

# From Stagnation to Modern Growth: Population, Technology and Inequality in the Process of Development

Bas van Groezen<sup>a</sup>

At the recent NAKE-workshop in Groningen, professor Oded Galor gave five interesting lectures on the evolution of economic growth in different contexts. This report summarizes his lectures. The first section deals with the explanation of the historical transition of economies from a Malthusian regime of stagnation to modern sustainable growth. After that, the U-shaped relationship between output per capita and the labour force participation of women is explained. Galor's fourth lecture, on ability biased technological transition, wage inequality and economic growth, is not in this report. The final section describes Galor's analysis on (the evolution of) income distribution in a macroeconomic context.

## 1 From Malthusian Stagnation to Sustainable Growth

Most economists nowadays believe in sustainable economic growth, and indeed this is what can be observed from the (recent) past. It may therefore sound surprising that up to some centuries ago, stagnation used to be the prevailing state of nature. Many economic studies either focus on the period up to the industrial revolution or on modern sustainable growth. But there are virtually no models that can explain the entire evolution from stagnation to sustainable economic growth. In his first lecture, Galor described a model that does explain the development of population growth, technological progress and output growth in the last several millennia. Three eras are distinguished that are characterised by different regimes: the Malthusian regime, applicable for the period before 1500, the Post-Malthusian regime, which falls between 1500 and 1870, and the period

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<sup>a</sup>Department of Economics and CentER, Tilburg University

after 1870, during which economies experienced a demographic transition and sustained economic growth. This section describes the model of Galor and Weil (2000), which explains the occurrence of these regimes and the transition from one to another.

## The Model

Consider an economy inhabited by individuals who live for two periods. In the first period of his life (childhood), the individual is raised by his parents and therefore requires some fraction of their time. This fraction increases with the quality of the child (e.g. the amount of education). In the second period of life (parenthood), the individual allocates his time between working and child rearing. Because he derives utility from both material consumption and the quality and quantity of his offspring, he not only chooses his consumption level and how many children to have, but also the quality of his progeny. However, someone only derives utility from consumption if it is above the minimum subsistence level.

Consumption goods are produced with a fixed factor (like land) and labour, according to a CRTS-production function. The effective amount of labour depends not only on the number of hours worked, but also on the amount of human capital per worker. The more time was spent on quality (i.e., education) one period before, the higher an individual's level of human capital. Furthermore, the rate of technological progress has a negative impact on human capital. This reflects the fact that progress implies the introduction of new technologies which require skills that differ from the existing ones and therefore have to be acquired.<sup>1</sup> This does not mean, however, that technological progress is bad for production: it increases the effective number of efficiency units of labour per worker and thereby also has a positive impact on production per capita.

But what drives technological progress? Obviously, the higher the level of human capital, the faster technologies improve. Furthermore, the size of the population is an important determinant: if an economy is inhabited by many people, then, for instance, the supply of new ideas will be high, which has a positive impact on the number of innovations and hence on technological progress.

## From the Malthusian Regime...

Suppose the economy starts off with a rather low level of technological progress. Because wages are low, people earn just enough to survive (consumption equals the subsistence

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<sup>1</sup>A good example is the development of computers: more education is required to make sure that people can use them.

level). Investing in the quality of children is not worthwhile as the return to human capital, the future wage rate, is quite low. Instead, the quantity of children is what people mainly choose for, and hence they have as many children as possible, i.e., up to the point where consumption equals the subsistence level. This is exactly what Malthus (1798) described. If a household gets a higher income, it would be able to raise more children (and indeed do so), so that after a while, the capital labour-ratio declines and wages (and output per capita) fall. If, on the other hand, the household income is below its subsistence level, people would by definition die due to malnutrition, disease and famine. This causes output per capita to increase to its equilibrium level. Hence, population growth equals the rate of economic growth (i.e., technological progress), so that output per capita is virtually stable. This is consistent with estimates of the (constant) standards of living until 1500 in e.g. Western Europe and the observed coexistence of both wide differences in technologies and small differences in standards of living across some countries prior to 1800.

### ...via the Post-Malthusian Regime...

In the Malthusian regime, technological progress is slow due to low spendings on child quality. However, population is growing steadily, which in itself has a positive (though moderate) impact on the rate of technological progress. Consequently, wages increase but cause population to increase as well, so wages decrease again. After some time, however, population growth is so high that the rate of technological progress reaches the level at which the wage rate is such that parents are induced to substitute child quality for quantity. Technological progress causes both an income effect (more resources available for raising children, so both quantity and quality increase), and a substitution effect (reallocation of resources from quantity to child quality). In the Post-Malthusian regime, the income effect is dominant<sup>2</sup>, so both the size and the quality of the population increases. Furthermore, output per capita increases, which is the fundamental difference with previous times. At some moment it will even be so that households are able to spend more resources on children as their income grows above the minimum subsistence level.

Empirical analyses for the period 1500-1870 confirm these developments for this regime.

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<sup>2</sup>As the number of children is high, it is quite costly to invest in the quality of each child.

## ...to Modern Times

In the Post-Malthusian Regime, population size and quality grow. Obviously, this has a tremendous and self-reinforcing effect on the level of human capital and thereby on the rate of technological progress: not only are there more people who can generate new ideas, but they are also better able to do so, due to higher spendings on education. This causes the wage rate (i.e., the return to human capital) to increase further. As a result, parents substitute more and more child quality for quantity. Besides, as the number of children decreases, it is less costly to educate each child. Subsequently, the above-mentioned substitution effect becomes dominant at some moment. This implies a declining rate of fertility and increasing output growth rates (also in per-capita terms). From around 1870, this is indeed what is observed. The economy gradually converges to a new steady state where output per capita grows at a positive rate and population growth is moderate.

## 2 The Gender Gap, Fertility and Growth

The analysis that was described above provides an explanation for the observed decline in the rate of fertility and a higher growth rate of (per capita) output. However, there are other empirical facts that have to do with endogenous fertility and the model does not take into account. One of them is the U-shaped relation between output per capita and the labour force participation of women. In his third lecture, Galor therefore paid attention to one of his models that explores the role of the gender gap in economic growth (see Galor and Weil (1996)).

### The Model

The analysis is based on an overlapping-generations model. The single good is produced with three factors of production, viz. capital, physical and mental labour. All factors are complements, but capital complements mental labour more than physical labour.<sup>3</sup> Because the economy is closed, its capital stock equals aggregate savings of the previous period. Both men and women decide how much time they spend on raising children, and, as a result, how much labour to supply. Furthermore, it is assumed that women have a comparative advantage in mental labour, as men have a higher endowment of physical strength but an equal endowment of mental labour.<sup>4</sup> Hence, the wage rate of men is

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<sup>3</sup>It may also be that capital and physical labour are substitutes.

<sup>4</sup>One could also assume that women are smarter.

higher than that of women.

Couples<sup>5</sup> derive utility from their number of children in the first period of their life and consumption when retired. They are restricted by a budget constraint that has two parts. If the total time spent on raising children is less than the time endowment per person, then only the woman will raise the children, and the marginal cost of an extra child is the woman's wage rate. But if raising the children takes more time, the man would also participate in bringing up the children. In that case, an extra child has a higher 'price', viz. the man's wage rate.

## The Evolution of Fertility and Women's Participation

The optimal number of children depends on the relative wage rate, and thereby indirectly on the capital-labour ratio. If all child rearing is done by women, then an increase in men's wage rates, due to technological progress, will cause a positive income effect on the number of children. Initially, this was the case. However, as the economy develops, its capital intensity increases (because of the technological progress as a result of population growth, as was described above).<sup>6</sup> Since capital is more complementary to mental labour, in which women have a comparative advantage, this implies an increasing relative wage of women. Consequently, at some moment in time, women are induced to participate in the labour force and raise fewer children. The capital-labour ratio then increases through two channels. First, the household's income rises, which increases savings and thereby the capital stock in a closed economy. Second, the rate of fertility declines, so there is more capital per worker available. This leads to a positive feedback loop: women's wages rise even more, fertility declines further, and so on. Eventually, the economy reaches a new steady state equilibrium with a lower fertility rate and higher labour force participation of women.

Up to now, the model provides an explanation for a decreasing fertility rate and increasing income growth and women's participation on the labour market. However, empirical analyses show a U-shaped pattern of female labour force participation. The model above can be extended in several ways to also incorporate this fact.

First, suppose that households with low incomes actually want a higher number of children than they can afford. Obviously, in a growing economy, fertility will rise - and women's labour force participation declines - because this supply constraint becomes less binding, until the point is reached that women find it more worthwhile to join the labour

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<sup>5</sup>Defined as a combination of a man and a woman.

<sup>6</sup>Without such progress, the economy would be trapped in this high-fertility, low-growth equilibrium.

force (as described above). Second, the existence of home-labour can explain the U-shaped pattern. If women work at home, which does not require capital, then raising a child does not imply high opportunity costs. As the economy grows, the positive income effect on fertility, caused by the higher male income, will first dominate the negative substitution effect of a higher relative wage of women that can be earned outdoors. Consequently, women's labour force participation decreases. But after a while, the latter effect will start to dominate the income effect, and the relation between female labour supply and fertility is reversed.

### 3 Income Distribution and Growth

The last of Galor's quintet of lectures dealt with the model of Galor and Zeira (1993) on income distribution and growth. From time series and cross section data it can be seen that there is a hump-shaped relationship between income inequality and the development stage (or GDP-level). In the neoclassical approach, the relation between income distribution is one-way, in the sense that growth has an impact on distribution. Hence, it is considered a passive variable. The approach of Galor and Zeira is different. Their analysis shows that income distribution itself influences economic growth, which subsequently leads to changes in income distribution. This section will discuss that model.

#### The Model

Consider a small open economy with perfect capital mobility, so the interest rate is equal to the (unchanging) world rate, and other factor prices are constant as well. The single good is produced either in the skilled sector, with capital and skilled labour, or in the unskilled sector, with unskilled labour only. Furthermore, the capital market is characterised by imperfections, which is reflected in a higher rate of interest for borrowers than for lenders.

Individuals live for two periods. When young, they decide whether to invest in human capital or not. Investments in human capital are assumed to be indivisible (one of the fundamental assumptions of this model). In case people do not invest, they work as an unskilled employee. People who do invest in human capital will be a skilled worker in the second period of life, the others remain unskilled. Each individual is endowed with the same potential skills. However, people are assumed to be altruistic towards their progeny; hence, they leave bequests, and the only way agents initially differ is therefore the capital inherited from their parents.

The assumption of capital market imperfections implies that individuals who borrow (for investing in human capital) face a higher rate of interest. To assure that not all individuals will choose to become skilled workers, it is assumed that investment in human capital is not beneficial for those who must finance the entire cost of education via borrowing. On the other hand, investment in human capital must be beneficial for individuals who can finance the entire cost of education without borrowing, if not all are to choose to stay unskilled. Whether one has to borrow or not depends on whether or not investments in human capital exceed the bequests received. Hence, occupational choice is fully determined by the inheritance: the higher it is, the more likely it is that someone will be skilled. The distribution of inheritances (i.e., wealth) therefore fully determines economic performance.

## The Dynamics of Wealth Distribution

The crucial variable for investment in education is the bequest one gets. If it is rather low, the level of education may be zero or positive, but the bequest left to offspring will not be very high. Eventually, bequest levels will decrease and descendants will become unskilled. Descendants of individuals who initially inherit quite much will likewise become skilled. So in the long run, two groups can be distinguished: skilled and unskilled workers, giving rise to a certain (unequal) income distribution. Thus, the amount and the distribution of initial wealth determine whether an economy ends up rich or poor. As Galor and Zeira put it, a country has better growth prospects if it has a relatively larger middle class.

But how does (in)equality affect economic growth, and more specifically, is inequality good or bad? Suppose we have a 'rich' economy, i.e., initial bequests are high on average. If this economy is characterised by an equal income distribution, the variation in bequests will not be high and in the long run, all people will be skilled and leave substantial bequests. But if the initial income distribution is unequal, say skewed to the left, then poor individuals cannot leave enough bequests for their children to become skilled, so eventually, the economy is characterised by two groups of people, skilled and unskilled, and consequently, an unequal income distribution and lower overall welfare result. Hence, according to this model, equality turns out to be good for a rich economy. On the other hand, if the economy is poor, in the sense that initially average bequests are low, then a rather equal wealth distribution implies that in the long run, all individuals will be unskilled and the economy is in an equilibrium of low output growth. But an income distribution that at first is skewed to the right, leads to a steady state in which there are two groups of people, skilled and unskilled, and a higher level of output. Redistribution

from the rich (skilled) to the poor (unskilled) may decrease the inequality and lead to a higher welfare. Hence, for a poor economy, some inequality is good, as it ultimately allows individuals to invest more in human capital.

## Modern Growth and Policy Implications

In a recent paper, Galor examines the issue of income (in)equality for modern societies, where the engine of growth shifts from physical to human capital. Because physical capital can be held in one hand only, the accumulation of such capital does not specifically require an equal distribution of wealth. However, an economy can only accumulate human capital if there is a spread of ownership, simply because human capital is indivisible. Therefore, more equality is and will be desired in modern economies. The question is whether a government should intervene. One of the crucial assumptions in the model above is the spread between the rate of interest of borrowers and lenders. This makes investing in education a costly matter, if one inherits a small amount and thus has to borrow. The government could therefore subsidize education, and finance these costs by a tax on skilled workers in the next period. It is shown that this not only increases investment in education in the short run, but also in the long run and can even lead to a Pareto-improvement because the government does not have to monitor every individual borrower as it can give a subsidy to all students and tax all high incomes. Furthermore, government policy could try to reduce the imperfections on the capital market and thereby reduce the gap between both interest rates, which is one of the main causes of inequality.

## References

- [1] Galor, O. and D.N. Weil (1996) "The Gender Gap, Fertility, and Growth" *American Economic Review* 86: 374-87.
- [2] Galor, O. and D.N. Weil (2000) "Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond" *American Economic Review* (forthcoming).
- [3] Galor, O. and J. Zeira (1993) "Income Distribution and Macroeconomics" *Review of Economic Studies* 60: 35-52.
- [4] Malthus, T.R. (1798) *An Essay on the Principle of Population*.