maternal education, household wealth, and access to prenatal care. These dimensions serve as proxies for household resource availability and capacity to buffer the nutritional consequences of fertility increases.

This study contributes to the literature in several important ways. It provides new evidence on how increases in fertility—caused by policy restrictions on family planning—can affect child nutrition in poor, urban communities. Most past research has focused on education, but this study expands the idea of child quality to include biological measures such as stunting and wasting. It also adds to the small number of studies that use unexpected changes in reproductive health policy to examine long-term effects on children's well-being. More broadly, the results show that local restrictions on family planning can unintentionally harm children's health, especially in settings where families already face poverty, food insecurity, and limited public services.

II. Review of Related Literature

The quantity–quality (Q–Q) theory, a central idea in modern family economics, holds that parents face a trade-off between the number of children and the "quality" of investment—such as education or health—they can provide to each. Quality in this context refers to the human capital of each child: attributes like education, health, and nutrition that enhance a child's future productivity and well-being. The genesis of this idea traces back to Gary Becker's seminal work around 1960, which for the first time treated children as economic goods subject to parental choice and budget constraints (Becker, 1960). Becker argued that as families become wealthier, they may not simply want more children, but rather better-raised children, much as a household might prefer a higher-quality car or house over a greater quantity of them. This proposition led to a formal theory in which increases in income or changes in economic conditions cause parents to substitute child quality for quantity, consistent with historical patterns of lower fertility and higher educational attainment during economic development (Galor and Weil, 2000).

In what follows, I review the theoretical foundations of the Q-Q model and its evolution in the literature. I begin with the static models of Becker (Becker, 1960) and Becker–Lewis (Becker and Lewis, 1973), which first formalized the trade-off within a household utility maximization framework. We then examine extensions to dynamic, intergenerational settings, including the contributions of Becker and Tomes (Becker and Tomes, 1976) on child endowments and the altruistic dynastic model associated with Barro and Becker (Barro and Becker, 1989). Next, I turn to macroeconomic and unified growth models, notably Galor and Weil (Galor and Weil, 2000) and Galor and Moav (Galor and Moav, 2002), which integrate the Q–Q mechanism into a general theory of demographic and economic transformation.

Finally, I discuss more recent refinements that enrich the basic model by incorporating credit constraints (Doepke, 2004), intra-household bargaining (Doepke and Kindermann, 2019), and multi-dimensional child quality (Hoddinott et al., 2013*b*; Kalemli-Ozcan, 2002), with a special emphasis on health and nutrition. The literature review focuses on how the Q–Q framework has been applied to understand fertility and child investment patterns, especially in developing country contexts where resource constraints and health outcomes are paramount.

A. Theoretical Background

Becker's Static Model

Becker's early work introduced an economic model of fertility and treated children as durable goods that provide utility to parents but impose costs (Doepke, 2015). In Becker's 1960 model, a household derives satisfaction from the number of children (n) and from the quality of each child (q), alongside conventional consumption of other goods (y). A simple representation is a utility function:

$$U = U(n, q, y),$$

with U increasing in each argument up to some satiation point. Here, quality q can be thought of as the expenditure or investment per child (e.g. education spending, health care, nutrition), assumed for now to be the same for each child. Parents face a budget constraint that links quantity and quality: raising more children dilutes the resources available per child. A prototypical budget constraint (in static form) can be written as:

$$p_y y + p_n n + p_q n q = I,$$

where I is total family income (or full income), p_n represents baseline, non-discretionary costs associated with each additional child (e.g. expenditures on food, shelter, or clothing that are incurred irrespective of quality-enhancing investments), and p_q denotes the marginal cost of investing in one unit of quality per child.The term $p_q n q$ captures total expenditure on quality for all children and is linear in n. As the number of children rises, parents must extend any chosen level of q across a broader base, which amplifies the total cost of quality. Conversely, the term $p_n n$ implies that the cost of an additional child rises with the quality level q already chosen, since each child must meet a higher standard of care or investment. For instance, a household that chooses to provide more education or better health care per child incurs an additional burden when it expands family size, as each child must receive the same enhanced level of investment. Similarly, a larger family increases the cumulative cost of quality, even if q remains fixed, due to the need to replicate expenditures across more children. In short, the shadow price of child quality increases with n, and the shadow price of child quantity increases with q. The cost structure induces a mutual dependence between quantity and quality, such that any adjustment along one dimension alters the effective cost of the other.

Becker and Lewis (1973) formalize the mutually reinforcing nature of the quantity–quality cost structure. An increase in n raises the total cost required to sustain a given level of q for each child, while a higher level of q raises the marginal cost associated with having an additional child. For example, allocating more resources to education or health per child increases the financial burden of expanding family size. This interdependence links the two decisions directly. The household cannot choose n and q in isolation; each choice alters the marginal cost of the other.

Mathematically, the trade-off appears in the first-order conditions of the household's optimization problem. Let λ represent the Lagrange multiplier on the full-income constraint.

$$\mathcal{L} = U(n, q, y) + \lambda \left(I - p_y y - p_n n - p_q n q\right).$$

The first-order conditions are:

$$\frac{\partial \mathcal{L}}{\partial n} = U_n - \lambda(p_n + p_q q) = 0, \quad \frac{\partial \mathcal{L}}{\partial q} = U_q - \lambda p_q n = 0, \quad \frac{\partial \mathcal{L}}{\partial y} = U_y - \lambda p_y = 0.$$

Combining the first two yields:

$$\frac{U_n}{U_q} = \frac{p_n + p_q q}{p_q n}.$$

This condition equates the marginal rate of substitution between quantity and quality to the ratio of their full marginal costs. The numerator rises with q, and the denominator rises with n. As one choice increases, the relative cost of the other becomes higher. This relationship induces substitution toward the less costly dimension. The trade-off between quantity and quality arises from the structure of the budget itself. It does not rely on specific assumptions about utility curvature or intrinsic substitutability (Becker and Lewis, 1973).

This formulation implies two core predictions. Firstly, although both child quantity and child quality may rise with income, the household's budget constraint can generate a negative relationship between income and fertility. As income increases, total spending on children tends to rise, but the allocation often favors quality over quantity. Becker illustrated this with the analogy of durable goods: wealthier households tend to upgrade the quality of a house or a car rather than acquire additional units. In a similar way, higher-income families often direct additional resources toward education, nutrition, or health per child. Within the model, an income increase ($\mathrm{d}I > 0$) produces a direct effect that makes children more affordable and an indirect effect that discourages fertility. As q rises, the shadow price of an additional child also rises. If the marginal utility from higher quality exceeds that from larger family size, then the substitution effect outweighs the income effect, leading to a lower optimal n. This mechanism offers a structural explanation for the demographic transition: fertility tends to fall as households become richer, even when preferences remain unchanged.

Furthermore, a similar logic applies to changes in the cost parameters p_q and p_n. A decline in p_q, such as through a policy that lowers the price of education or health care, increases q and raises the marginal cost of quantity. This effect reduces optimal fertility. A rise in p_n, which may reflect higher child-rearing costs or a greater opportunity cost of parental time, reduces the appeal of larger families and can shift resources toward child quality. These outcomes follow from the structure of the budget constraint, without requiring any explicit preference for quality over quantity. Becker and Lewis noted that these comparative static results align with observed patterns. For example, increases in women's wages often reduce fertility more than they reduce educational spending per child. This asymmetry reflects the model's central feature: quantity and quality are linked through their cost structure. An increase in one raises the marginal cost of the other. The model explains how households make trade-offs between the number of children and investments in each.

Intergenerational Models: Altruism and Child Endowments

While the early Q–Q models were static (one-period) representations, subsequent contributions extended the framework to consider fertility and child investment over multiple periods or even multiple generations. The main development in this literature was the incorporation of intergenerational human capital dynamics, where parents derive utility not only from the number and quality of children in the present, but also from the long-run outcomes of their offspring. These extensions allowed child quality to evolve endogenously across time, rather than being determined solely within a single period.

One of the earliest and most influential models of this kind was proposed by Becker and Tomes (1976). In their formulation, each child enters the world with an exogenous endowment E, which may reflect factors such as cognitive ability (e.g., measured IQ or language acquisition speed), early health status (e.g., birth weight or incidence of neonatal complications), genetic predispositions (e.g., risk for chronic illness, temperament, or neurodevelopmental traits), or family background characteristics (e.g., parental education, household stability, or neighborhood conditions). Furthermore, parents can augment this endowment by investing resources q in the form of education, nutrition, and other quality-enhancing inputs. The effective adult human capital of the child might be expressed as $H = E + f(q)$ (in a simple additive form) or a multiplicative variant $H = E \cdot f(q)$, where $f(q)$ is an increasing concave function of parental investment.

Becker and Tomes (1976) emphasized that variation in endowments E can shape how parents allocate investments q across children. When the productivity of investment increases with endowment, parents may concentrate resources on children with higher E, who are more likely to convert additional investment into future success. In other cases, parents may attempt to compensate for lower endowments by directing greater investment toward disadvantaged children. Put simply, child-specific variation in initial conditions affects not only outcomes but also strategic parental choices. Because of this, the relationship between income and the demand for child quality is not uniform. The income elasticity of demand for quality may differ across households, depending on the distribution of endowments within the family and across the broader population.

Furthermore, Becker and Tomes (1976) showed that at low income levels, much of what constitutes child quality comes from exogenous endowments, i.e., factors like public education, neighborhood environment, or access to basic healthcare that are not privately purchased. In these settings, small increases in parental income may not lead to significant changes in fertility or investment behavior. Since most of the child's future outcomes are determined by the fixed endowment component, marginal investment plays a smaller role. However, as income rises, private resources become a larger part of what determines quality, and the classic Q–Q trade-off begins to shape behavior. Parents begin to allocate more income toward fewer children in order to enhance quality through direct investment. Under certain theoretical conditions, such as equal utility elasticities for quantity and quality, this framework produces a non-monotonic relationship between income and fertility. Fertility may decline as income rises at first, which reflects the desire to invest more intensively per child. However, beyond some point, once the marginal return to investment begins to flatten or saturate relative to the fixed endowment, fertility may increase again.

The U-shaped prediction emerges only under specific assumptions, and its validity depends on both the shape of the utility function and how endowments relate to parental background. More broadly, Becker and Tomes (1976) enriched the Q–Q framework by incorporating elements that reflect real-world variation. They argued that not all differences in child outcomes are the result of deliberate parental choice. Random factors, biological traits, and socioeconomic settings play a role. In this light, public policies, such as subsidized schooling, early childhood programs, or universal healthcare, can influence private fertility and investment decisions by shifting the effective value of E across the population. If government programs raise the floor for child endowments, then even low-income parents can achieve better outcomes without large private sacrifices. These policy-induced shifts in E alter the perceived return to having more children or investing more per child.

Becker and Tomes (1976) also considered the possibility that endowment is not randomly assigned but may vary systematically with income. Higher-income households may produce children with higher E due to better maternal nutrition, access to prenatal care, lower exposure to environmental risk, or assortative matching on traits associated with educational or occupational success. In these families, not only are the resources available for investment greater, but the potential gains from investment may also be higher, because children are better positioned to benefit from those inputs. This interaction deepens the divide between high- and low-income households, making it harder for disadvantaged families to catch up. As a result, inequality can persist or even widen across generations.

Finally, the model provides a mechanism for understanding how imperfections in credit markets can lead to persistent disadvantages. If parents with low income and low-E children cannot borrow to finance quality-enhancing investment, then the next generation begins life with the same disadvantage. Without external intervention or structural change, this loop continues, which results in a pattern where poor families remain poor and rich families accumulate further advantage. The Becker-Tomes framework thus connects household-level decisions to bigger questions about the intergenerational transmission of human capital.

Parallel to Becker and Tomes's static analysis of endowments, another strand of the literature developed a fully dynamic version of the Q-Q model by incorporating parental altruism toward children's welfare. In this framework, introduced by Barro and Becker (1989), parents care not only about the number and quality of their children but also about the utility their descendants will enjoy in the future. Altruism in this context means that parents treat their children's utility as part of their own, thus extending the household's objective across generations. For example, a parent may reduce personal consumption to pay for a child's schooling, motivated not just by the child's immediate benefit but by the satisfaction the parent gains from the child's long-term success. This leads to a formulation of dynastic utility, where the household's objective spans infinitely many periods and takes the form of a recursive altruistic structure. A representative formulation is

$$U_0 = \sum_{t=0}^{\infty} \beta^t \, u(c_t, n_t),$$

where c_t denotes the consumption of the t-th generation, n_t the number of children, and $\beta \in (0, 1)$ the intertemporal discount factor. Given this structure, having an extra child n_t enters utility positively, but each child is assumed to receive the same utility as the parent if raised at a comparable standard of living. As a result, parents confront an intertemporal trade-off: having more children expands the number of future utility streams but also stretches current resources, since each child requires support. This trade-off gives rise to an Euler equation for optimal fertility choice, analogous to an optimal growth condition.

An implication of the dynastic model is that fertility decisions are sensitive to macroeconomic conditions, such as the interest rate or the rate of return on capital. A rise in interest rates increases the opportunity cost of channeling resources into children rather than saving, which tends to reduce current fertility—a substitution effect across generations. At the same time, higher returns make future generations wealthier, and this anticipated prosperity enters the utility calculations of parents in more complex ways. Barro and Becker (1989) demonstrated that the model can account for observed fertility responses to economic fluctuations and policy interventions It can also explain historical phenomena such as postwar baby booms and subsequent fertility declines through shifts in returns or labor-market opportunities.

In many dynastic models, child quality appears indirectly, often through the child's future human capital or income. One variant assumes parents value the aggregate human-capital stock of their children. This specification, combined with altruism, produces a similar trade-off: concentrating resources in fewer children raises each child's human capital, which raises the dynasty's long-run welfare. These intergenerational extensions link micro-level fertility decisions to macroeconomic outcomes. By the late 1980s, work by Becker, Barro, and others had recast fertility as an endogenous choice that interacts with capital accumulation, income distribution, and policy. This laid the foundation for unified growth theories, which view the quantity–quality mechanism as central to demographic transition and long-run development.

Unified Growth Models

The unified growth theory, developed in the late 1990s and 2000s (notably by Oded Galor and co-authors), seeks to explain in one framework the entire sweep of economic development – from Malthusian stagnation, through the demographic transition, to modern growth. A central puzzle it addresses is why fertility rates, which were historically high and invariant to income in the Malthusian era, began to decline sharply in tandem with industrialization and rising incomes, eventually stabilizing at much lower levels in developed economies. The Q–Q trade-off provides a key part of the answer in these models. Galor and Weil (2000) and Galor and Moav (2002) explicitly incorporate parental choices about the quantity and quality of children and show how changes in the economic environment alter those choices and trigger demographic transitions.

In Galor and Weil (2000)'s model, for instance, technological progress gradually increases the return to human capital, especially in skilled occupations. In the early stages, when production relies on basic tools and techniques, unskilled labor holds more value. Under these conditions, parents have little reason to invest in formal schooling. Children are expected to contribute economically through agricultural work, domestic tasks, or low-skill jobs in workshops and factories. Fertility remains high because children impose a low financial burden and generate immediate returns. As technology becomes more advanced—such as during the Industrial Revolution—the earnings gap between skilled and unskilled labor widens. Education begins to offer significant advantages in the labor market. In response, parents adjust by having fewer children and placing greater emphasis on each child's development, including school attendance and better health care.

Evidently, industrialization raises the economic value of skilled labor, which alters household incentives. As returns to education increase, parents begin to favor investments in child quality over child quantity. This shift results in declining fertility because families choose to have fewer children and allocate more resources to each. The feedback effect is significant: higher educational investment raises productivity in the next generation, which in turn accelerates technological advancement and further increases the returns to human capital. Over time, the economy moves from a state of high fertility and low growth to one characterized by low fertility and sustained growth.

Furthermore, Galor and Moav (2002) introduced an evolutionary refinement to the unified growth framework by accounting for heterogeneity in parental preferences. During the Malthusian period, some families placed greater emphasis on child quality, such as education, while others prioritized quantity. In a stagnant economy with limited returns to education, high-fertility lineages maintained a numerical advantage and suppressed average human capital. As technological progress increased the returns to education, families that valued quality gained an economic edge. Their children acquired more human capital and achieved higher income and survival rates. These advantages allowed such families to grow in relative size. Over time, this process resembled a form of evolutionary selection, gradually favoring quality-oriented parental types and shifting the population toward greater emphasis on child human capital. These dynamics strengthened the shift from high-fertility, low-education regimes to low-fertility, high-investment family structures. In formal overlapping-generations models, Galor and Moav (2002) demonstrate that this evolutionary adaptation accelerates the demographic transition. Their framework accounts for the rapid and widespread drop in fertility once it takes effect. Higher returns to human capital push parents to favor quality, while preferences for quality begin to dominate within the population. These forces support the emergence of a low-fertility, high-investment equilibrium and establish a unified explanation for both economic development and demographic change.

Importantly, unified growth models identify several complementary mechanisms that reinforce the basic Q–Q trade-off during development. One is the decline of child labor. As the economy modernizes, the value of child labor falls, both because legal reforms often restrict child labor and because parents realize the earnings their children could make as unskilled laborers are paltry compared to the potential returns if those children instead spend time in school. Hazan and Berdugo (2002) formally show that when child labor becomes less profitable relative to adult (skilled) labor, parents further reduce fertility and invest more in each child's education. Historical evidence from England, for instance, indicates that during industrialization the wages of children (relative to adults) dropped significantly, especially in skilled families, and this was accompanied by parents pulling children out of work to send them to school. Galor and Moav (2006) even argue that capitalist industrialists supported public education laws and child labor bans as a way to increase the human capital of the workforce, inadvertently hastening the fertility transition.

Another mechanism is the rise in life expectancy and child survival. Improvements in sanitation, nutrition, and medical knowledge in developing societies led to more children surviving to adulthood. While the earliest unified growth models treated mortality as exogenous or ignored it, later research demonstrated that declining child mortality can trigger lower fertility as well– parents no longer need "extra" births for insurance once they are confident their existing children will survive. In other words, increased child survival and the quality–quantity trade-off are complementary explanations for fertility decline that operate in tandem. When fewer births are lost to disease, parents can achieve a desired number of surviving offspring with fewer total births, and they tend to reallocate effort into each child's health and education.

The overall effect is a reinforcing cycle: better health raises the returns to schooling (healthier children can learn more effectively and have longer working lives), which further encourages educational investments and reduces fertility. Indeed, Galor notes that human capital should be interpreted broadly to include health as well as schooling; in unified growth theory, improvements in nutrition and physical well-being were crucial to making labor more productive and thus were part and parcel of the rise in demand for human capital.

The unified growth literature places the Q–Q model within a more general account of economic and demographic change. In this framework, higher income or stronger returns to child quality reduce fertility and help shift economies from stagnation toward sustained growth. Several mechanisms support this transition, such as a fall in child labor, a drop in child mortality, and a shift in parental priorities. These models explain not only the presence of a quantity–quality trade-off but also its rising influence at a specific point in history. The evidence supports these claims: countries that saw earlier increases in returns to education experienced earlier fertility decline, while delays in reforms, such as public education or health access, corresponded to prolonged high fertility. As a result, the Q–Q mechanism forms a key component of unified growth theory.

REFERENCES

Alderman, Harold, John Hoddinott, and Bill Kinsey. 2006. "Long Run Returns to Early Childhood Nutrition." *World Bank Economic Review*, 20(1): 97–118.

Angrist, Joshua D., Victor Lavy, and Analia Schlosser. 2010. "Multiple

Experiments for the Causal Link Between the Quantity and Quality of Children." *Journal of Labor Economics*, 28(4): 773–823.

Barro, Robert J, and Gary S Becker. 1989. "Fertility choice in a model of economic growth." *Econometrica: Journal of the Econometric Society*, 481–501.

Becker, Gary S. 1960. "An Economic Analysis of Fertility." *Demographic and Economic Change in Developed Countries*, 209–240.

Becker, Gary S, and H Gregg Lewis. 1973. "On the interaction between the quantity and quality of children." *Journal of Political Economy*, 81(2, Part 2): S279–S288.

Becker, Gary S, and Nigel Tomes. 1976. "Child endowments and the quantity and quality of children." *Journal of Political Economy*, 84(4, Part 2): S143–S162.

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes. 2005. "The More the Merrier? The Effect of Family Size and Birth Order on Children's Education." *Quarterly Journal of Economics*, 120(2): 669–700.

Doepke, Matthias. 2004. "Accounting for fertility decline during the transition to growth." *Journal of Economic Growth*, 9: 347–383.

Doepke, Matthias. 2015. "Gary Becker on the quantity and quality of children." *Journal of Demographic Economics*, 81(1): 59–66.

Doepke, Matthias, and Fabian Kindermann. 2019. "Bargaining over babies: Theory, evidence, and policy implications." *American Economic Review*, 109(9): 3264–3306.

Dumas, Christelle, and Arnaud Lefranc. 2019. ""Sex in Marriage Is a Divine Gift"? Evidence on the Quantity-Quality Trade-off from the Manila Contraceptive Ban." *The World Bank Economic Review*, 33(1): 259–285.

Galor, Oded, and David N Weil. 2000. "Population, technology, and growth: From Malthusian stagnation to the demographic transition and beyond." *American Economic Review*, 90(4): 806–828.

Galor, Oded, and Omer Moav. 2002. "Natural selection and the origin of economic growth." *The Quarterly Journal of Economics*, 117(4): 1133–1191.

Galor, Oded, and Omer Moav. 2006. "Das human-kapital: A theory of the demise of the class structure." *The Review of Economic Studies*, 73(1): 85–117.

Grantham-McGregor, Sally, Y.B. Cheung, Santiago Cueto, Paul Glewwe, Linda Richter, and Barbara Strupp. 2007. "Developmental Potential in the First 5 Years for Children in Developing Countries." *The Lancet*, 369(9555): 60–70.

Hazan, Moshe, and Binyamin Berdugo. 2002. "Child labour, fertility, and economic growth." *The Economic Journal*, 112(482): 810–828.

Hoddinott, John, Harold Alderman, Jere R. Behrman, Lawrence Haddad, and Susan Horton. 2013*a*. "Adult Consequences of Growth Failure in Early Childhood." *American Journal of Clinical Nutrition*, 98(5): 1170–1178.

Hoddinott, John, Harold Alderman, Jere R Behrman, Lawrence Haddad, and Susan Horton. 2013*b*. "The economic rationale for investing in stunting reduction." *Maternal & Child Nutrition*, 9: 69–82.

Kalemli-Ozcan, Sebnem. 2002. "Does the mortality decline promote economic growth?" *Journal of Economic Growth*, 7: 411–439.

Rosenzweig, Mark R., and Kenneth I. Wolpin. 1980. "Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment." *Econometrica*, 48(1): 227–240.

Victora, Cesar G., Linda Adair, Caroline Fall, Pedro C. Hallal, Reynaldo Martorell, Linda Richter, and Harshpal Sachdev. 2008. "Maternal and Child Undernutrition: Consequences for Adult Health and Human Capital." *The Lancet*, 371(9609): 340–357.

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Mathematical Appendix