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Demographic transition and post-transition population dynamics: a review of micro and macro economic models and interactions

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This literature review contrasts microeconomic fertility models during the demographic transition and post-transitional periods, evaluating their implications for macroeconomic growth models. While microeconomic fertility models stress the trade-off between child quality and quantity during the demographic transition, the extensive and intensive margin fertility model applies to the post-transition period, with implications for childlessness and the postponement of childbearing. The impact of micro decisions on economic growth is better documented during the demographic transition compared to the post-transition period. The post-transition micro models have not yet led to models and evidence of sharp technological progress. At the macro level, low or negative population growth during the post-transition period may stall economic growth due to the population size effect.

Keywords Fertility. Demographic transition. Child quality. Extensive margin. Intensive margin. Economic growth model. Unified growth theory. Human capital. Technological progress.

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Introduction

The link between population growth (or size) and economics has been pervasive from ancient times to the present day. The "Malthusian" model dominated the pre-industrial period of humanity; the macro-level operation of institutions associated with marriage and celibacy was crucial. A transition from the "Malthusian" to a "Post-Malthusian" economy was still driven by important macro-level aspects, with emphasis on the role of population size and density. A significant shift occurred with the transition to the "Modern Growth Regime". The demographic transition became the main driver of this shift, a process guided by micro-level determinants.

In the field of demography, there are diverse formulations to explain the demographic transition leading to a fertility decline. One such formulation is the microeconomic or demand approach. Some versions of the demand approach have been in use in demography for a long time. Still, economists have revisited these models in the last thirty years to relate them to economic growth. The demographic transition had a role in explaining the sustained economic growth in endogenous macro-level models.

The demographic transition played a crucial role in modern economic growth due to the interaction between fertility decline and educational attainment, associated with Gary Becker's theory of the trade-off between child quality and quantity. Economists have incorporated education as a production factor in their growth models, formulating endogenous growth models in which total factor productivity (TFP) rises due to factors such as schooling, population size, and the quality of institutions, among others.

After the total fertility rate (TFR) reaches replacement level (TFR=2.1), societies enter the "post-transition" period. Several empirical stylized facts that were previously observed to hold until the completion of the demographic transition appear to no longer be valid. The microeconomic models are also different; now the discussion associates 'women's career and the gender labor division with decisions in two margins: extensive (childless or not) and intensive (number of children). The macroeconomic questions change during this post-transition period. Is it possible to observe technological progress with zero or declining population growth? Will micro-level gender models enhance the growth in TFP?

The paper begins by describing the "Malthusian" and "Post-Malthusian" regimes, then proceeds to the economic discussion of the demographic transition. A section on the stylized facts of the demographic transition and post-transition periods illustrates the demographic and economic relationships in these two periods, highlighting their differences. Another section is devoted to the new microeconomic models applicable to the post-transition period, followed by a section contrasting macroeconomic consequences and TFP in the two periods, asking whether the modern micro-level models enhance the same potential human capital has played in modern economic growth. The final section discusses the consequences of stagnating or declining population size on economic growth and technological progress. We conclude that the second wave of economic behavior associated with 'women's decisions had a proven significant impact on the determination of below-replacement fertility, but a predictable effect on TFP remains to be proven.

Malthusian and post-Malthusian economies

Since Malthus, there has been a demographic and economic connection that correlates population growth with growth in *per capita* income. While population and product growth were low in Western Europe, fluctuating around zero during most of the preindustrial period, population and product started to grow annually around 0.5% in the eighteenth century (population slightly above product). They increased to grow around 0.6% in population and 1.6% in *per capita* income during the first two-thirds of the nineteenth century.

In this item, we describe the unified framework for growth theory, described by Galor (2011). It summarizes the essential role of the demographic transition in this critical area of economic theory. Galor identifies three phases of development: the Malthusian Epoch, the post-Malthusian Regime, and the Modern Growth Regime. Our main suggestion is that population growth is at the core of economic growth models in all three phases, with a macro level focus at the beginning and a focus on micro-macro interactions towards a micro formulation of an economic explanation of the demographic transition in the third phase. This theory is needed because it becomes central to explain sustained growth. This paper aims to a broader audience comprised of interdisciplinary social-science scholars and economists. Galor (2011) serves as an inspiration for the unified framework; we take inspiration from the formalization presented in Jones and Vollrath (2013), Chapter 8.

The Malthusian epoch is characterized by a model that posits population growth is self-equilibrating in the absence of technological advancements or increases in resource availability. According to the model, any increase in available resources would be offset by a corresponding increase in population size driven by the positive income-fertility relationship, leaving the standard of living unchanged over time.

The modern era employs constant-returns-to-scale technology, using both labor and capital. Initially, only Malthusian technology was used, due to the limited stock of usable knowledge, which rendered the Solow production process unprofitable. As usable knowledge accumulates, allocating labor and capital to Solow's technology becomes profitable. Ultimately, production transitions to Solow-type technology, even as the Malthusian mechanism remains active. This phase characterizes the post-Malthusian Regime, as discussed in several papers, including Becker *et al.* (1990), Galor and Weil (2000), and Hansen and Prescott (2002). During this phase, both technological progress and population growth will occur at faster rates than during the Malthusian epoch. Despite population growth, this phase marks the onset of rising income *per capita*, leading to improved living standards. The argument here aligns with Boserup's (1981) formulation, which posits that population size affects technological progress, as well as with Lee (1986) and Kremer (1993). Population influences both the supply and demand for innovations, interacting with the division of labor and increased trade.

In these first two regimes land is a fixed factor. In the second regime technological progress or the production of ideas is a function of population growth. This is an endogenous theory of technological progress in the production of ideas in line with Kremer (1993). The endogenous model of technological progress fits the post-Malthusian regime better than the standard Malthusian model, entailing a virtuous cycle between technological change in ideas and population growth that does not adjust with the decline in population growth during the demographic transition. Up until this point, the macro population growth models have prevailed, with a positive correlation between *per capita* income and crude birth rates, and a negative correlation with crude death rates. If a micro fertility model is to be considered in this second regime, it should expect a positive income effect on the demand for children.

BOX 1
Malthusian epoch

Micro aspects
- Income x fertility (+)
  - (Preventive check)
- Income x mortality (-)
  - (Positive check)
- Less micro, more societal
  - Reproduction marriage mechanism
  - (Proportion single and age at marriage)

Macro aspects
- *Per capita* income stagnated
  - “Iron law” of wages
- Technological progress implies:
  - Larger population ize
  - Constant wage or income

BOX 2
Post-Malthusian regime

Micro-level fertility models
- The domination of the positive income effect on fertility
- Income effect on the decline of infant and child mortality
- Early trade-off between child quantity and quality
  - (Induced by decline in mortality)
  - (Induced by initial demand for human capital via technological progress)

Macro aspects
- Population and *per capita* income grow simultaneously
- Population-induced technological progress
- Incipient human capital induced technological progress

The demographic transition

The last quarter of the nineteenth century through the first three decades of the twentieth century witnessed a slight decline in population growth, accompanied by a notable increase in *per capita* income growth, reaching nearly 2%. In the remainder of the twentieth century, the annual population growth rate declined to around 0.5%, while the annual income growth rate was almost 3% (Galor; Weil, 2000). Let's examine the economic and demographic dynamics during this extended period in Western Europe and the developed countries. We will transition from a more macro context in the pre-industrial era to a "micro-macro" context of this economic-demographic relationship.

The demographic transition is a pivotal element in modern growth theories, marking the shift from a Malthusian epoch, characterized by high fertility and mortality rates, to a regime of sustained economic growth with low fertility and mortality rates (Modern Growth Regime). This transition is driven by technological progress and human capital accumulation. The relationship between income and population growth changes as the demographic transition progresses.

Galor (2012) thoroughly reviews the demographic transition, identifying key factors such as technological progress, rising incomes, and improved public health as the primary drivers of the transition from high to low fertility and mortality rates. He argues that the demographic transition is crucial for accumulating human capital. Initially, higher income leads to higher population growth (Malthusian epoch), but eventually, higher income results in lower population growth due to increased investments in human capital and reduced fertility rates (Modern Growth Regime). The models of Galor and Weil (2000) and Becker *et al.* (1990) emphasize the crucial role of human capital in economic development and the transition from stagnant to sustained growth. According to Galor and Weil (2000), the transition from the Malthusian epoch to the Modern Growth Regime is driven by technological progress, which increases returns to human capital investment and induces a demographic transition. Similarly, Becker *et al.* (1990) propose that as the stock of human capital increases, the rates of return on human capital rise, leading to multiple steady states. These steady states include a Malthusian equilibrium, characterized by high fertility and low human capital, and a developed equilibrium, characterized by low fertility and high human capital. Both models incorporate endogenous fertility, recognizing that economic incentives and returns on investment in human capital influence decisions regarding family size.

'In "*A treatise on the family*," Becker (1981) argues that his theory improves on the Malthusian formulation of fertility. In broad terms, the improvement is related to a 'shift from a positive income effect in the early models, compatible with the positive income birth rate relationship that arises from Malthus' preventive check, to a proposed negative income effect due to the trade-off between child quantity and quality. Notice that Malthus' preventive check was a macro-level formulation related to norms and the marriage pattern, while Becker's formulation had a micro foundation in the demand for children. In any case, the change in the signal of the income effect in the fertility equation is a clear indicator of the shift in theoretical formulation. There are several alternative explanations for the demographic transition in ‘demography, but Becker's is the main economic explanation. Any factor that causes the demographic transition will bear economic implications.

A second microeconomic explanation for a decline in fertility in ‘Becker's model is the cost of children, related to mothers' time allocation. As ‘women's market wages and labor force participation rise over time, the demand for children (fertility) would fall.

The two microlevel formulations above – the trade-off between child quality and quantity, and ‘women's role in the cost of children – are associated with two empirical regularities found in many countries between the last quarter of the nineteenth century and the final decade of the twentieth century: a negative correlation between income and fertility, and a negative relationship between female labor force participation and fertility.

Stylized facts and correlations during and post demographic transition

Below-replacement fertility is now spread in a variety of regions in the world. Table 1 shows the groups of countries in "Europe, North America, Australia, and New Zealand" and "Eastern and South-Eastern Asia" reached below-replacement fertility levels in 1973 and 1993, respectively. Several of the countries in these groups are now in the lowest-low fertility category. "Latin American and the Caribbean" countries reached this milestone in 2014. The world as a whole is expected to cross below-replacement fertility in 2050.

TABLE 1
Total fertility rate
World and by groups of countries – 1994-2054

Groups	TFR 1994	TFR 2024	TFR 2054	Adol. birth rate 1994	Adol. birth rate 2024	Adol. birth rate 2054	Year of TFR ‹2.1
World	2.93	2.25	2.07	73	38	27	2050
Central and Southern Asia	3.92	2.24	1.95	127	25	12	2033
Eastern and South-Eastern Asia	1.98	1.34	1.48	22	14	11	1993
Europe, Northern America, Australia and New Zealand	1.63	1.48	1.56	36	9	4	1973
Latin America and the Caribbean	2.98	1.8	1.68	87	50	31	2014
Northern Africa and Western Asia	3.96	2.71	2.19	61	36	23	2062
Oceania (excluding Australia and New Zealand)	4.46	3	2.3	73	49	34	2071
Sub-Saharan Africa	6.06	4.26	2.74	133	93	54	2092

Source: United Nations (2025).

Exploring the fertility dynamics in the pioneer groups of Europe and the United States, Table 2 compares two birth cohorts (born in the 1940s and 1960s) who completed their reproductive years between 1990-2000 and 2010-2020. Childlessness among women is at a high level and growing; some countries present extremely high rates for these two groups of cohorts (Switzerland, Netherlands, USA, and Austria). The increasing mean age assesses the postponement of childbearing at first birth between the two cohorts.

TABLE 2
Completed cohort fertility rate (CFR), share of childless women (CHL), and mean age at first birth (CMAB1)
Analysed countrie –1940s and 1960s cohorts

Country	CFR 1940s	CFR 1960s	CFR diff	CHL 1940s (%)	CHL 1960s (%)	CHL diff (%)	CMAB1 1940s	CMAB1 1960s	CMAB1 diff
Austria	1.96	1.74	-0.22	13.0	16.0	+3.0	22.6	24.8	2.2
France	2.17	1.98	-0.2	11.0	14.0	+2.0	23.9	26.3	2.4
Great Britain	2.23	2	-0.24	10.0	15.0	+5.0	23.6	25.7	2.1
Italy	1.91	1.62	-0.3	12.0	15.0	+4.0	25.2	27.1	2
Netherlands	2.01	1.81	-0.2	12.0	19.0	+7.0	24.4	28.3	3.9
Norway	2.16	2.09	-0.07	12.0	11.0	0.0	23.9	25.5	1.6
Poland	2.19	2.11	-0.08	11.0	10.0	-1.0	23.2	24	0.8
Sweden	2.04	2.1	0.07	8.0	9.0	+1.0	24.5	26.9	2.4
Switzerland	1.79	1.55	-0.23	20.0	26.0	+6.0	25.1	27.7	2.7
United States	2.34	1.96	-0.38	13.0	17.0	+4.0	22.7	26.6	3.9

Source: Beaujouan, Zeman and Nathan (2023).

Doepke *et al.* (2023) contrast old and new facts regarding the comparison between the demographic transition and post-transition contexts. The main aspects to consider are fertility and income, fertility and education, fertility and labor force participation, and the earnings gender gap associated with the child penalty.

Fertility and income

Regarding the relationship between fertility and income, historical data from the demographic transition indicate a strong negative correlation between the TFR and *per capita* income, as observed in cross-sectional graphs of countries during the twentieth century, suggesting a trade-off between child quantity and quality. Doepke *et al.* (2023) show that in 2000, the relationship between TFR and *per capita* income in a cross-section of developed countries became positive. Fox *et al.* (2019) conclude that the likelihood of a positive relationship between fertility and economic development is increasing, particularly within highly developed, gender-egalitarian, and policy-supportive contexts. Economic prosperity no longer suppresses fertility, but may facilitate it by improving the reconciliation of work and family life. This relationship remains a topic of debate in the context of developed countries.

Fertility and children's education

The negative relationship between fertility and children's education, accompanied by a positive relationship between educational attainment and *per capita* income, is strong evidence of the trade-off between child quality and quantity during the demographic transition. In developed countries, fertility rates have declined, while children are leaving school later, and public education covers a significant portion of their life course from birth until transition to adulthood. In this context, the trade-off between quality and quantity has shifted from a formal schooling margin to parental time and career costs in more developed economies (Doepke *et al.*, 2023). In the following section, we will suggest that child quality relevance appears in the context of 'women's career decisions.

Fertility and female labor force participation

The relationship between fertility and female labor force participation was traditionally negative. This negative relationship was found even among a cross-section of developed countries in 1980. A cross-sectional correlation coefficient between the TFR and female labor force participation in OECD countries between the early 1970s and the early 2010s shows a shift from -0.5 in the early 1970s to a reversal to 0.75 in the early 1980s, followed by some stability around 0.4. The negative correlation between fertility and female labor force participation was associated with the costs of 'women's time in the choice of fertility. In contrast, 'women's career choices in the most recent period are related to decisions regarding the timing of fertility (Doepke *et al.*, 2023). This aligns with the U-shaped relationship between female labor force participation and fertility during the development process. Notice that this is the U-shape between FLFP and TFR, not the FLFP-GDP curve.

Marriage and child penalties

Kleven and Landais (2017) demonstrate that the gender gap in earnings in a panel of 53 countries decreases with *per capita* income, decreasing from around 65% in countries with an income of around US$ 5,000 to around 35% in countries with an income of around US$ 25,000. Marriage penalty is the gender gap in earnings associated with the traditional gender role essential at low- to middle-income levels. Still, it disappears in high-income settings, while the child penalty is associated with the long-term loss from motherhood. Child penalty is currently the main driver of the gender wage gap in advanced economies. Using microdata from 134 countries (censuses, household surveys, and administrative panels), Kleven *et al.* (2023) estimate the "child penalty" (also known as the motherhood penalty) in earnings via pseudo-event studies around first births and validate these estimates against actual panel-data event studies. In subsistence-agriculture dominated countries, child penalties are minimal – often near zero – so parenthood explains only a trivial share of gender gaps. Child penalties are positively correlated with salaried work, urbanization, and the shares of the industrial and service sectors. Combined "family penalties" (marriage and child) track development, shifting from marriage-driven at low incomes to child-driven at high incomes. The stylized facts about child penalties during development contrast with the ones about female labor force participation and fertility described above. As fertility loses its direct impact on 'women's work, the penalty of a first child on the gender earnings gap increases.

Microeconomic models, below replacement fertility, and post-transitional aspects

Doepke *et al.* (2023) discuss how these changes are partly driven by advancements in female education and employment opportunities, leading to more egalitarian household gender roles. Their analysis shows that spending patterns shift as women gain more control over household resources and decision-making, particularly toward investments in children's human capital. They analyze post-transition demographic dynamics and introduce key concepts. 'Women's key role in these models entails making decisions aimed at reconciling career and family goals. Fertility decisions now include two aspects: extensive and intensive margins, the former regarding childlessness, which means the decision to have children or not, and the latter regarding how many children one will have if deciding to have children. Increasing childlessness is now associated with shifts in social and economic factors. Women's education has become a key variable, sending signals that differ from those expected in the classic demographic transition. The microeconomic models mentioned in this item primarily relate to the stylized facts described above.

Models of childbearing postponement

Doepke *et al.* (2023) review new life-cycle models introducing returns to experience (γ) and a probability of late infertility (π), so that women optimally choose both a career investment e and whether to have a child early or delay it. As γ rises, more women postpone childbirth to build human capital. An increase in π makes postponement riskier and should lower the share of women who delay childbearing. Conversely, improvements in reproductive health or access to ART should decrease π (due to improved reproductive health and assisted reproductive technologies, or ART), raising the share of women who delay childbearing to build human capital, thereby flattening the income-fertility slope. Female fecundity is a crucial proximate determinant of fertility (Bongaarts, 1978). Declining with age, it drops sharply after age 35, leading to rising subfecundity and sterility rates. ART reduces the biological constraint produced by the postponement of childbearing, raising the probability of conception among infertile women.

Models of childlessness

Concerning models of childlessness, voluntary and involuntary childlessness are growing phenomena in many developed countries, influenced by socio-economic factors and cultural norms. The concept of voluntary childlessness, particularly in highly educated women, is driven by the high opportunity costs associated with having children. Siuda (2024) presents a dynamic model of fertility that examines how economic fluctuations and the timing of fertility decisions influence childlessness. As women delay childbearing to pursue higher education and career opportunities, the likelihood of remaining childless increases, particularly as fecundity declines with age (see previous item). The empirical findings in the paper indicate that in Germany, voluntary childlessness accounts for a substantial portion of overall childlessness, primarily due to the postponement of childbearing to pursue career aspirations. In Germany, the trend of delayed childbearing and increasing childlessness is prevalent. The paper suggests these trends are closely linked to higher levels of female education and increased labor market participation. Childlessness increases due to the opportunity costs of childbearing, combined with social policies that may not fully support work-family balance.

Another dimension of childlessness, as suggested by Baudin *et al.* (2018), is the addition of a new aspect associated with two essential types of childlessness: "opportunity-driven" and "poverty-driven." "Opportunity-driven" arises due to the high opportunity costs faced by highly educated women, who often forgo having children. "Poverty-driven" affects low-educated women, and is caused by economic hardships associated with malnutrition, lack of healthcare, and poor living conditions. These two types of childlessness may explain the U-shaped relationship between childlessness and education, with low education driven by poverty and high education by opportunity.

The analysis of childbearing postponement in Europe by d'Albis *et al.* (2017) also contrasts career-related postponement *versus* hardship-related postponement. Birth postponement is common in Europe, with an increase in the mean age at first birth between 1970 and 2010. While there is a positive gradient between education and age at first birth, this gradient has declined in recent cohorts. Economic uncertainty is another factor affecting the timing of childbearing, but results are ambiguous (unemployment delays childbearing in some studies but not in others).

The marketization of childcare hypothesis

Bar *et al.* (2017) try to explain the reversal of the classic negative income fertility pattern to a U-shaped pattern with an emphasis on unequal societies where "marketization," defined as the process of outsourcing home production tasks such as childcare, is a possibility, thus influencing fertility among higher-income women. Hazan *et al.* (2021) follow the "marketization" line along with the extensive and intensive margins of fertility discussed above. In the US, using the CPS survey from 1980 to 2000, the authors found that fertility converged as the fertility gap between low and high-educated women closed. The reduction in childcare costs explains 11.9% of the increase in the number of children ever born among highly educated women. The analysis of "marketization" on the extensive margin shows a decline in childlessness rates among women with advanced degrees. The decrease in childcare costs relative to wages can account for 16.1% of the decline in childlessness. The analysis in the intensive margin indicates an increase in the number of children among mothers with advanced degrees over time. The reduction in childcare costs explains 6.6% of the rise.

The U-shape hypothesis presented here differs from the one associated with childlessness and described in the previous paragraph. Here, the analysis focuses on the role of childcare costs both at the extensive and intensive margins.

Mediating factors behind 'women's attempts to reconcile career and family goals

Doepke *et al.* (2023) mention four factors that facilitate women's combination of 'women's career and family goals': family policy, cooperative fathers, favorable social norms, and flexible labor markets.

Family policy is associated with the public provision of subsidized or free childcare. This type of policy may enhance a positive relationship between female labor force participation and fertility. The percentage increase in the proportion of GDP spent on early childhood education is positively associated with TFR and the female employment-population ratio. Variations in policies regarding childcare provision, parental leave, and taxation account for the reversal in income and female labor force participation across countries, as well as the relationship between education and fertility within a country (Doepke *et al.*, 2023).

Cooperative fathers' attitudes concerning family size can be modelled in family bargaining models that have significant fertility effects in high-income countries. Cooperative fathers' involvement in childcare is associated with a positive relationship between fertility and female labor force participation (Doepke *et al.*, 2023).

Social norms can significantly impact women who wish to balance their family and career responsibilities. Developed countries with a large proportion of people who agree that mothers of young and school-aged children should stay at home to care for them are likely to have lower TFRs and higher child penalty in earnings (Doepke *et al.*, 2023). Culture plays a significant role in family arrangements and cultural norms. They play a pivotal role in shaping fertility decisions. In countries like South Korea, with a strong cultural emphasis on education and social status, fertility rates are among the lowest globally. Kim *et al.* (2024) discuss how status externalities in education contribute to low birth rates in Korea, where parents' competition over educational outcomes for their children leads to high child-rearing costs, thereby discouraging larger families. The cultural context, particularly in East Asian countries, reinforces traditional gender roles that further complicate the balancing act between career and family life.

Goldin (2025) asks why modern societies, especially affluent ones like the U.S., exhibit sustained low fertility, and what economic and social mechanisms explain this "downsize" of fertility. She argues that the "downsize" of fertility is not ideational (associated with individualism and values) but a structural outcome that explains the paradox between a lack of decline in desired family size and the actual decline in realized fertility. The same forces that empowered women economically – education, careers, autonomy – also reshaped family formation, creating "invisible opportunity costs" that depress fertility even in prosperous societies. She acknowledges a shift from quantity to quality of children. Still, the observed fertility decline in contemporary developed countries stems less from price-induced demand for child quality (Becker) than from the incompatibility between high-value time and inflexible work structures. Work flexibility and the couple's expectations regarding gender division in time allocation towards child-rearing are the key drivers of low fertility.

Labor market frictions may lead to career- childcare incompatibility. A combination of high unemployment, a high prevalence of temporary jobs, and difficulties in obtaining permanent jobs may lead countries to a low TFRs compared with countries with stable employment and higher TFRs, a pattern observed in Southern Europe. These frictions have become more pronounced in the last few decades, which may have contributed to the cross-sectional reversal of the negative relationship between female labor force participation and TFR (Doepke *et al.*, 2023).

Macroeconomic consequences: demographic transition and post-transition

We previously described microeconomic models that explain the demographic transition and low fertility in the post-transition period. This section integrates the importance of the demographic transition at the macroeconomic level with the modern growth regime, and explores the possible economic growth implications of post-transition dynamics.

In Box 3, the fertility decline during the demographic transition is crucial for generating the macroeconomic consequences of sustained economic growth. Still, several possible mechanisms operate to translate this transition into sustained economic growth. Among the five theories of demographic transition, items 2, 3, and 5 are alternative drivers operating through the Becker's trade-off already listed in item 1.

BOX 3
Modern growth regime

Micro-level fertility models
- Predominance of substitution over income effect on fertility
- Higher demand for human capital
  - Strong trade-off between child quantity and quality
- Five theories of demographic transition:
  1- Income effect – trade-off quality and quantity
  2- Mortality decline – rise in returns of human capital
  3- Decline in gender wage gap
  4- Old age security hypothesis
  5- Rise in the returns of human capital

Macro aspects
- Sustained economic growth:
  1- Technological progress
  2- Human capital growth
  3- Declining rate of population growth (demographic transition)

The economic growth literature emphasizes the roles of factors (capital, labor, and human capital) and Total Factor Productivity (TFP).[1] Using a Cobb–Douglas framework with labor-augmenting TFP (Z), physical-capital deepening (K/Y), and human-capital composition (H/L), Jones shows that TFP accounts for roughly 80% of U.S. output-per-hour growth (2.0 of 2.5 pp) since 1948, with labor composition and capital deepening contributing the rest. A decomposition of cross-country differences in GDP per worker into three components – physical capital deepening, human capital accumulation, and total factor productivity (TFP) – is performed using 2010 data from the Penn World Table, assuming a common capital share of income, $\alpha = 1/3$. On average, most cross-country variations in output per worker reflect differences in TFP, rather than differences in physical or human capital inputs alone (Jones, 2015).

A significant portion of economic growth during the modern growth regime is attributed to the rise in educational attainment, closely tied to the demographic transition and its increasing role. Education affects TFP indirectly and directly. The indirect channel is associated with the role of education (human capital, H) in increasing the quality of labor, a factor that has an augmenting effect. Improving labor quality through higher human capital augments the effective labor input; it only appears indirectly in TFP when growth accounting omits human capital, and the Solow residual absorbs the effect. The direct channel operates by facilitating innovation, accelerating diffusion, enhancing institutional capabilities, and improving returns on technological investments. The endogenous growth model leads to the role of deliberate education policies.

Galor (2011) highlights factors that affect human capital formation (the ability of individuals to finance the cost of education and foregone earnings, public education, cultural and religious composition of society, and the stock of knowledge) and technological progress (cultural and religious composition of society, composition of interest groups, cultural diversity, and abundance of natural resources). Acemoglu (2009) emphasizes the following factors that contribute to technological progress: geography, culture, and institutions. Jones and Volrath (2013) review the TFP concept, which implies producing more with the same number of inputs or factors; technological progress and effective institutions are the primary determinants of TFP. In the endogenous growth model, they emphasize the notion that an "idea" is a non-rival good, in the sense that it can be utilized by multiple agents, thereby associating technological progress with increasing returns. Population size matters for technological change, as it expands the market for ideas and increases the probability of producing innovators.

In conclusion, the demographic transition is associated with the consolidation of the modern growth regime, particularly through the roles of human capital growth and technological progress. As human and physical capital accumulation reach their peaks, country-specific characteristics become even more important in determining income growth.

[1] The "solow residual" is the empirical measure of TFP.

In the post-transition period, as the accumulation of factors (physical and human capital) approaches its peak in many developed countries, TFP may become even more critical. The question is to evaluate the extent to which the new economic micro-level models will entail growth in TFP and *per capita* income.

The post-transition period[2] is defined as the one observed after TFR reaches the replacement level (TFR = 2.1 per woman of reproductive age). During this period, most growth literature focuses on gender issues and the rise in female labor force participation, while other trends are less emphasized. Fluchtmann *et al.* (2024) analyze how past trends in gender equality impacted economic growth and its future potential. The impact of gender equality is evaluated in terms of increased labor force participation and higher productivity, using growth accounting to describe past contributions and the OECD Long-Term Model to make projections. Previous literature on gender equality and economic growth stressed the positive impacts of increased female labor force participation and the role of barriers to 'women's full economic potential. 'Women's employment rates increased by 11 percentage points between 2000 and 2022, reducing the gender employment gap from 18 to 11 percentage points. Decomposing GDP's *per capita* growth, female employment added 0.37 percentage points to annual growth, and men's employment added 0.14 percentage points. The working-age share of the population decreased by 0.16 percentage points, and labor productivity increased by 1.73 percentage points. Gender equality significantly contributes to economic growth, and substantial gains will be made from closing gender gaps by 2060. In the context of a significant increase in Female Labor Force Participation (FLFP) in the late 20th century, Baerlocher *et al.* (2021) examined the channels through which increased FLFP affects national development. FLFP may raise a nation's living standard through higher labor input and aggregate output, increased capital *per capita*, and improved total factor productivity. They found a positive and statistically significant effect of FLFP growth on economic growth, a positive but non-statistically significant effect of initial FLFP, and no evidence of secondary effects through education or population growth.

Doepke *et al.* (2023) and Doepke and Tertilt (2016) suggest several implications for economic growth derived from the demographic transformations associated with female empowerment during the post-transition period. The authors examine how shifts in gender roles, family dynamics, and fertility patterns impact economic outcomes. There are three critical implications. First, female empowerment impacts human capital investment, as women's gain of control over household resources increases the allocation of resources to children's education and health. This is relevant in economies where human capital is a significant driver of economic growth. Second, increased female empowerment may reduce overall household savings as more resources flow to the immediate consumption related to children. Reduced savings might lead to lower capital accumulation, slowing growth in economies that rely heavily on physical capital investments. Third, declining fertility and

[2] Second demographic transition is sometimes an alternative to this term, but it is a concept relative to the demographic literature. It also carries values and cultural formulations.

increased female labor force participation have a direct impact on economic growth. Lower fertility rates for a long time will lead to a declining working-age population. During the demographic transition, immediately after a fertility decline, changes in the age structure may generate a demographic dividend; this is not the case in the post-transition period. Still, higher participation from the female labor force may offset the impact of the declining working-age population.

The capital composition of the countries' economies (more dependent on human or physical capital) makes the economic consequences of the demographic trends different. While low fertility leads to challenges like population aging and shifts in government expenditures, the broader implications of post-transition dynamics, such as delayed childbearing, increased female labor participation, and evolving gender roles, are also significant. Doepke *et al.* (2023) discuss how these shifts, driven by female empowerment and changing family dynamics, influence economic outcomes, particularly in human capital investment and savings patterns. During the post-transition period, the real-world behaviors highlighted by the extensive and intensive margins model, along with egalitarian gender roles, had a positive impact on human capital accumulation and factor growth through increased female labor force participation. Although the role of FLFP on economic growth is well-documented, the effects of gender and other post-transition demographic trends on TFP or technological progress demand a deeper analysis.

It is not yet clear whether this new empowerment of women, particularly those with career development (childless or with low fertility), will play a similar role in technological progress as human capital accumulation did during the demographic transition. In the context of what demographers call "the second demographic transition," micro changes associated with egalitarian gender roles, less xenophobia, less racial discrimination, and more acceptance of LGBTQ+ may raise TFP or enhance technological progress. However, we did not discuss it, and it remains to be proved.

Slowing positive or negative population growth and the size effect

Population size and growth rate are crucial dimensions of every growth model, from the Malthusian epoch to all growth regimes inspired by Solow's growth model improvements, as described in Boxes 1 and 2. Population size (factor L) and human capital (H) are, along with capital (K), the proximate determinants of economic growth in most models. If this is the case, then the post-transitional low population growth, with the possibility of turning negative, poses a challenge to global economic growth. This is further exacerbated by the slowing of human capital accumulation and less robust waves of technological change, resulting from the development of new ideas. The possibility of economic growth with a declining population size challenges the conventional growth models.

Jones (2023) provides an outlook on long-term economic growth. Using a stylized model, income *per capita* is directly linked to the total number of ideas, which depends on the number of researchers, proportional to a country's population size. Some recent stylized facts in advanced economies are the slowing pace of TFP, stagnating educational attainment, the need for more researchers to sustain the same level of innovation, and slowing population growth.

Population growth becomes the dominant factor in the long run, implying that slowing or negative population growth could severely slow economic growth. However, these factors could be counteracted by the role of emerging economies (such as China and India), the global circulation of talent (including the participation of women and minorities in innovation), and artificial intelligence (AI), which may substitute for human researchers. As global population growth begins to decline, the circulation of talent is challenged. Jones (2022) notes that the observation of negative population growth leads to stagnation in the stock of knowledge and living standards, a phenomenon referred to as the "Empty Planet" by the author. In an alternative model with endogenous population growth, multi-equilibrium outcomes are generated, one of which is still the "Empty Planet." Optimal population strategies may create an escape from an "Empty Planet" (EP) by implementing timely population growth and human capital accumulation strategies that would generate an "Expanding Cosmos" (EC).

Jones (2022, 2023) leads us to conclude that the future of economic growth is uncertain, with significant headwinds (including slowing population growth and increasingly complex ideas generation in terms of technological progress) and potential tailwinds (emerging economies, AI, and improved talent allocation). The potential for automation to replace unskilled labor (population size effect) and for AI to replace human capital in future economic growth models is only at the early stages of theoretical development. These are all aspects associated with the formalization of technological progress.

We could argue that even a scenario with negative population growth would lead to growing *per capita* income through the operation of capital deepening, as in the basic Solow model, despite negative total GDP growth. However, the discussion above suggests that this may lead to the EP scenario. The dilemma posed by Jones and colleagues is that we could have either positive population growth, leading to increased research and rising living standards (EC), or negative population growth, resulting in stagnation in the number of researchers and the cessation of economic growth (EP).

Adhami *et al.* (2025) introduce a discussion regarding the concept of an "optimum population" as a potential solution to the debate. Conventional growth metrics focus on *per capita* consumption, but a total utilitarian perspective also counts population increases as welfare gains. In other words, economists focus on individual well-being (on *per capita* income or consumption), which means making people happy. Another, more philosophical view would be making happy people, which is weighted by population size. By expressing both consumption growth and population growth in "consumption-equivalent" (CE) units, the authors show that global welfare growth since 1960 is far higher – over 6% per year – than *per capita* consumption growth alone (≈2%). The population's contribution averages

4.1 pp (66% of the total), while consumption adds 2.1 pp. Table 3 displays the role of population growth in welfare growth using the optimum population perspective.

A proposed Social Welfare function is given by,

$$W_t = N_t \,.\, u(c_t) \quad (1)$$

The proposed broader growth measures are:

$$g_{\text{total}(\lambda)} = g_{\text{consumption per person (c)}} + v_c \,^\star\, g_{\text{population(n)}} \quad (2)$$

- $g_{\text{total}(\lambda)}$ denotes the consumption-equivalent social welfare growth.
- v_c is the value of a year of life, measured as a ratio of *per capita* consumption. This is typically greater than 1, reflecting the consumer surplus associated with life.
- Population share is $(v_c \,.\, gN)/g\lambda$.

TABLE 3
Welfare growth rates
Selected countries – 1960-2019

Country	CE welfare growth (g(λ))	Consumption growth (gc)	Population growth (gN)	Value of life (v(c))	Population contribution (v(c).gN)	Population share (%)
Mexico	8,6	1,8	2,1	3,4	6,8	79.0
Brazil	7,9	3,1	1,8	2,8	4,8	61.0
South Africa	7,8	1,4	2,1	3,1	6,4	82.0
United States of America	6,5	2,2	1	4,4	4,3	66.0
China	5,8	3,8	1,3	1,8	2	34.0
India	5,4	2,6	1,9	1,6	2,8	52.0
Japan	4,9	3,2	0,5	3,8	1,7	34.0
Ethiopia	4,4	2,5	2,7	0,7	1,9	44.0
Germany	3,7	2,9	0,2	4	0,8	22.0

Source: Adhami *et al*. (2025)

Population aging is another dimension associated with the demographic transition and the post-transition period. It has implications for intergenerational transfers and demographic dividends. The economic literature regarding this aspect is well-established. The "National Transfer Accounts (NTA)" project reviews a variety of contributions in this area. The focus on population size here relates to the fact that size (through Labor – L) is a proximate determinant of income in the growth models and of technological progress in some economic models. The first and second demographic dividends can be analyzed under NTA´s framework. Regarding aging, although the second dividend may entail capital deepening, the impact on total factor productivity is less clear.

International migration is often cited as a potential solution to the challenges of population aging and population size (growth). This is not the case globally; the net migration flow is always close to zero. The role of international migration can be evaluated at the country level. Billari (2022) argues that demography has long been dominated by what he calls the "slow demography" paradigm, which views population change as gradual, inertial, and largely predictable through trends in fertility and mortality. This macro view describes the demographic transition at the macro level, serving as the primary driver of economic and social changes. This view is incomplete in the post-transition. Migration, crises, political decisions, and technological shifts shape "fast demography", which can be evaluated by population turnover rates (PTR) – a measure of the speed of population change, defined as the sum of crude birth, death, immigration, and emigration rates (different from the traditional demographic balance equation); and by migration share of turnover (MST) – the proportion of total turnover explained by migration (immigration plus emigration rates).

At the global level, PTR is driven by crude birth and death rates, as net migration tends to cancel out. It declined from 56 (1990-1995) to 26 (2015-2020) per 1,000, confirming the decline in global population growth rate. The drop in PTR at the country level was much lower. The average PTR declined from 52.7 (1990-1995) to 42.8 (2015-2020) per 1,000, while the average MST rose from 27.6% to 32.2%, indicating that migration has become increasingly important in driving population change. Accounting for development, population change is faster in highly developed countries, not due to births or deaths, but rather to migration turnover.

Charles-Edwards *et al.* (2023) complement Billari's paper. The paper examines how international migration redistributes the global population and how this impact has changed from 1990 to 2020. The paper works with three concepts – "migration intensity" (CMI), which is the share of the population that migrates internationally within a given period; "migration effectiveness" (MEI) – the imbalance between inflows and outflows, indicating how much migration redistributes population *versus* just circulating people; and "aggregate net migration rate" (ANMR), a combination of the previous concepts representing the percentage of the world's population redistributed by migration in five-year periods.

The global pattern between 1990 and 2020 shows a stability of CMI (around 1.4%) between 1990-1995 and 2015-2020, a decline in MEI from 40% to 28%, and a decline in ANMR from 0.56% to 0.39%. Their findings regarding development levels suggest that migration between developed countries is intense but reciprocal (low MEI). In contrast, migration between low-developed countries is less frequent but more unidirectional (high MEI). The steeper the development gradient, the more asymmetric and redistributive migration becomes. There is a developmental asymmetry; a high MEI between low- and high-developed countries indicates persistent inequality, while a high CMI among highly developed countries indicates mobility and integration. For the population size debate, the ANMR results suggest a low and declining percentage of the world's population redistributed by migration.

In summary, international migration cannot increase global population size, although it can be observed at the national level. In terms of turnover at the country level, the MST is growing, while there is a slight decline in PTR. The intensity of migration has remained approximately constant, but the ability to redistribute populations among countries has declined.

The economic implications of post-transitional demographic outcomes require further understanding. The role of factor accumulation in economic growth is reaching a limit, with a ceiling in educational attainment, and the possible exhaustion of increased female labor force participation (these are some of the proximate determinants of income in growth models). Changes in TFP due to gender equality and other post-transitional demographic outcomes could be a favorable economic implication, but it is far from being proven. The general decline in population growth and eventual decrease in population size announce a possible future of economic stagnation. This could be counteracted by artificial intelligence and automation; however, the potential modeling of these aspects interacting with population dynamics is part of the future agenda.

Final discussion

The demographic transition was crucial to the consolidation of the modern growth regime. The two micro-level economic formulations of the demographic transition are the trade-off between child quality and quantity, and the role of women in the cost of children. These two formulations are associated with two empirical regularities: a negative correlation between income and fertility, and a negative relationship between female labor force participation and fertility. The formulation associated with the trade-off between child quality and quantity is the most critical aspect. At the macro level, human capital growth and technological progress are the primary factors driving sustained economic growth. A significant portion of economic growth during the modern growth regime is attributed to the rise in educational attainment. Education affects TFP directly and indirectly. The indirect channel is associated with the role of education (human capital, H) in increasing the quality of labor, a factor that has an augmenting effect. The direct channel operates by facilitating innovation, accelerating diffusion, enhancing institutions, and improving returns on technological investments. The endogenous growth model leads to the role of deliberate education policies. In some models, “idea” is a non-rival good, meaning it can be utilized by multiple agents, thereby associating technological progress with increasing returns. Population size matters for technological change, as it expands the market for ideas and increases the probability of producing innovators.

The post-transitional period is characterized by the operation of other micro-level models that seek to explain the rise of childlessness and the increasing prevalence of late childbearing. The extensive and intensive margin model is crucial for explaining women’s decision-making. Rather than the trade-off between child quality and quantity, during the post-transition period, child quality remains essential. Still, it has already reached a high level in terms of formal education, now depending more on the time intensity that parents (mothers) devote to their child’s life cycle quality. Women’s tertiary education and their career investments have become more critical. Women’s opportunity costs are now more closely related to their career’s long-term prospects. It is a structural outcome that explains the paradox between a lack of decline in desired family size (around two children) and the actual decline in realized fertility. The structural outcome relates to two aspects: the flexibility of work and the couple’s expectations regarding the gender division of time allocation toward child-rearing. These are the key drivers of low fertility. The same forces that empowered women economically – education, careers, autonomy – also reshaped family formation, creating "invisible opportunity costs" that depress fertility even in prosperous societies.

TFR could rise from well below replacement to, at most, the replacement level. Factors such as more flexible work environments, egalitarian gender values, and market or state-provided care would favor this change. The diffusion of ART among women at late reproductive ages would favor this shift in TFR. Still, this change would result in population growth shifting from negative to zero. International migration also presents limitations for generating a "slow demography" rise in population size. With fertility at or below replacement and migration limited, both population growth and the eventual headcount are likely to be too small to fuel further increases in idea production. We conclude that the issue of population decline and its connection to economic growth is of great significance.

Besides population size, what other factors would drive TFP? The micro-level models that enhance women's career development and lead to below replacement fertility do not seem to present the same power for generating a productivity revolution in the way that education did during the modern growth regime. We can speculate about the interactions between the micro-level gender revolution observed in the post-transition period and technological progress driven by automation and artificial intelligence, but this remains to be proven.

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Resumo

Transição demográfica e dinâmica populacional pós-transição: uma revisão dos modelos e interações micro e macroeconômicos

Esta revisão de literatura contrasta os modelos microeconômicos de fecundidade durante a transição demográfica e no período pós-transicional, avaliando suas implicações para os modelos macroeconômicos de crescimento. Enquanto os modelos microeconômicos de fecundidade enfatizam o *trade-off* entre qualidade e quantidade de filhos na transição demográfica, o modelo de fecundidade nas margens extensiva e intensiva aplica-se ao período pós-transicional, com inferências para a ausência de filhos (*childlessness*) e o adiamento da fecundidade. O impacto das decisões em nível micro sobre o crescimento econômico está mais bem documentado durante a transição demográfica do que no período pós-transicional. Os modelos micro do pós-transição ainda não conduziram a formulações e evidências que indiquem um progresso tecnológico acentuado. Em nível macro, o baixo ou negativo crescimento populacional no período pós-transicional pode estagnar o crescimento econômico devido ao efeito do tamanho da população.

Palavras-chave: Fecundidade. Transição demográfica. Qualidade da criança. Margem alargada. Margem intensiva. Modelo de crescimento econômico. Teoria unificada do crescimento. Capital humano. Progresso tecnológico.

Resumen

Transición demográfica y dinámica de la población tras la transición: una revisión de los modelos microeconómicos y macroeconómicos y sus interacciones

Esta revisión de la literatura contrasta los modelos microeconómicos de fecundidad durante la transición demográfica y en el período postransicional, evaluando sus implicaciones para los modelos macroeconómicos de crecimiento. Mientras los modelos microeconómicos de fecundidad enfatizan la compensación (trade-off) entre calidad y cantidad de hijos en la transición demográfica, el modelo de fecundidad en los márgenes extensivo e intensivo se aplica al período postransicional, con implicaciones para la ausencia de hijos (childlessness) y el aplazamiento de la fecundidad. El impacto de las decisiones a nivel micro sobre el crecimiento económico está mejor documentado durante la transición demográfica que en el período postransicional. Los modelos micro del pos-transición todavía no han conducido a formulaciones y evidencias que indiquen un progreso tecnológico marcado. A nivel macro, el bajo o negativo crecimiento poblacional en el período postransicional puede estancar el crecimiento económico debido al efecto del tamaño de la población.

Palabras clave: Fecundidad. Transición demográfica. Calidad infantil. Margen extensivo. Margen intensivo. Modelo de crecimiento económico. Teoría unificada del crecimiento. Capital humano. Progreso tecnológico.

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