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# Inside the black box of population growth: Tracing the roots of Unified Growth Theory

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# Inside the black box of population growth: Tracing the roots of Unified Growth Theory

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## Abstract

This article traces the roots of Unified Growth Theory, a strand of growth theory that aims at explaining the patterns of economic development over the very long-run, in various attempts to open the black box into which population growth was initially put. Doing so tells a story of long-standing efforts to unify theories of stagnation and sustained growth, the distinct object of study of two fields that parted ways in the mid 20th century, development economics and growth theory, by building a theory of the entire *process* of development in which population dynamics plays a central role. Unified growth models have become an integral part of growth theory alongside endogenous growth models, and their respective trajectories share similarities, as the treatment of population growth as a black box mirrors that of technological progress in the development of post-war growth economics.

## Keywords

Unified Growth Theory, history of macroeconomics, modern growth theory, development economics, population growth, fertility decisions, multiple equilibria

## JEL codes

B20, B21, B22, O10, O40

## Introduction: The black box of population growth

Unified Growth Theory (UGT henceforth) is a strand of growth theory that aims at explaining the broad patterns of long-run economic development: both the long stagnation of standards of living prior to the industrial revolution and the subsequent 'take-off' to growth and prosperity. More precisely, by UGT I refer to a class of models—so-called unified growth models—that feature, by definition, a regime of stagnation, a regime of sustained growth, and an endogenous transition between the two. UGT, today mainly championed by Oded Galor who coauthored seminal papers (Galor and Weil 2000, Galor and Moav 2002, Galor 2005) and wrote the eponymous textbook of reference (Galor 2011), emerged in parallel to New Growth Theory (NGT henceforth) in the 1990s, but has received little attention from historians of economics thus

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far.[2] The objective of this paper is not to provide an exhaustive overview of the rich body of work that constitutes UGT today, but rather to trace its intellectual roots in earlier attempts to model the entire development process and thereby unify theories of stagnation and growth.

Because of the central role played by population dynamics in UGT—the stagnation is explained by the classical Malthusian population doctrine and the transition to growth is accompanied by a demographic transition—, the guiding thread of the narrative I advance here is the treatment of population in growth theory in the second half of the 20th century that I interpret as the opening of a black box. This metaphor that has been used to describe how technological progress was at first left exogenous in early neoclassical models before being progressively made endogenous. The title of the present paper is indeed a reference to Nathan Rosenberg's early attempt to *« break open and to examine the contents of the black box into which technological change has been consigned by economists »* (Rosenberg 1982, p.vii). Martin Weitzman used the same language and described NGT as *« an attempt to go inside the black box »* that revealed further « *black boxes within black boxes »* (Weitzman 1998, p.332), and Mata and Loucã (2009) also mobilize the concept to tell the history of the Solow residual.

In this paper, I argue that UGT emerged from attempts to delve into the black box of population growth. Population growth was indeed put in a black box at the onset of growth theory when Roy Harrod abandoned the classical population doctrine (Boianovsky 2018a, 2018b), although its potentially deleterious effect on standards of living had occupied the classics' minds at least since the publication of Thomas Malthus' *Essay on the Principle of Population* in 1798.[3] Acknowledging that the *« doctrine may still have relevance to large poverty-stricken areas of the world of today »* (Harrod 1948, p.18), Harrod argued that, when studying the developed economies of industrialized countries, *« we may regard the size of the population not, as in the old classical system, as a dependent but as an independent variable »* (p.19). Population growth was subsequently left exogenous in the development of neoclassical growth theory, *« in the spirit of the Harrod model »* (Solow 1956, p.67). As Gustav Ranis put it in the early 1960s: *« demography was being relegated to the sociologist and technological change to the engineer »* (Ranis 1963, p.621).

The justification for leaving population growth in a box was the distinction between the study of so-called advanced and backwards economies, which marked a point of departure between growth theory and development economics when the two nascent fields went separate ways in the mid-1950s (Boianovsky and Hoover 2009, Alacevich and Boianovsky 2018). The treatment of population growth was therefore a product of the dichotomy between two fields concerned with different objects of study—namely, stagnation and growth—that UGT would later aim to encompass within a single theoretical framework. Endogenous population growth was nonetheless recognized as a potential bridge between them by scholars evolving at the intersection of the two fields and interested not only in the sources of growth or the causes of stagnation but in the entire development process. Proto-unified growth models in which population dynamics drives the transition from stagnation to growth indeed emerged in the late 1950s and early 1960s from the first attempts to open the black box of population in neoclassical growth models, making the metaphor well suited to tracing the roots of UGT.

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[2] Galor (2024) provides his own survey.

[3] Although the population doctrine has come to be associated with Malthus, the Irish-French economist Richard Cantillon had already argued that *« men multiplied like mice in a barn if they have unlimited means of subsistence »* (1755, part. 1, chap. 15) in his *Essai sur la Nature du Commerce en Général*, written before his death in 1734 but published only in 1755.

The trajectory of population growth as a black box also mirrors that of technological progress in several respects. Those early attempts featured multiple steady-state equilibria, or poverty traps, an idea already present in the writings of the classics, Malthus in particular, which failed to be systematically integrated in neoclassical growth theory as interest in the field dried out in the 1970s. Just like the concept of increasing returns, central to Adam Smith and already discussed in the context of the first wave of endogenous growth models (Pomini and Tondini 2006, Warsh 2006, Spear and Young 2017), it is only with the revival of growth theory in the 1980s that multiple equilibria and their role in the process of development were brought back into the neoclassical growth framework. It could only happen as a black box within the black box was also opened and a theory of fertility decisions able to account for an endogenous demographic transition provided microeconomic foundations with the new standards of macroeconomic modeling that allowed the emergence of UGT.

## Opening the black box: Multiple equilibria and the stages of growth

Counterintuitively perhaps, the first attempts to open the black box of population growth occurred as soon as it was sealed, at the very beginning of neoclassical growth theory. Both Robert Solow and Trevor Swan, when independently codiscovering the neoclassical growth model, indeed considered some implications of endogenous population growth (Boianovsky and Hoover 2014). While Swan (1956) devoted an entire section to 'a classical case' in which population increases with standards of living in a Malthusian fashion and is confronted to the diminishing returns of land as a fixed factor of production, Solow's seminal 1956 paper in the *Quarterly Journal of Economics* contains a short discussion that can easily go unnoticed. Solow did not explicitly cite Malthus but nonetheless argued that the rate of population growth could first decline for low values of the capital to labor ratio, before increasing with standards of living and eventually decreasing to suggest a potential demographic transition. This nonlinear shape of the fertility locus modifies the dynamics depicted by the Solow diagram as it intersects the concave savings locus twice. The system now features multiple stationary equilibria, or steady states: one that is stable for a relatively low capital to labor ration, and one that is unstable at a higher ratio, implying both the existence of a poverty trap and the possibility of self-sustaining growth if the economy can move past the unstable equilibrium.[4]

Poverty traps, defined by Brian Snowdon as *« self- reinforcing inefficient steady-state equilibria at low levels of per capita income »* (Snowdon 2009, p.249), naturally emerge from standard Malthusian assumptions in the neoclassical growth model. The concept was also used by Richard Nelson, the same year in which Solow's paper was published, to explain the stagnation of underdeveloped economies. Resolutely geared towards the analysis of backward countries, Nelson's analysis shared many similarities with Solow's: a stable low-level equilibrium in standards of living arises from endogenous population growth, but self-sustaining growth can nonetheless be achieved if a country escapes the poverty trap (Nelson 1956). Nelson also acknowledged that his analysis was similar in

[4] Throughout this paper, I use the term equilibrium to refer to a stationary equilibrium, a steady state of a dynamical system. The existence of multiple stationary equilibria should not be confused with the potential multiplicity of equilibria derived from agents' extrinsic beliefs in sunspots models (see Cherrier and Saïdi 2018).

many respects to Harvey Lebeinstein's PhD dissertation, *Towards a Theory of Demographic-Economic Development,* submitted to Princeton University in 1950 and published in 1954 while Nelson was writing his own article. Leibenstein, a development economist then at the University of California, Berkeley, lamented that the interaction between demographic and economic variables had been neglected by economists and was calling for endogeneizing population growth. Introducing population dynamics and the Malthusian population problem in a growth model *à la* Harrod-Domar, Leibenstein focused on the resulting multiplicity of equilibria and their respective stability. His view of the entire development process was one of transition from a poor equilibrium to a better one, or in his own words: « *the transition from a condition of high birth rates, low expectation of life at birth and low levels of average income to a state of relatively low birth rates, relatively high expectation of life at birth, and relatively high levels of average income »* (Leibenstein 1950, pp.8-9).

Various factors can trigger the transition from one equilibrium to the other. Solow noted that *« a major burst of investment can lift the system into a self-generating expansion of income »* (Solow 1956, p.91), an idea that was also being pushed forth under the label of 'Big-Push' by development economist Paul Rosenstein-Rodan, Solow's colleague at MIT at the time (Boianovsky and Hoover 2014). Leibenstein, in his subsequent work, *Economic Backwardness and Economic Growth* (1957), also shared Rosenstein-Rodan's idea that a 'minimum effort' to raise per capita income above some unstable threshold level could lead to self-sustaining growth, and Snowdon (2009) argues that the Nelson model has been used as a justification for foreign aid in hopes of providing this initial boost out of the poverty trap. Patrick Buttrick, one of the few to have noticed Solow's speculative one-page discussion at the time, also listed several factors that would make the low-level equilibrium vanish, in a short note published in the *Quarterly Journal of Economics* in 1958. A reduction of fertility rates shifting the population locus down, or latent changes in either culture (Buttrick refers to the increase in the propensity to save often associated to the Protestant Reformation) or technology progressively raising the savings locus, could trigger the transition from stagnation to self-sustaining growth. Rather than an exogenous increase of capital, Buttrick found promising the latter interpretation that, he deemed, « *provides the beginnings of a theory of the 'industrial revolution' that does not require any special set of fortuitous and exogenous events, »* displaying his own enthusiasm by concluding: *« this is a real advantage! »* (Buttrick 1958, p.635).

Viewing the development process as the transition from an equilibrium of stagnation to one of self-sustaining growth suggests the existence of stages of growth, a notion that was very much in the air at the time and that came to be associated with Walt Whitman Rostow. Another colleague of Solow, Rostow was an economic historian working in the Center for International Studies (CENIS) at MIT along with Paul Rosenstein-Rodan. He also shared the view that less developed economy could be lifted out of stagnation via the same substantial investment suggested by the multiple equilibria models of Solow, Nelson, and Leibenstein. In an influential article, 'The Take-Off Into Self-Sustained Growth' published in the *Economic Journal* in 1956 and an even more famous book, *The Stages of Economic Growth: A Non- Communist Manifesto* that came out in 1960, he devised a theory of the entire process of development divided into distinct stages. Rostow coined the term term 'take-off' to describe a *« brief time interval of two or three decades when the economy and the society of which it is a part transform themselves in such ways that economic growth is, subsequently, more or less automatic »* (Rostow 1956, p.25). The notion of take-off from a stage of stagnation to growth one of self-sustaining growth implies some non-gradualism in the process of development as in multiple equilibria models, and the term would later be widely used in UGT.

The hypothesis advanced by Rostow was widely debated, and a conference organized by the International Economic Association in Konstanz, West Germany, in September 1960, to assess his 'Economics of the Take-off' allowed Solow and Leibenstein to discuss the role of population in the process of development. Presenting a paper entitled 'Population Growth and the Take-Off Hypothesis', Leibenstein argued at the conference that Malthusian population dynamics could indeed explain stagnation. Pondering about the effect of a potential fertility decline that would occur during the take-off period, he also thought *« possible that (at least in some cases) fertility declines gives that extra push to sustained growth necessary for a* successful *take-off »* (Leibenstein 1963, p.181).[5] In the discussion that followed the presentation, Solow concurred with the need to treat population growth as endogenous and resorted to his own extension to formalize Leibenstein's ideas with the help of his modified diagram (Rostow 1963, p.407). Boianovsky and Hoover (2014) recount however the strong and negative views that Rostow held of the kind of economic theorizing Solow and Leibenstein were conducting that he deemed unable to account for the complexity of the growth process emphasized by both economic historians and development economists. In addition to the distinction between the study of advanced and backward economies, the propensity to use formal models was indeed another marker of the dichotomy between growth theory and development economics, a perspective also shared by Paul Krugman and Robert Solow (Snowdon 2009).[6]

Harvey Leibenstein is nevertheless illustrative of a strand of theory-oriented scholars evolving at the frontier between the two fields: rather than focusing solely on the long-run dynamics of advanced industrialized countries or on the stagnation in so-called backward economies, their object of study was the development process in its entirety, and the transition between the various stages of growth studied independently by both fields. It was precisely the existence of multiple equilibria depicting those distinct stages of development that allowed to nest them within a single framework. Dale Jorgenson, then Leibenstein's colleague at Berkeley, explicitly sought to *« begin a frontal attack on the gap between theories of growth and theories of development »* (Jorgenson 1961, p.310) by introducing endogenous growth of population multiple equilibria in a model of structural change. In the dual economy he considered, the same kind of Malthusian poverty traps as in Leibenstein's, Nelson's, and Solow's models might prevent the transition from a traditional to a modern sector.[7] Opening the black box of population was therefore seen as a promising alley toward the unification of development economics and growth theory.

However, population growth remained treated as an exogenous variable in the subsequent development of growth theory, as shown by the very brief coverage models with endogenous population growth got in the exhaustive survey of growth theory written by Frank Hahn and Robin Matthews for the *Economic Journal* in 1964. The short length of the subsection in which Leibensten's and Jorgenson's work are mentioned was justified *« because [the rate of growth of the labour force] has not occupied such a prominent place in the recent literature as the other possibilities to be considered »* (Hahn and

[5] Leibenstein admitted being being *« sympathetic with Rostow's central hypothesis »* and even *« committed to being sympathetic since the type of theories that [he had] attempted to develop in the past [had] been in conformity in what [he interpreted] to be Rostow's central* non-gradualist *position »* (p.171).

[6] Snowdon (2009, p.243), pondering on the lack of influence of the Solow model on development economics before the 1980s, puts forth Krugman's and Solow's views that development economists were not interested in model building.

[7] Jorgenson acknowledged being directly inspired by Leibenstein, whom he credited with one of the *« most important among [development] contributions, from a theoretical point of view »* (p.309).

Matthews 1964, p.785). Hahn and Matthews nonetheless attributed a special significance to such models with endogenous population growth, arguing that *« they provide a link between the theory of growth in the sense used in this survey and the theory of development »* (p.804), abiding to the distinction between growth and development when they write that *« growth theory of the type dealt with in this survey can be thought of as limited in its application to the advanced sector »* (ibid.).[8] Despite Jorgenson's explicit efforts to unify the two fields, neoclassical growth theory thus remained, as Albert Hirschman would put it when drawing the frontier of development economics (Alacevich and Boianovsky 2018), the 'economics of the special case' that focused on the few industrialized and developed economies that had managed to escape the Malthusian poverty trap. Although the two approaches were judged complementary rather than competing by their main protagonists (Findlay 1980), growth theory and development economics kept on evolving as two separate fields.

A few scarce attempts to elaborate on Solow's early exploration and open the black box of population growth in the neoclassical growth model were made in the early 1960s, but they remained largely short-lived. Examples are an article by Jürg Niehans and one by Sho-Chieh Tsiang, published respectively in 1963 in the *Quarterly Journal of Economics* and in 1964 in *Econometrica,* both proposing more sophisticated extensions of the neoclassical growth model than Solow's, with the same neo-Malthusian assumptions regarding population growth resulting in both a stage of stagnation and an endogenous take-off to self-sustaining growth. Niehans, who was actually mentioned in Hahn's and Matthews' survey, acknowledged that despite him not remembering Solow's treatment of population in the 1956 article such ideas were *« in the air »* (Niehans 1963, p.350). Tsiang makes his inspiration from Rostow transparent from the title of his article: 'A Model of Economic Growth in Rostovian Stages'. Interestingly, he did not stick to Rostow's five stages of development but identified three instead that coincide almost exactly with the three regimes that Galor and Weil would later define in their seminal UGT paper.[9] However, neoclassical growth theorists in the early 1960s largely kept the black box of population growth closed as they were trying to open another one, that of technological progress (Spear and Young 2017).

## The black box within the black box: The microfoundations of fertility decisions

In those early attempts to open the black box of population growth, neo-Malthusian assumptions were introduced through a reduced-form law of motion of population, the shape of which was justified by the way standards of living might influence the difference between fertility and mortality rates. Whether mortality falls (Nelson 1956) or fertility rises (Jorgenson 1961) with standards of living, the result is a rate of growth of population that increases function of income per capita (or sometimes the capital to labor ratio), up to some plateau reflecting various physiological constraints on either death or birth rates. However, it had long been recognized that

[8] Leibenstein and Jorgenson, but also Solow and Buttrick, come back later in Hahn's and Matthews' survey when the possibility of diminishing returns to land and the resulting Malthusian traps are reviewed, with a connection made between the existence of multiple equilibria and the notion of 'take-off' from stagnation to growth.

[9] Tsiang's three stages are: (1) the traditional stagnant society, (2) the preparatory stage for the takeoff, and (3) the takeoff into self-sustained growth, which are very close to the three regimes identified in UGT: (1) Malthusian, (2) Post-Malthusian, and (3) Modern.

the transition from stagnation to growth that developed countries had experienced was accompanied by a demographic transition: a substantial reduction in fertility rates that allowed to break the Malthusian check on standards of living. While Solow did assume that fertility might eventually decline at higher standards of living and showed how it could lead to self-sustaining growth, there lacked an explanation of the underlying mechanism. The demographic transition lied outside the realm of economics, despite the conviction of a few theorists that fertility decisions had to be driven by socioeconomic factors.

*« Of course, there are always black boxes within black boxes, so that after the first black box has been opened a second one inevitably appears »* wrote Weitzman about the *« production function for new knowledge »* that he thought had not been given *« proper microfoundations »* by new growth theorists (Weitzman 1998, p.332). Fertility decisions were also another black box within the black box of population growth, which scholars would eventually seek to open. Among those was Leibenstein who, while resorting to reduced-form relationships between economic variables and population growth in his dissertation, had proposed in *Economic Backwardness and Economic Growth*, a book published in 1957, a rational choice theoretic framework in which the decisions of having an additional child was made by balancing various utilities and disutilities. Leibenstein would recall years later, in a 1974 reflective article in the *Journal of Economic Literature*, that his attempt at opening the black box of fertility decisions was precisely motivated by the *« important lack of even a semi-formal explanatory structure of Stage III in the demographic transition theory »* (1974, p.460), that is, of the decline in fertility at higher standards of living that his framework could explain.

Leibenstein was not the only economist studying fertility, and the theory that eventually proved more influential was developed by Gary Becker when he was at Columbia. In 1960, Becker published a paper entitled 'An Economic Analysis of Fertility' in the *Demographic and Economic Change in Developed Countries* NBER volume in which he proposed a *« generalization and development »* (1960, p.209) of the economic framework used by Malthus to understand population growth. The novelty was to consider children as durable goods, the demand for which would be determined by tastes, income and prices, as in standard microeconomic theory. Importantly, Becker distinguished between the quantity of children and their quality, the amount families spend on them. Drawing a parallel with other durable goods of various qualities, and offering a colorful comparison of Chevrolets and Cadillacs, Becker conjectured that at high income levels, the quality-income elasticity would be much greater than the quantity-income elasticity. Becker's so-called quantity-quality trade- off provided an explanation of the demographic transition as standards of living rise that would later become a central piece of UGT, under his own impulse.

The concept of child quality mobilized by Becker is intrinsically linked to idea of investment in man, or investment in human capital, an idea that was developed and pushed to the forefront by Theodore Schultz in his presidential address to the American Economic Association in 1960. Schultz's reflections on human capital had always been motivated by the need to understand growth, and fueled by the important role attributed to the residual by the Solow model, and so were Becker's (Teixeira 2014, Weiss 2015). In parallel to his theoretical inquiry on the determinants of fertility decisions, Becker had also started to work on his theory of human capital and Schultz was instrumental in promoting his work. When Becker presented his famous 'Investment in Human Capital: A Theoretical Analysis' at the Exploratory Conference on Capital Investments in Human Beings held in 1961, Schultz ndeed decided to place the paper first when publishing the proceedings in the *Journal of Political Economy* the year after. As noted by Bowman (1980), Schultz

was a formidable *« research entrepreneur »* able to open exploratory roads by organizing conferences, and orient research by putting forward contributions he deemed important in symposia.

Less documented is Schultz's venture in the economics of fertility, along Becker, and his role in the opening of the black box of fertility decisions. He organized two conferences in 1972 and 1973 that resulted in two additional supplements to the *Journal of Political Economy*: 'New Economic Approaches to Fertility' in 1973, and 'Marriage, Family, Human Capital, and Fertility' in 1974. Both issues featured and promoted the work of Becker, but also pushed for the opening of the black box of population growth in growth theory. In his own paper in the 1973 symposium, Schultz indeed lamented that (modern) growth economists had shied away from Malthus by mostly treating population growth as exogenous, focusing on the effect of population growth on economic growth rather than the effect of economic growth on population growth. He argued that a theory that treated population growth as exogenous had little chance to answer what he deemed the most interesting question asked by demographers: *« What is the explanation of the demographic transition, that is, how do we explain the economic and social processes and family behavior that accounts for the marked decline from very high birth and death rate to modern very low birth and death rates? »* (Schultz 1973, p.S4). In the 1974 symposium, Marc Nerlove from the University of Chicago also argued that explaining the demographic transition was the *« grand problem of the new home economics »* (Nerlove 1974, p.S212) and explicitly called for the integration of the new microeconomic approach to fertility decisions and human capital investments into growth theory, that is, to open the black box within the black box of population growth.

What Gary Becker himself labeled « Family Economics » quickly took hold, spurred both theoretical and empirical research, proved controversial, and ultimately came to be associated with the University of Chicago. However, and perhaps surprisingly, although the University of Chicago was among the places where the introduction of human capital in the first wave of endogenous growth models was being worked out at the time, notably under the impulsion of Hirofumi Uzawa (Spear and Young 2017), attempts to incorporate fertility decisions in growth theory remained scarce. A notable exception was a paper by Assaf Razin and Uri Ben Zion, who had both obtained their PhD from the University of Chicago, published in the *American Economic Review* in 1975.[10] Their aim was to establish the missing *« link between population theory and economic growth theory »* (Razin and Ben Zion 1975, p.923) by introducing Becker's child quantity-quality trade-off in an intertemporal model of population growth with capital accumulation.[11] While the black box of fertility decisions was indeed opened, they took a normative rather than a positive approach: instead of accounting for the demographic transition and describing the process of development, they focused on the optimal growth rate of population and considered how various government policies such as education subsidies would affect consumption and capital accumulation.

Razin's and Ben Zion's paper would nonetheless prove quite influential as it spurred a collective effort to endogeneize and provide microfoundations to population growth, not in so-called endogenous growth models that were not seen as a promising avenue for young theorists

[10] Razin in particular was a student of Uzawa in the 1960s, he participated actively to the influential growth seminar that his supervisor organized at Chicago, and his dissertation was precisely about introducing human capital investments in growth theory (Spear and Young 2017).

[11] Razin and Ben Zion abstracted from human capital: instead, quality amounts to the stock of capital left to each individual from the next generation (some of which can be interpreted as human capital if human and physical capital are perfect substitutes in production).

anymore (Warsh 2006), but in optimal growth models instead. Razin had left Chicago for Tel Aviv University after a brief year in Minnesota, but would indeed keep working on optimal growth models with endogenous fertility. He teamed up with Efraim Sadka, also from Tel Aviv, and Chicago's Marc Nerlove to publish a series of papers on population, efficiency, and welfare in the 1980s. This literature on optimal population growth that used Becker's framework blossomed and in 1989, Klaus Zimmerman coordinated an issue of *Microeconomic Studies* entitled 'Economic Theory of Optimal Population'. Contributors included Razin, Sadka and Nerlove, but also Zvi Eckstein, Kenneth Wolpin and Steven Stern who had coauthored a series of papers on optimal population size in growth models with endogenous fertility. Again, the focus of the symposium was more normative than positive, and while endogenous population growth was introduced in growth theory in a microfounded way, the questions regarding the role of the demographic transition in long-run development were mostly set aside. Nevertheless, interest for the economic study of fertility decisions and population dynamics was growing, and what was now called population economics was institutionalized as a field of its own with the creation of the *Journal of Population Economics* by Zimmerman in 1988 and the publication of the first textbooks that would soon follow, including one written by Razin and Sadka, *Population Economics*, published in 1995

## Boxes wide open: Rediscovering multiple equilibria and the stages of growth

The mid 1980s saw a resurgence of interest for growth theory, under the impulse of Robert Lucas and most notably his former student in Chicago, Paul Romer. 'Increasing Returns and Long-Run Growth', a paper based on Romer's PhD dissertation and published in the *Journal of Political Economy* in 1986 is often credited with starting a new literature on endogenous growth that would come to be called New Growth Theory (NGT). Robert Lucas's Marshall Lectures 'On the Mechanics of Economic Development' given at Cambridge in 1985 also proved tremendously influential. The version published in the *Journal of Monetary Economics* in 1988 remains, perhaps surprisingly, his most cited paper by a wide margin. Like Romer and other NGT theorists however, Lucas refrained from opening the black box of population growth and kept it as an exogenous parameter to focus instead on human capital accumulation as an engine of growth.[12]

Keeping the black box of population growth closed was nevertheless not satisfactory to Lucas who deemed that *« abstracting from the economics of demography »* was a *« serious omission »* (Lucas 1988, p.6). Confessing his lack of knowledge on the matter, he pointed instead toward ongoing work by Becker and Robert Barro as well as preliminary results by Robert Tamura, then his and Becker's PhD student at the University of Chicago.[13] Becker himself had indeed set out to open the box by refining his own microeconomic theory of fertility decisions before integrating it into the neoclassical growth model, teaming up with Barro. In 1985, they presented a paper entitled 'Population Growth and Economic Growth' at the Workshop in Applications of Economics in

[12] Lucas introduced human capital in the neoclassical growth model, drawing on Schultz's and Becker's work, while also paying due respect to Hirofumi Uzawa who had developed a similar model in the 1960s.

[13] Robert Tamura wrote his PhD dissertation at the University of Chicago under the supervision of Becker and Lucas as well as Robert Murphy and Sherwin Rosen on the interaction between fertility, human capital and economic development, entitled *Fertility, Human Capital and the "Wealth of Nations"* and submitted in 1988.

Chicago, a paper that would eventually turn into two publications: the paper Lucas referred to, 'A Reformulation of the Economic Theory of Fertility' published in the *Quarterly Journal of Economics* in 1988 (Becker and Barro 1988), and a sequel entitled 'Fertility Choice in a Model of Economic Growth' the next year in *Econometrica* (Barro and Becker 1989). In this series of papers, Barro and Becker aimed to study the relationship between fertility decisions and capital accumulation across generations, as well as the interplay between population growth and other macroeconomic variables. Although both papers were framed as contributions to the theory of optimal growth just as Razin's and Ben Zion's more than a decade before, Becker used the opportunity given by his term as president of the American Economic Association to lay out an agenda integrating family economics and macroeconomics in general, with a particular emphasis on positive rather than normative growth theory.

In his presidential address, delivered in 1987 and published in the *American Economic Review* in 1988, Becker reminded the audience of the successes and failures of both the Malthusian and neoclassical models. The Malthusian model could explain the period of stagnation of standards of living, but failed to account for the decline in fertility as income rose in developed economies throughout the nineteenth and twentieth centuries. The neoclassical growth model featured capital accumulation derived from utility maximization, but took *« a sizable step backward from Malthus by assuming that fertility and other dimensions of population growth are independent of wages, incomes, and prices »* (Becker 1988, p.3). Becker explicitly called for a union of the two models and the integration of Malthusian population dynamics in neoclassical growth theory through explicitly microfounded fertility decisions, the black box within the black box that he had himself contributed to opening.[14] Also referring to Tamura's work, he conjectured that a negative relation between fertility and income could be a destabilizing force leading an economy to transition from a high fertility and low per capita income steady state to a low fertility and high per capita income one, just as Leibenstein had argued in the 1950s. Becker deemed that to account for self-sustaining growth however, one would also need to consider human capital accumulation as an additional driving force. Mentioning the recent advances in NGT by quoting Romer and Lucas, but also the earlier attempts of Arrow and Uzawa, Becker alluded to his own ongoing work with Kevin Murphy from the University of Chicago that they would present a few months later at a conference at the State University of New York at Buffalo.

The conference, organized by Isaac Ehrlich and the Institute for the Study of Free Enterprise in May, 1988, was covered extensively by David Warsh (2006) as it is there that Paul Romer presented his 'Endogenous Technological Change' paper. The proceedings were indeed published in a special issue of the *Journal of Political Economy* edited by Ehrlich in 1990 and named 'The Problem of Development' that featured Romer's influential paper. Endogeneizing technological progress—or in Ehrlich's words, to consider it *« as the outcome of entrepreneurial decisions motivated by market forces rather than the consequence of autonomous scientific discoveries »* (Ehrlich 1990, p.S3-S4)—was naturally on the agenda, but it is much less known that treating population growth (as well as human capital accumulation) as endogenous and resulting from individual decisions was also listed among the themes of the conference. As such, when NGT was delving inside the black

[14] Becker was well aware of the earlier attempts at endogeneizing population growth in models of with multiple equilibria, poverty traps, and stages of growth, citing the discussion in Solow's original paper, as well as the papers by Nelson and Tsiang mentioned earlier.

box of technological progress, that of population growth was also being opened, but in a way that abided much better to the new microfoundational standards of macroeconomics than earlier attempts. Furthermore, Ehrlich's introduction to the symposium echoed the discussions that had taken place in the 1960s as he noted the dichotomy between growth theory and development economics, *« treated largely as separate subjects of study—the first seemingly applicable to advanced market economies and the second stressing the role of noneconomic factors and market failures in less developed countries—rather than as part of a unified theory »* (Ehrlich 1990, p.S1), stressed the role of the demographic transition during the take- off from stagnation to growth, and emphasized the need to understand the entire *process* of development.

The published version of the paper that Becker and Murphy presented at the conference featured Tamura as an additional coauthor. They laid out a full-fledged endogenous growth model with fertility decisions that featured the multiple equilibria that were dear to Leibenstein in the 1950s: *« a 'Malthusian' undeveloped steady state with high birth rates and low levels of human capital, and a developed steady state with much lower fertility and abundant stocks of human and physical capital »* (Becker et al. 1990, p.S14). Multiple equilibria and Malthusian poverty traps could finally come back to the front scene now that the black box of fertility decisions had been opened. Ehrlich himself would then build on Becker, Murphy and Tamura with his colleague at the State University of New York, Francis Lui, to propose a model in which improvements in longevity can trigger the transition from a Malthusian steady state to a stage of self-sustaining growth (Ehrlich and Lui 1991).[15] Irrespective of the potential mechanism underlying this transition and the accompanying reduction in fertility rates, a growing number of theorists were now placing population dynamics derived from explicitly microfounded fertility decisions at the center of their models. There was a sense, as Costas Azariadis and Allan Drazen would put it when surveying growth models with endogenous fertility, that *« any theory of economic growth is necessarily incomplete if it concentrates on growth in output but ignores determinants of growth in population »* (Azariadis and Drazen 1993, p.3). Endogenous population growth and fertility decisions came to be more systematically integrated in growth theory in the course of the 1990s, as shown by more surveys written later in the decade (Ehrlich and Lui 1997, Nerlove and Raut 1997).

## The emergence of Unified Growth Theory

As the recent contributions of Romer and NGT in general were attracting most of the attention, a parallel literature emerged in the 1990s as a cast of theorists sought to leverage the multiple equilibria revealed by the opening of the black boxes of population growth and fertility decisions to account for both stagnation and growth in a unified framework. Multiple equilibria indeed described distinct stages of development, namely stagnation and growth, and while NGT was motivated by the need to understand the mechanics of technological progress or knowledge accumulation, the object of study of those scholars became the *process* of development: the transition from a state of Malthusian stagnation to a modern regime of self-sustaining growth. Adopting a more historical perspective, scholars focused on explaining specific events such as the demographic transition and the industrial revolution. The Kuznets Lectures that Lucas was invited

[15] The paper was initially written for the follow up conference, Human Capital and Economic Growth, also held by the Institute for the Study of Free Enterprise Systems, at the State University of New York at Buffalo, May 1989.

to give at Yale in November, 1996, on the industrial revolution perfectly encapsulate the motivations of this group of growth theorists whose efforts would culminate into UGT in the late 1990s and that included, among others, Oded Galor and David Weil, Gary Hansen and Edward Prescott, Michael Kremer, Charles Jones, Robert Tamura, and Lucas himself. In a set of notes prepared for the lectures that he circulated in 1998 but did not publish before including the material as the fifth and last chapter of his 2002 book *Lectures on Economic Growth*, Lucas reformulated the dichotomy between growth and development as one between what he dubbed classical and modern theories of production, and explicitly called for unification.[16]

For Lucas, the *« central theoretical problem of growth theory »* at the time was precisely to unify theories of stagnation and growth: *« To understand the industrial revolution, and hence to understand a world in which some economies have joined the industrial revolution and others have not we will need to unify these conflicting theories of production. That is to say, we need to discover a more general theory of which the two we now have can be seen as special cases, a theory that lets us see the nature of the transition from the situation of stable incomes that has characterized most of history to the sustained growth that has emerged in the last two centuries »* (Lucas 2002, p.110-111). As Lucas viewed the industrial revolution and the demographic transition as two sides of the same coin, he believed that endogenous population growth would be the key to the unification. Acknowledging the role played by Becker, Murphy, and especially Tamura in the change of his own thinking about growth since the time of his Marshall Lectures, he argued that demography should no longer be omitted and fertility decisions ought to be systematically integrated into growth theory.[17] Lucas's call suggests that, while NGT developed from the efforts of growth theorists to open the black box that was the Solow Residual (Mata and Louçã 2009), UGT emerged in the 1990s from the opening of the black boxes of population growth and fertility decisions.

At the time of the Kuznets Lecture, Lucas admitted however having failed to propose *« a model capable of unifying classical and modern growth theory [...], a model that can be simulated to exhibit a transition from per capita income stagnation to sustained growth »* (Lucas 1998, p.60). What lacked to Lucas, but also to Becker, Ehrlich, and their coauthors, was an endogenous transition from stagnation to growth, a defining feature of unified growth models. Although those early models of the process of development did encompass both a high fertility-stagnation equilibrium and a low fertility-growth equilibrium and could therefore account for contemporary cross-country differences in fertility and standards of living, the transition from the former to the latter was still the result of various exogenous shocks, for example to productivity (Becker et al. 1990) or longevity (Ehrlich and Lui 1991).[18] Lucas conjectured that an essential ingredient of the transition would be an endogenous rise in the returns to human capital accumulation that eventually triggers the switch

[16] The classical theories of Malthus and Ricardo accounted for the stagnation of standards of living in the face of technological progress as population growth prevented any sustained increase in income per capita, while modern theories, whether exogenous or endogenous growth theories, explained how technological progress allowed for sustained economic growth while abstracting from any effect on the dynamics of population. Lucas deemed that each *« succeed in accounting for the central features of the contemporary behavior of production and population »* but that the *« the predictions of both theories, however, conflict sharply with the data the other was designed to explain »* (2002, p.110).

[17] Tamura had published part of his thesis in *Economic Theory* in 1994, emphasizing the multiplicity of steady states and the transition from stagnation to growth, and followed up with a theory of the demographic transition in the *Journal of Economic Dynamics and Control* in 1996.

[18] Multiple steady-state equilibria also emerged from various externalities in models with exogenous population growth, and Rosenstein-Rodan's concept of a Big-Push out of an underdevelopment trap was discussed again (Murphy et al. 1989, Azariadis and Drazen 1990).

from quantity to quality and the resulting reduction in fertility, and also noted the necessity to account for structural change and the declining role of land as a factor of production during industrialization.[19]

The 1990s saw the group of scholars mentioned above trying to bring together various pieces of the puzzle in the first properly unified growth models. Although they shared the objective to explain the entire process of development from stagnation to growth, the modeling strategies and emphases naturally differed. Some kept reduced-form laws of motion of population, in which population growth was assumed to be a non-linear function of either income per capita or consumption, in order to focus on the interaction between population growth and technological progress (Kremer 1993, Strulik 1997) or to calibrate population dynamics to match historical data (Hansen and Prescott 1998). Some also abstracted from human capital accumulation, but incorporated elements from NGT to microfound technological progress (Jones 1999). Some treated technological progress as an exogenous driving force that eventually endogenously trigger a transition from agriculture to manufacturing (Hansen and Prescott 1998), or a demographic transition brought about by the rising female labor force participation (Galor and Weil 1996). Some focused on explaining the inverted U-shape of population dynamics through differential fertility and shifts in the income distribution in models with single (Dahan and Tsiddon 1998) or multiple equilibria (Kremer and Chen 1999, Morand 1999).

It is in the context of this collective and conscious effort to unify theories of Malthusian stagnation and self-sustaining growth that Oded Galor and David Weil, both from Brown University, built what would eventually be considered the canonical model of UGT. In a working paper circulated in 1998, summarized in the *Papers and Proceedings of the American Economic Association* in 1999, and eventually published in the *American Economic Review* in 2000, they brought together several of the ingredients previously studied independently to develop what they explicitly called a unified model consistent with the historical process of development of the last millennia. At the heart of their modeling strategy was naturally the multiplicity of equilibria, but as Galor would later recall, the fact that the transition from stagnation to growth was a swift but gradual process made substantial but exogenous destabilizing shocks not desirable explanations (Galor 2005). Instead, the stable Malthusian equilibrium vanishes endogenously following the evolution of latent variables of the dynamical system, in the same spirit as Buttrick's favored interpretation of the modified Solow diagram forty years earlier.[20]

Drawing inspiration from Kremer, Jones, and NGT more generally, Galor and Weil emphasized the interaction of population and technology as the driving force of the endogenous transition. They assumed a positive effect of the size of the population on the evolution of technology, and it is the gradual acceleration of technological progress that provides the rise in the returns for human capital that Lucas had suggested. In the Malthusian Regime, education is at a corner solution and there is no investment in human capital, such that improvements in technology translate into higher fertility, which keeps standards of living at the subsistence level. However, as technological progress accelerates because of the positive externality of population size, income

[19] Lucas noted that land played no role in Becker et al. (1990) and as such that the high fertility- stagnation equilibrium was not truly Malthusian. Regarding structural change, he referred to a 1994 working paper by John Laitner that would eventually be published in the *Review of Economic Studies* in 2000, in which an agricultural sector uses land while a manufacturing sector employs physical capital but population growth is kept exogenous (Laitner 2000).

[20] The idea of a bifurcation in the dynamics that occurs when an absorbing steady-state equilibrium disappears was already present in Galor (1996).

per capita starts to rise with population growth in a transitory regime that Galor and Weil refer to as the Post-Malthusian Regime. Eventually, technological progress reaches some threshold above which parents switch from child quantity to quality in a Beckerian fashion, invest in education and human capital which fuels technological progress even more, the resulting demographic transition makes the Malthusian check on standards of living disappear, and the Modern Growth Regime emerges.[21]

If the various other working papers circulated in the 1990s eventually got published in the early 2000s (Jones 2001, Hansen and Prescott 2002, Kremer and Chen 2002, Lucas 2002, Tamura 2002), Galor's and Weil's model ultimately proved seminal, probably because of the instrumental role that Oded Galor himself would play in cementing UGT as a distinct branch of growth theory. He popularized the term 'Unified Growth Theory' in an extensive chapter in the *Handbook of Economic Growth* edited by Philippe Aghion and Steven Durlauf in 2005 (Galor 2005), as well as in various prestigious lectures, including the Klein Lecture organized by the International Economic Association at Osaka University in 2008 and his own Kuznets Lecture at Yale in 2009.[22] Galor also introduced to the model ingredients of Darwinian evolution with Omer Moav to trace the deeper roots of long-run development in the natural selection of human traits most complementary to the growth process during the Malthusian Regime (Galor and Moav 2002). He would eventually publish the eponymous textbook, *Unified Growth Theory* (Galor 2011), in which he laid out his refined vision of UGT and of comparative economic and human development more generally, based on more theoretical as well as empirical research conducted up to this day.[23]

The use of the term UGT to refer to the variety of growth models—so-called unified growth models—explaining the development process as an endogenous transition from stagnation to growth surged in the 2000s.[24] Galor's long-standing role as the editor in chief of the *Journal of Economic Growth* that he created in 1995 and still runs today was probably influential in establishing UGT as a thriving collective endeavor. Although writing a history of the journal and the part it played in shaping the research agenda of growth theory lies outside the scope of this paper, it published a considerable number of articles studying the transition from stagnation to growth and explicitly setting themselves within UGT as early as in the late 1990s and throughout the 2000s.[25] Now that the foundations of unified growth models had been laid, scholars could expand them in a number of directions to explore alternative or complementary mechanisms of the transition from

[21] Although Becker's original version of the child quantity-quality trade-off yields a switch from quantity to quality, and therefore a reduction in fertility rates, when income per capita surpasses some threshold, in Galor's and Weil's model, the returns to human capital accumulation are brought about by the rate of technological progress rather than the level of income.

[22] The term was also used by Hansen and Prescott in the 1998 working paper version of their article, but disappeared from the version published in the *American Economic Review* in 2002.

[23] Notable examples of empirical papers are Ashraf and Galor (2011, 2013) and Galor and Ozak (2016), for theoretical papers exploring various complementary mechanisms of the growth process, see for example Galor and Moav (2006), Galor and Mountford (2008), Galor et al. (2009), Galor and Michalopoulos (2012). See Galor (2024) for the most recent survey.

[24] It should be noted here that the use of the term UGT that I make in this paper to refer to the strand of growth theory that models the development process as an endogenous transition from stagnation to growth is broader than Galor's specific theory of long-run development.

[25] A non-exhaustive list features Dahan and Tsiddon (1988), Morand (1999), Kögel and Prskawetz (2001), Kalemli-Ozcan (2002), Kremer and Chen (2002), Lagerlof (2003), Doepke (2004), O'Rourke and Williamson (2005), Lord and Rangazas (2006), Voigtlander and Voth (2006), Strulik and Weisdorf (2008), Cervellati and Sunde (2011).

stagnation to growth. Illustrative examples include two sectors models to study the process of structural change (Kögel and Prskawetz 2001, Tamura 2002) or the direction of technological progress (O'Rourke et al. 2013), models of endogenous mortality and life expectancy to investigate effect on the child quantity-quality trade-off (Kalemli-Ozcan 2002, Boucekkine et al. 2003, Cervellati and Sunde 2005, 2011, Soares 2005), models in which the dynamics of gender equality influence the transition (Lagerlof 2003, Diebolt and Perrin 2013), the introduction of various government policies such as education subsidies (Doepke 2004) or child-labor bans (Hazan and Berdugo 2002, Lord and Rangazas 2006), alternative mechanisms of schooling decisions and human capital formation (Boucekkine et al. 2002, 2007, Galor and Moav 2006) or fertility decisions (Strulik and Weisdorf 2008), models of international trade to study its role in the escape from the Malthusian trap (O'Rourke and Williamson 2005, Galor and Mountford 2006, 2008), as well as quantitative exercises using historical data (Lagerlof 2006, Voigtlander and Voth 2006), proof that UGT had become a dynamic research avenue and a distinct branch of growth theory.

## Concluding thoughts: Unified Growth Theory, unifying what exactly?

In this paper, I have attempted to trace the deep roots of UGT, a strand of growth theory that emerged in parallel to NGT but has received little attention from historians of economics, using the metaphor of the successive opening of black boxes: population growth and fertility decisions. By doing so, I have told a story of long-standing efforts to unify theories of stagnation and sustained growth, the distinct object of study of two fields, respectively development economics and growth theory, that parted ways in the mid 20th century, by looking instead for a theory of the entire *process* of development in which population dynamics plays a central role. Early attempts to endogeneize population growth in neoclassical growth models revealed multiple steady-state equilibria, suggested the possibility of stages of growth, and called for explanations of the take-off from stagnation to growth. Although such notions were widely debated in the 1960s, they only resurfaced in the 1990s when microfounded fertility decisions came to be more systematically integrated into growth theory. While NGT was opening another black box, that of technological progress, explicit calls from prominent scholars to encompass both stagnation and growth within a single unified framework eventually led to the establishment of UGT as a dynamic research agenda in the 2000s. Unified growth models, models that feature an endogenous transition from Malthusian stagnation to self-sustaining growth, have become an integral part of growth theory alongside endogenous growth models and a tool to study the long-run trajectory of economic development as well as contemporary cross-country inequality.

Given its focus on the entire process of development and a particular emphasis on specific events such as the industrial revolution and the demographic transition, UGT is an inherently historical approach to growth theory.[26] The relationship between growth theory and economic history however has always been conflictual despite obvious similarities in their object of study. The conference in Konstanz in 1960 mentioned earlier saw a debate between Solow and Rostow that highlighted seemingly irreconcilable tensions between a *"world of problems of simplicity"* and a

[26] James Mirrlees classified growth model according to their various uses and argued that they could be utilized to understand historical patterns of events (Mirrlees et al., 1973).

*"world of organized complexity"* in Rostow's words (Boianovsky and Hoover 2014). Such tensions were still unresolved twenty years later when economic historians and growth theorists met at the 1984 meeting of the American Economic Association, for a redux of the Solow-Rostow debate in which Kenneth Arrow also took part.[27] In 1996, it is Paul Romer and Martin Weitzman that were sided again against economic historian Nicholas Crafts at the annual meeting of the Association to assess the contributions of NGT.[28] It is no surprise that such a discussion, initiated by Steve Broadberry, Giovanni Federico, Kevin O'Rourke, Karine van der Beek at the EUI in Florence in 2007, also took place following the rise of UGT, featuring Oded Galor. The dichotomy between growth theory and economic history has thus been tackled by practitioners of both fields, and the discussion is still ongoing today as various scholars are trying to build bridges between them.[29] Although in the present paper I refrain from asking whether UGT can also be seen as an attempt to unify growth theory and economic history, the relationship between the two fields is a pressing question for historians of economics.

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[27] A session called 'Economic History: A Necessary though not Sufficient Condition for an Economist', organized by William N. Parker and Charles Kindleberger, the proceedings of which were published in a small book entitled *Economic History and the Modern Economist*. Thirty years later, Ran Abramitzky published in the *Journal of Economic History* in 2015 and article with a title echoing the volume edited by Parker, 'Economics and the Modern Economic Historian', a sign that the discussion is still ongoing.

[28] The session was entitled "New Growth Theory and Economic History: Match or Mismatch?'

[29] Two relatively recent handbooks, the third edition of the *Handbook of Cliometrics* (Diebolt and Haupert 2024, first edition initially published in 2016) and the *Handbook of Historical Economics* (Bisin and Federico 2021) contain reflections about the use of theory in economic history.

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