# Introduction

Population economics studies how demographic variables such as fertility and mortality respond to economic incentives and affect the economic development of societies. The population of a country changes very slowly over time: most of the people who will populate a given territory next year are already alive this year. However, despite slow dynamics and high predictability in the short–medium run, the effect of population on the economic outcomes are far from negligible. On the contrary, as time passes, changes in the population size and composition have dramatic effects. In some sense, as formulated by Pearce (2010):

> Demography is destiny.

Population change depends on fertility, mortality, and migration. We focus on fertility, and, more precisely, on the relationship between fertility and resources (or income in a broad sense). Starting from the data, this relationship is characterized by four stylized facts:

**Fact 1:** In all species, when available resources are more abundant, reproduction increases. This is true for plants, animals, and humans before the Industrial Revolution.

**Fact 2:** Before the Industrial Revolution, the rich had more surviving children than the poor.

**Fact 3:** The transition from income stagnation to economic growth is accompanied by a demographic transition from high to low fertility.

**Fact 4:** Now, both within and across countries, the rich and educated households have fewer children than poor and unskilled households.

The first fact is well known from the biology literature. For humans, it was stressed by Malthus in his *Essay on the Principle of Population* (1798).

Table 1. *Total fertility rates by education*

| | | Total fertility rate | | |
|---|---|---|---|---|
| Survey | Countries | <Elementary | Elementary | Secondary+ |
| WFS, 1975–1979 | 13 rich | 2.40 | 2.17 | 1.79 |
| WFS, 1974–1982 | 30 poor | 6.5 | 5.5 | 4.0 |
| DHS, 1985–1989 | 26 poor | 5.7 | 4.9 | 3.6 |
| DHS, 1990–1994 | 27 poor | 5.29 | 4.72 | 3.29 |

*Source*: Kremer and Chen (2002).
WFS: World Fertility Survey. DHS: Demographic and Health Survey. "Secondary+" is the average of low secondary, high secondary, and post-secondary, where appropriate.

The second fact is the cross-section implication of the first. It is less documented, but the available evidence in Clark's (2007) seems indeed to suggest that the rich had more reproductive success than the poor, and most authors seem to accept this evidence.

The third fact is one of the most important phenomena of the last two centuries. As countries shifted one after another into a regime of sustained growth in per capita income, their mortality rate first declined, followed by a decline in fertility. This happened in almost every country of the world. Economic modeling of this process has been developed in the last ten years by Galor and various co-authors (see his magnum opus entitled *Unified Growth Theory*, Galor (2011)).

Fact 4 is stressed by Jones and Tertilt (2008) for the US. In a broader perspective, Skirbekk (2008) carries out a meta-analysis of the large empirical literature in demography on the correlation between education and fertility. The results show a strong and stable pattern of differential fertility, with lower fertility of households with higher educational background. Table 1 shows that fertility falls with the mother's education both in developed countries (first row) and in developing countries (last three rows). The fertility differential between women with high and low education is especially large in developing countries.

There is a fifth fact, not as firmly established as the ones above:

**Fact 5:** Most of the literature finds that the income of the father positively affects fertility, while the income of the mother negatively affects fertility.

Three references are Baudin (2009), Hotz and Miller (1988), and Merrigan and Saint-Pierre (1998). If Fact 5 is true, it would support the economic approach to fertility, according to which a higher wage of the mother implies a higher opportunity cost of having children, while a higher wage of the father entails a simple income effect.

It is fair to acknowledge that demographers and economists largely disagree on the forces underlying these observations. Demographers stress the knowledge of and access to contraception technology as important factors underlying the demographic transition. They also stress the importance of norms and culture (the Princeton European Fertility Project found that drops in fertility across Europe often followed linguistic and religious contours).

Economists, on the contrary, do not believe that a significant part of observed fertility is involuntary and would not have materialized if contraception was available. They insist on the influence of incentives faced by parents to have many or fewer children. For example, according to Pritchett (1994), 90 percent of the differences across countries in total fertility rates are accounted for solely by differences in women's reported desired fertility.

Economists have accordingly developed different models where the number of children flows as a result of households optimization problem. Most of the literature uses the notion of the quantity–quality tradeoff introduced by Becker (1960) and Becker and Lewis (1973): parents face a tradeoff between having many children and spending large resources on the health and education of each of them. This tradeoff results from the budget constraint of the family:

$$\text{Income} = \text{number of children} \times \text{spending per child} + \text{other spending}$$

Having more children impedes parents' ability to spend much on the quality education, health, etc. of each of them.

What is the motive for having many children, and why has this motive been weakened during the demographic transition? One school of thought models children as a way to save resources for the future and to obtain some support when old (see Ehrlich and Lui (1991)). The introduction of a state pension system thus weakened the need for children. This is the old-age support hypothesis. A second school of thought studies the interplay between fertility and child mortality, stressing that lower mortality reduces the need for high fertility in order to obtain the same number of children reaching adulthood (see Bar and Leukhina (2010b) and Doepke (2005)). This is the child replacement hypothesis. A third idea explains fertility decline during the demographic transition as a consequence of the rise in the income and education of mothers. Since for educated women the opportunity cost of child-rearing time is high, they will prefer to invest in the education or "quality" of a small number of children. For less educated women, by contrast, the opportunity cost of raising children is low, while providing education is expensive relative to their income. As women's education and income improved during the nineteenth century, those with better education and a higher income preferred to have fewer children but invest more in the education of each child. A fourth strand of the literature stresses that, if the skill premium increases, because of, for example, the demand by industrial firms for more educated workers, the rate of return of quality rises relative to the implicit return of quantity. Again this may trigger the demographic transition as parents cannot invest more in quality without reducing the quantity (Galor and Weil (2000)).

While the quantity–quality model can account for the behavior of fertility over time in the demographic transition, it was originally developed to account for fertility rates in the cross-section of a given country. In almost every country, fertility in the population at a given moment of time is a negative function of income. The quantity–quality model explains this observation in the same way it accounts for the demographic transition. Mothers with little education and low income have many children but invest little in the education of each child. From recent research on developing economies we know that fertility differentials between highly and poorly-educated mothers can be quite large (Kremer and Chen (2002)).

The purpose of this book is to develop a model where heterogeneous households decide about fertility and education in the spirit of quantity–quality tradeoff models. Heterogeneity will imply that different types of households will have different numbers of children. Our objective is to look at the consequences of this differential fertility for future inequality, growth, education, and sustainability. When we started to work on the subject in 2000, Althaus (1980) was the only existing model to analyze the effects of differential fertility on growth. However, in Althaus' model fertility differentials are exogenously given, and the role of human capital is not considered.

Our analysis provides a new perspective on the link between economic growth and population growth. Existing studies have found little correlation between the growth rates of population and output per capita (see Kelley and Schmidt (1999)), which has led some researchers to conclude that population does not matter for growth. The results in this book suggest that it is not overall population growth but the changes in the composition of the population and the distribution of fertility within the population which are important. In other words, who is having the children and whether children are socially mobile matters more than how many children there are overall.

**Outline of the book**

The benchmark model of Chapter 1 has endogenous inequality (measured below by the Gini coefficient) and income per capita. In Chapter 2 we will explore in more detail the link between inequality and growth in income. In particular, we will analyze the contribution of endogenous fertility to the relationship between inequality and growth. To this end, the benchmark model will be extended in several directions: introduction of a third period of life (retirement) to give a motive for individual savings and capital formation, and introduction of technical progress and human capital externalities to discuss the basic ingredients of growth models. Finally, rather than relying on two classes of workers, we will introduce a continuous distribution of human capital to get closer to the data.

In Chapter 3 we wonder whether the model developed in Chapters 1 and 2 can be useful to understand the fertility decline during the demographic transition. To this aim we focus on forerunners: groups within Europe that experienced substantial fertility decline decades or even centuries before the mass of the population. To allow for alternative explanations for fertility decline in addition to the channels at the heart of the quantity–quality literature, we extend the model to take account of the role of mortality, on both the child and the adult level.

If fertility and education are joint decisions, government policies regarding education will also have an effect on fertility behavior. In Chapter 4 we analyze the properties of different education systems in a framework that accounts for the joint decision problem of parents regarding fertility and education. We consider separately public and private education regimes.

In most countries, public and private education coexist. In Chapter 5 we therefore extend the set-up developed in Chapter 4 to allow for this coexistence. Households still decide about fertility and education, but also vote for the quality of public schools and the corresponding tax rate. Households are allowed to opt out of the public education regime if the decided quality is not high enough for them. This model focuses on the determinant of the mix of public and private funding at a given period (the dynamic implications are not considered here).

Chapter 6 compares some predictions of Chapters 4 and 5 to various data. We look at US states, data on education funding, at household data on fertility, education, and income from the US Census, at World Bank cross-country data on public and private education spending, and, finally, at data from the OECD Program for International Student Assessment (PISA).

In the following chapters we move to implications of the theory for policy and sustainability. There are many definitions of sustainability in the literature. Here, we consider that a given policy or institution is sustainable if the corresponding competitive equilibrium exists. In Chapter 7 we abandon temporarily the set-up with endogenous education to focus on a new motive to have children: the gain of political power. When distinct population groups compete for political power, and if group size is an important factor, there can be a population race between groups, leading to a higher level of population than that resulting from a cooperative outcome. Moreover, in the context of a fragile ecosystem, such a population race can lead to unsustainable outcomes. The model of Chapter 7 accordingly describes the joint dynamics of population, relative size of groups, and environment. It is applied to the historical case of Easter Island, which has become a classical allegory for environmental collapses.

In Chapter 8 we go back to our benchmark model and consider the effect of an environmental tax. As a tax on output would affect the wages and hence the opportunity cost of children, households would reallocate their time towards non-market activities, such as leisure and reproduction. As reproduction today generates pollution tomorrow, the problem will be even worse in the future. Population will tend to increase and production per capita to decrease as generations pass. The conclusion of the endogenous fertility model would therefore be that capping emissions will gradually lead to larger and poorer successive generations.

Chapter 9 proposes a solution to the issue highlighted in Chapter 8. It looks at a population policy from a specific angle: Boulding's proposal of tradable procreation rights. We generalize those entitlements, aimed at combating over population, to both cases of pro-natalist and anti-natalist policy. Procreation rights can be seen as a generalization of current policies such as child allowances in France or the one-child policy in China, in which the intensity of the policy depends on the state of the population. We consider the effect of these policies on fertility, education, and, most importantly, inequality.

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# PART ONE

## Differential fertility

# 1

# Benchmark model

In this chapter, we present the simplest possible dynamic set-up in which skilled and unskilled households have different numbers of children. We then calibrate the model on world data.

## 1.1 The model

The model economy is populated by overlapping generations of people who live for two periods: childhood and adulthood. Time is discrete and runs from 0 to $\infty$. All decisions are made in the adult period of life. We assume a unitary representation of the household, neglecting the possible bargaining between spouses. There are two types of agents, indexed by $i$, unskilled (group $i = A$) and skilled (group $i = B$), who differ only in their wage $w_t^i$. The size of each group is denoted $P_t^i$. Agents represent households within a country, but we can also interpret them as countries within the global economy. Adults care about their own consumption $c_t^i$, the number of their children $n_t^i$, and the probability $\pi(e_t^i)$ that their children will become skilled. This probability depends on the education $e_t^i$ they receive. Preferences are represented by the following utility function:[1]

$$\ln[c_t^i] + \gamma \ln[n_t^i \pi(e_t^i)]. \tag{1.1}$$

The parameter $\gamma > 0$ is the weight attached to children in the household's objective. Notice that parents care about both child quantity $n_t^i$ and quality $\pi(e_t^i)$. As we will see below, the tradeoff between quantity and quality of

[1] The logarithmic utility function is chosen for simplicity; any utility function representing homothetic preferences over the bundle $(c, n, e)$ would lead to the same results.

children is affected by the human capital endowment of the parents. Notice also that parents do not care about their children's utility, as would be the case with dynastic altruism, but they care about their future human capital. $\gamma \ln[\pi(e_t^i)]$ reflects an ad-hoc altruism factor which is referred to in the literature as "joy-of-giving" (or warm glove), because parents have a taste for giving (see e.g. Andreoni (1989)). In the usual "joy-of-giving" framework, the utility obtained from leaving a bequest or making a gift depends only on the size of the bequest or the gift. Here, it also depends on the efficiency of the gift in bringing quality, through the function $\pi()$. The alternative set-up with dynastic altruism is proposed by Barro and Becker (1989). Recent results using this set-up can be found in Jones and Schoonbroodt (2007) (quantitative theory) and Baudin (2011) (normative aspects). Finally, notice that the logarithmic formulation prevents households from choosing $n_t^i = 0$ (a utility allowing for voluntary childlessness is proposed by Gobbi (2011)).

To attain human capital, children have to be educated. Parents freely choose the education spending per child $e_t^i$. Apart from the education expenditure, raising one child also takes a constant fraction $\phi \in (0, 1)$ of an adult's time. This fraction of time cannot be cut down. Therefore it limits to $1/\phi$ the number of children one family can possibly raise.

Parents provide education to their children because it raises the probability that their children will be skilled. Specifically, given education $e$, the probability $\pi^i(e)$ of becoming skilled is given by:

$$\pi^i(e) = \mu^i \ (\theta + e)^\eta, \quad \eta \in (0, 1).$$

The parameter $\theta \geqslant 0$ measures the education level reached by a child in the absence of any education spending by the parents. This education level is obtained for free and is a perfect substitute to the education provided by the parents. $\eta$ measures the elasticity of success to total educational input $\theta + e$. The parameter $\mu^i$ depends on the type $i$, and we assume the children of skilled parents have, ceteris paribus, a greater chance of becoming skilled themselves, i.e. $\mu^B > \mu^A$. Note that, in what follows, $e$ is always bounded from above; hence we can always define the constant term $\mu^i$ as a function of the other parameters of the model such that the function $\pi^i()$ returns values in the interval [0, 1].

The budget constraint for an adult with wage $w_t^i$ is given by:

$$c_t^i = \left[w_t^i(1 - \phi n_t^i) - n_t^i e_t^i\right]. \tag{1.2}$$