Economic Growth

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Definition and Measurement

Economic growth is the process by which the amount of goods and services one can earn with the same amount of work increases over time. It generally implies that income per person rises over time (unless hours of work fall steadily).

Almost everything people buy today requires fewer days of work than it did in the past. A classic example is provided by Nordhaus (1996, Table 1.6) in his history of lighting. According to him, 10 minutes of work today buys 3h of reading light each night of the year, while it only bought ten minutes of light per year two centuries ago.

Growth theory attempts to model and understand the factors behind this process. It is a relatively young field of research, as one can establish by searching for "economic growth" in all the books published which have been scanned by Google (about 10% of all books). Figure 1 shows that the emergence of the field can be dated to the fifties.

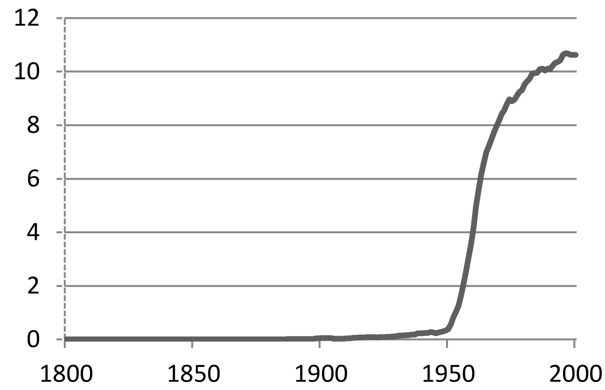

Figure 1. Occurrence of "economic growth" in books by publication year

For a relevant theory of growth, one needs good data first. Measuring growth is difficult, especially for periods for which little information is available. National Accounts were set up in most countries after World War II. They provide different ways to measure income per capita (Gross Domestic Product, etc...). Making data comparable across countries requires correcting for differences in price levels to obtain estimates that capture the real purchasing power of income. The most comprehensive database so far is the Penn World Tables version 8.0 (Feenstra et al. 2013) which provides information on relative levels of income, output, inputs and productivity, covering 167 countries between 1950 and 2011. Going back in time was the task undertaken by Maddison (2001). Based on a broad set of historical studies, he reconstructed income per capita data over the past two centuries, and added some point estimates for earlier periods (in 1CE, 1000CE, 1500CE, 1600CE and 1700CE). Such estimates very often require educated guesses on unobservable trends, but they have the great merit of showing the best which can be done given what is known at one point in time. Very recently, Maddison's successors have been revising and completing his work (the "Maddison project", Bolt and van Zanden, 2013). Figure 2 presents the latest estimates for GDP per capita.

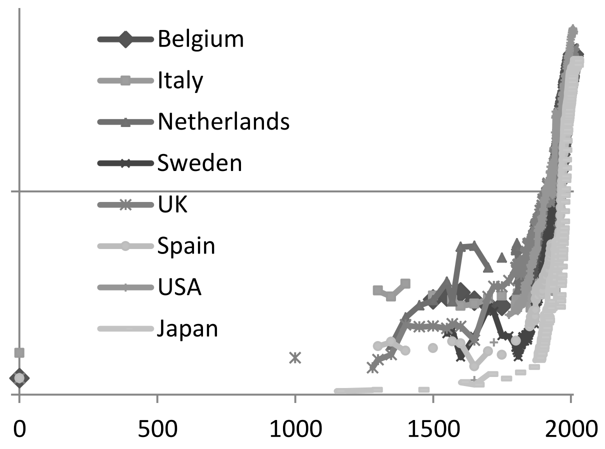

Figure 2. GDP per capita in selected countries, 1-2010CE. Logarithmic scale. Horizontal line = 5,000 dollars (1990 GK$).

Figure 2 shows that, over the past millennium, income per capita in our selected countries has increased 32-fold, from $717 per person per year around the year 1000 to $23,086 nowadays. This contrasts sharply with the previous millennia, when there was almost no advance in income per capita. The figure shows that it started rising and accelerating around the year 1820 and it has sustained a steady rate of increase over the last two centuries. One of the main challenges for growth theory is to understand this transition from stagnation to growth and in particular to identify the main factor(s) that triggered the take-off.

Before looking into possible explanations, it is worth wondering how robust the finding that there was stagnation in the standard of living until 1820 is. This claim is particularly striking given that mankind experienced significant technological improvements that can be expected to increase productivity and income per person, from the Neolithic revolution to the invention of the printing press. Three facts corroborate the idea that there was indeed stagnation over the most part of human history: first, estimates of life expectancy computed on specific groups across time and space do not display any trend before 1700CE (de la Croix and Licandro 2013). Second, body height computed from skeletal remains does not display any trend either, while height is known to depend very much on nutrition when young (Koepke and Baten, 2005). This indicates that there was no systematic improvement in nutrition over time. Third, real wages computed from historical sources did not tend to rise in any sustained way before the Industrial Revolution (Allen, 2001).

Theories of Stagnation

How can it be that technical progress did not lead to a better standard of living before the last few centuries? The answer can be provided by mobilizing the so-called "Malthusian theory", attributed to Malthus (1798), inspired by previous work such as the chapter on the obstacles which oppose the excess of population in the human species by Bruckner (1767). This theory was formalized recently by Ashraf and Galor (2011). The theory has two basic ingredients. The first one is the production technology. It assumes that farms produce output from land and labor, where land is a fixed factor, and labor displays diminishing marginal returns. Diminishing returns imply that adding more labor while holding land constant yields lower productivity per person. The second ingredient is the assumption that fertility net of mortality is an increasing function of food per person. Less food per person yields higher mortality ("positive checks" in Malthus' terminology) and lower fertility (people marry later and have fewer children, "preventive check" for Malthus). When there is an increase in technology, for example when metal tools were invented, the generation at the time of the invention is better off. When there is more food per person, fertility increases. The next generation is more populous, which lowers each worker's productivity because of diminishing marginal returns (the fields are crowded with laborers). As time passes, the population converges to a new steady state, and the food per person goes back to its initial level: the increase in productivity made possible by the discovery of metal tools is exactly offset by the decrease in productivity generated by the rise in population. In sum, technological improvements lead to a larger population, but not to a higher standard of living.

Before describing how economies can escape this logic, let us contrast the Malthusian model with the theories accounting for growth in the recent period.

Theories of Growth: Neo-Classical Growth

The rise in per capita income did not happen everywhere in the world. The gap between the leading regions and the poor ones has actually increased over time. Citizens from Western Europe were three times richer than African citizens around the year 1820: now they are thirteen times richer. To understand why countries differ so dramatically in terms of standard of living, the factors behind the success or the failure of the growth process in different parts of the world must be identified.

The first possible factor in the growth process is the accumulation of physical capital. For capital to drive growth steadily, the output of an economy needs to be proportional to the stock of capital used in production. In this case, growth will be proportional to investment. This accumulation through investment may come about either through local saving or investment from abroad. A theoretical argument against this view claims that marginal returns to capital are decreasing, i.e. one cannot increase production per worker indefinitely simply by increasing the stock of capital per worker. If machines per employed person grow at a constant rate, the growth of output will eventually drop to zero. Workers, whose number is bounded by the active population, cannot deal with many machines with the same efficiency as they cope with fewer machines.

While decreasing marginal returns on capital may make it impossible to sustain growth by investment alone, it remains true that capital is one of the most important determinants of growth in the medium run. McGrattan (1998) finds a strong positive relationship between average rates of investment and growth in postwar data for a large cross-section of countries. The typical example of such a relationship is the emergence of the East Asian tigers, which managed to catch up with rich countries in the second half of the twentieth century essentially by accumulating capital. However, Zambia's experience provides a counter-example. If all the aid to that country had been invested, and if investment had gone into growth, Zambia's income per capita would actually be $20,000 instead of $600 (Easterly, 2001.)

Since physical capital cannot be the engine of growth when marginal returns are decreasing, another variable must account for rising per capita income over time. Neo-classical growth theory, pioneered by Solow (1956), assumes that technological change is exogenous to the economic system. In his model, technological change is the main source of growth by making labor more efficient, i.e. better able to work with many machines. Such technological change is labeled 'labor-saving technical progress'. In Solow's model, population growth is exogenous and does not respond to an increase in standard of living. In addition, there is no fixed factor, such as land, in the production process. These two features explain why technological progress drives growth in the Solow model, but not in the Malthus model.

Neo-classical growth, with its decreasing return to capital and exogenous technical progress, has strong empirical implications. First, it implies that there should be a convergence in income per capita across countries, i.e. countries which are further away from their long-run balanced growth path should grow faster than countries which have already accumulated most of their capital. This is because the benefits from increasing capital (i.e. the marginal productivity of capital) are higher in countries with little capital, and lower in countries with a lot of capital. According to this theory, investment should flow from rich countries to poor countries in search for better returns, and the income gap between countries should shrink over time. There is a vast empirical literature studying the existence and the speed of such cross-country convergence (see Durlauf and Quah 1999), At the end of the nineties, the consensus was that there is some convergence in the data, but at a much slower pace than predicted by the theory. Moreover, some groups of countries seem to be trapped on a low-growth path. This conclusion is now partly reversed, with the fast growth experience of East Asia, and inequalities across countries are clearly on the decline (van Zanden et al., 2014).

A second implication of neo-classical growth is that policy affects the level of income per capita, but has no grasp on its long-run growth rate. Bad governance cannot affect the growth rate of the economy, as the latter is determined by the growth rate of exogenous technology. Comparing the growth experience of countries with similarities (suspected of having the same growth rate of exogenous technology), this prediction of the theory seems at odds with the data – as exemplified by the experience of Haiti and the Dominican Republic. The two countries share the same island, had the same GDP per capita in 1950 (1,027 dollars per person for the Dominican Republic and 1,051 for Haiti), but their growth trajectory diverged, as shown in Figure 3. This divergence is likely to be attributed to better governance in the Dominican Republic. If this divergence of the two countries is considered as a long-run phenomenon, one should conclude that policy really matters for the long-run growth rate, which calls for developing another theoretical framework. This is what endogenous growth models are about.

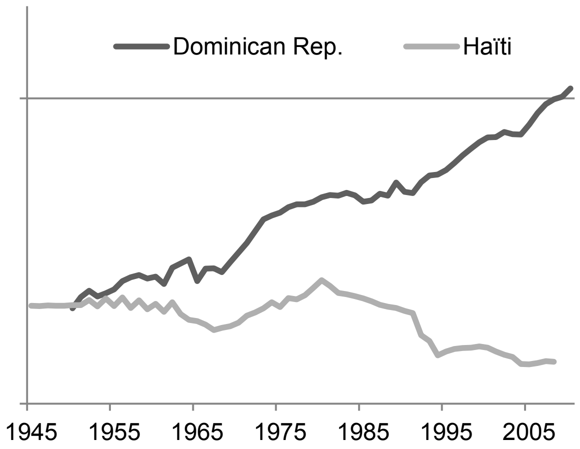

Figure 3. GDP per capita in Haiti and Dominican Republic. Logarithmic scale. Horizontal line = 5,000 dollars (1990 GK$).

Theories of Growth: Endogenous Growth

Modelling growth itself as an endogenous phenomenon requires getting rid of the decreasing returns to factors of production that the economy can accumulate (physical or human capital). Externalities (spill-overs) play a central role here. If, when a firm or an individual invests, this investment has positive spill-overs on other firms or individuals, the private return of the investment (to the firm or the individual) is smaller than the social return (to all firms or individuals together). Investments may thus still have decreasing private returns, but constant social returns thanks to spill-overs. For example, investments in research leading to advances in knowledge benefit the firm which has invested in them, but with decreasing returns (otherwise the firm would tend to invest infinitely). Such advances, however, benefit the whole society at a higher, and non-decreasing, rate.

Accordingly, endogenous growth can be based on the fact that advances in knowledge, e.g. in basic science, have led to technological progress. Growth theorists have pointed to the importance of what they have termed a research and development sector, which either invents new goods or increases the quality of existing goods (See Barro and Sala-I-Martin, 1995.) This theory attributes a preeminent role to the R&D sector in generating growth, and makes a crucial link between innovation and market power. Indeed, the incentive to innovate is provided by monopoly rights on the new goods, which grant extra profits to research firms. Such models also open up interesting policy debates, essentially on the optimal patent protection laws, and the optimal level of subsidies required to stimulate research.

Accumulating human capital is the other way to sustain a growth process. Indeed, even if a country cannot increase its supply of labor indefinitely, it can enhance the quality of labor. This quality is referred to as ‘human capital’, and incorporates education, experience, and health. Human capital can be accumulated in two ways: during the early stage of life by going to school and spending on education; during the working life by accumulating experience (learning-by-doing) or by on-the-job training. Investment in formal education has increased substantially all over the world. In England for example, the number of years spent at school went from two on average in 1820 to more than fourteen today. In developing countries, school enrolment grew rapidly between 1960 and 2000. Although many poor countries experienced an educational boom, they did not start growing more quickly. In general, empirical studies stress the lack of correlation between educational attainment and growth performance. The accumulation of human capital is a necessary condition for growth, but it does not seem to be a sufficient condition.

Institutions are often blamed or praised for their role in promoting growth. In endogenous growth models, good or bad policy may indeed permanently affect the growth rate of the economy itself. Acemoglu et al. (2002) argue that relatively rich countries colonized by European powers in the 1500s are now relatively poor and vice versa. They explain this ‘reversal of fortune’ by the types of institutions imposed by European settlers. ‘Extractive’ institutions were introduced in the relatively rich countries for the benefit of the settlers rather than to increase general prosperity. In the relatively poor areas, there were fewer incentives to plunder, and so to prevent the development of investment-friendly institutions. As a result, the decline or rise of those countries is rooted in a major – exogenous – institutional change linked to colonization. A number of authors have also linked the poor performance of many developing countries with governance issues: corruption, ethnic fragmentation, wars etc.

Theories of Growth: Poverty Traps

An alternative explanation to the lack of convergence across countries relies on poverty trap models. They are based on the idea that the marginal return of capital is not systematically decreasing: for some range of values of capital, there can be increasing marginal returns. For example, suppose that two technologies of production exist, the traditional one and the modern one. Switching to the modern technology allows for a discrete jump in the productivity of factors of production, but requires accumulating a certain level of capital per worker. If an economy has a capital stock close to this level, a small increase in capital will lead to a large jump in productivity, hence displaying increasing returns around the critical level of capital. A similar reasoning can be applied to human capital as well. Such a framework leads to predictions that differ drastically from the neo-classical growth model. Instead of a convergence of all countries to a similar long-run balanced growth path, now the long-run outcome depends on the initial conditions. An initially poor country with a low level of capital per worker might be “trapped” in a low equilibrium, while an initially richer country may grow towards the high balanced growth path. For the same reason, countries that are very similar initially may have a diverging growth experience, if they start on each side of a critical threshold. With poverty trap models, Figure 3 can be interpreted as reflecting that Haiti had slightly worse initial conditions, and this led to a drastically different development. Here, it is not governance which is to be blamed, but bad luck.

Endogenous growth models and poverty trap models also differ drastically in their policy prescriptions. While endogenous growth leads to advise countries to improve governance and productivity, poverty trap models require some aid to be given to the country, to help it bypass the critical level of accumulation it needs to grow in a sustained way.

Poverty trap models essentially capture vicious cycles. In the example above, low development prevents the country from adopting modern technology, which perpetuates low development. Other mechanisms can be invoked: because government employees are underpaid, they ask for bribes, which discourages investment, keeping the country in poverty. Alternatively, a low level of human capital implies bad teachers, which perpetuates broken education systems and low human capital.

Poverty trap models are not only able to account for successful and unsuccessful growth experiences, but they can also explain why some economies have experienced relative, or sometimes absolute, periods of decline. Kindleberger (1996) defends the view that economies, like human bodies, go through a life cycle, in the course of which ‘vitality’ varies, depending on how entrepreneurial each generation is. The Venetian Maritime Republic declined when leaders started devoting more time to consumption rather than to investing in the improvement of shipping techniques, the discovery of new maritime routes, etc. Florence and its famous banking sector declined when Lorenzo the Magnificent delegated power over the Medici bank branches as he was spending more time on luxury and pleasure. In order to capture the idea that rich regions tend to rest on their laurels, and are inclined to favor consumption over investment in knowledge, habit consumption models can be used (see Artige et al., 2004). This approach suggests that the desire to consume depends positively on past consumption (either of the individual, or of his or her parents, or of society as a whole). Eventually, the new generation in the richer regions develops living standards that are incompatible with the continuing investment in knowledge that is required to maintain economic leadership. This reduces the growth rate in comparison with other regions. At some point in this process of decline, consumption falls to a low level once again, and a new growth cycle may start.

The Transition to Modern Growth

The models of neo-classical and endogenous growth describe very aptly what happened in the last two centuries, but they are totally unable to explain the stagnation period. The Malthusian model, on the contrary, gives a very nice description of stagnation, but cannot account for growth take-offs. Finding a single framework which can explain the whole path of income over history has been the task of growth researchers in that last 15 years. Explanations can be divided into two broad classes. The first class relies on exogenous causes; the second one builds a set-up in which everything is endogenous.

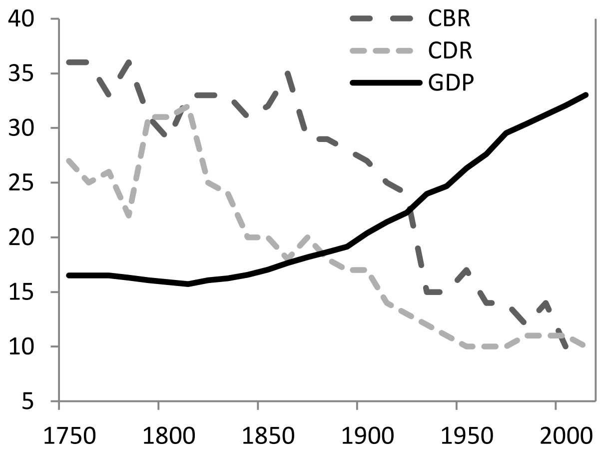

Figure 4. Left axis: crude birth rate (dark gray dashes) and crude death rate (light gray dots) in Sweden in per 1,000. Right axis: GDP per capita. Logarithmic scale (1990 GK$).

Before turning to the different types of set-ups which have emerged to explain the full pattern from stagnation to growth, it is necessary to stress that the growth take-off was systematically accompanied by a demographic transition. Figure 4 shows the demographic transition in Sweden, together with the growth take-off. Birth and death rates were systematically high before the takeoff, then mortality went down, while fertility stayed high for some time. During this period, population size increased fast. Then fertility dropped quickly and population growth decelerated. Once the transition was achieved, both birth rate and death rate were low, and population growth became negligible (or even negative in some cases). The demographic transition took two centuries in England and other European countries. In East Asia, it was much faster, of the order of half a century. Causality between the two transitions goes both ways: the demographic transition was triggered by the income take-off, at least as far as the drop in mortality is concerned, while the take-off was made possible by the demographic transition, because allowed to invest in the education and health of a smaller number of children.

Exogenous Models of the Transition

To return to the inability of the stagnation model and/or the neo-classical growth model to account for the whole historical path of income, Hansen and Prescott (2002) show that the two approaches can be combined in a single framework which models the take-off. The idea is as follows. There are two sectors of production, agriculture, and industry. Initially, the technological level and productivity in the industry are very low, so that the resources of the economy, including labor and capital, are all employed in the agricultural sector. As this sector is subject to decreasing returns to labor and to the constraint on available land, the model behaves as the Malthusian model. Then, with exogenous technological improvements, the industry sector becomes profitable and starts attracting resources. As time passes, resources move from agriculture to industry. The economy becomes more and more similar to the one described in Solow's neo-classical growth model.

In this theory, the process forcing the transition is exogenous. If interpreted literally, it consists of improvements in the productivity of the industry. In a broader sense, it can also reflect (exogenous) improvements in institutions. The Enlightenment can be seen as one of those changes which made knowledge more useful for growth (see Mokyr 2012), through the primacy they gave to reason over superstition and tyranny. The Enlightenment itself was rooted in the Protestant Reformation, which opened the path to questioning received authority, and hence, to critical scientific thinking.

Other types of exogenous explanations for the take-off rely on incentives to accumulate human capital. If, for some reason, it becomes profitable for households to invest in education, growth can be sustained thanks to the human capital externalities stressed in the endogenous growth model literature. Two types of shocks are considered here. The first is based on Ben-Porath (1967)'s idea that the return to investment in education depends on the length of time during which education will be productive, implying that a longer active life makes the initial investment in human capital more profitable. Provided that human capital is an engine of growth, an initial increase in longevity (for exogenous biological/climatic/medical reasons) may in turn sustain the permanent accumulation of human capital and income growth (see e.g. Cervellati and Sunde 2005). The second type of shock triggering education can be institutional. For example, Engerman and Sokoloff (2002) identify conditions under which a country will introduce public education early, favoring a skilled workforce and a rapid industrial revolution.

Finally, the quest for deeply exogenous mechanisms to explain growth and development has led several authors to look at the prehistorical determinants of modern growth patterns. The most well knows approach is the one put forward by Diamond (1999) for whom Europe and Asia benefitted from two geographical advantages compared to other continents: the natural availability of domesticable plants and animals (among the ancestors of the fourteen big domestic animals, thirteen come from Eurasia and North Africa, with the four most important ones coming from the Fertile Crescent), and the East-West orientation of the continent, which favored the spread of knowledge and diseases (hence allowing immunization).

Unified Growth Theory

Unified growth theory, a term coined by Galor (2011) and his coauthors, shares the same ambition to explain income history in a single set-up. Contrary to the previous approach, it does not rely on exogenous changes in technology or institutions, but embeds the mechanisms of change into the model itself. In the early stage, the economy is characterized by a stable Malthusian equilibrium. Population increases slowly as a consequence of technological progress. The slow increase in population density accelerates the pace of technological progress, as a denser population generates more ideas, allows for more specialization, and sustains bigger cities. Faster technical progress itself requires education to be implemented, and this rise in education leads the economy to accumulate human capital. As in endogenous growth models, this allows for sustained economic growth.

In the model above, population size plays a key role. During the stagnation period, all variables (income per person, etc.) are constant except for population size. At some point in time, it reaches a threshold above which the transition starts. Instead of basing the take-off in income on the latent increase in population density, one can model the industrial revolution as resulting from a change in the composition of the population. Suppose that there are two types of people, and that one of the types, when present in large numbers in the population, generates the take-off in income. If, during the stagnation period, this type benefits from an evolutionary advantage (which means it reproduces faster), then its share in the population rises slowly over time, and the take-off ultimately occurs. This "growth enhancing type" can be one which values the education of children (Galor and Moav 2002), or one with an entrepreneurial spirit (Clark, 2007). The question of the transmission of the type from parents to children, either genetically, or culturally, remains open. For this mechanism to work, a strong persistence of type across generations is indeed required.

The Quality-Quantity Trade-off

Galor (2011) and many other authors have stressed that the link between the demographic transition and the economic growth take-off goes through the "quality-quantity trade-off". This originates in a simple budget constraint, which holds both at the individual level and at the country level:

Total spending on children = number of children x spending per child

Keeping the total spending constant, enhancing the “quality” of children by spending more on each child requires reducing their number. Consequently, the drop in fertility observed during the demographic transition allows to increase education and health spending, thereby making the accumulation of human capital from one generation to the next easier. Figure 5 shows for Sweden that the drop in fertility comes with a sharp increase in formal education, with a rise in adult longevity, and with a rise in people’s height, which signals better nutrition and a lower exposition to disease when young (see de la Croix and Licandro 2013). Both education and health are key components of human capital.

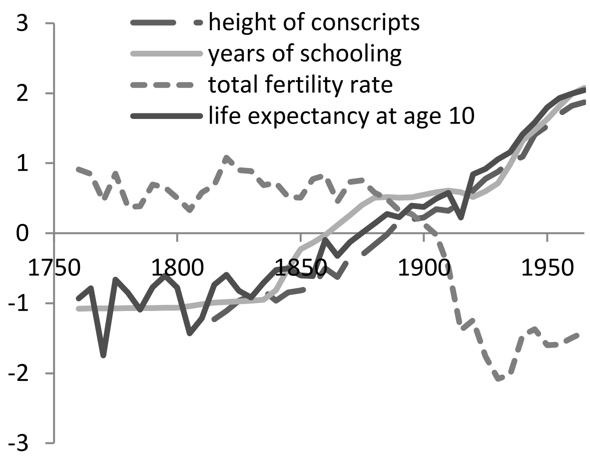

Figure 5. The quantity-quality trade-off for 1760-1965 birth cohorts in Sweden. Three measures of quality (body height, years of schooling, life expectancy at age 10), vs. total fertility rate. All data normalized.

Demographics also matter for growth through the “demographic dividend” (see Lee and Mason, 2006). The view promoted by neo-classical growth was that a high rate of population growth could not be supported by a corresponding increase in investment, thus lowering growth of income per capita. This negative relationship between population and economic growth calls for population control policies. More recent empirical literature finds that in general there is a non-significant correlation in cross-country studies. From these studies, it is also clear that the impact of population growth has changed over time and varies with the level of development. The composition of the population, as well as age-specific variables, is relevant to growth. A decrease in the death rate of workers in particular does not have the same effect as a decrease in the death rate of dependents, young or old (Lindh and Malmberg 2007).

Growth and Inequality

Finally, the relationship between growth and inequality has drawn attention. The question is twofold. First, does inequality evolve along with economic growth? The ‘Kuznet curve’ suggests that inequality first increases and then decreases in the course of the growth process. Second, is inequality good or bad for growth? Most of the existing literature on inequality and growth concentrates on the channels by which inequality affects growth, through the accumulation of physical capital. For example, in countries with many poor people, there is a high demand for redistribution policies, which in turn lead to tax distortions that slow down growth. Inequality can also influence growth because of its effects on the accumulation of human capital, in particular if the poor are subject to credit constraints, preventing them from investing enough in education. Finally, demographic variables must be taken into account in assessing the effects that economic growth may have on income distribution (differential fertility and mortality).

References

Acemoglu D., S. Johnson and J. Robinson (2002), Reversal of fortune: Geography and institutions in the making of the modern world income distribution, *Quarterly Journal of Economics*, **117**, 1231-1294.

Allen R. (2001), The Great Divergence in European Wages and Prices from the Middle Ages to the First World War, *Explorations in Economic History*, **38**, 411-447.

Artige L., C. Camacho, and D. De la Croix (2004), Wealth breeds decline: reversals of leadership and consumption habits, *Journal of Economic Growth*, **9**, 423-449.

Ashraf Q. and O. Galor, (2011), Dynamics and Stagnation in the Malthusian Epoch, American Economic Review, 101, 2003-41.

Barro R. and X. Sala-I-Martin (1995), *Economic Growth*, New York.

Bolt, J. and J. L. van Zanden (2013). The First Update of the Maddison Project; Re-Estimating Growth Before 1820. Maddison Project Working Paper 4.

Bruckner J. (1767), Théorie du système animal, Jean Luzac, Leyde.

Cervellati, M. and U. Sunde (2005), Human Capital Formation, Life Expectancy and the Process of Development, *American Economic Review*, **95**, 1653–72.

Clark G. (2007), *A Farewell to Alms*, Princeton University Press.

De la Croix D. (2012), *Fertility, Education, Growth and Sustainability*, Cambridge University Press.

De la Croix D. and O. Licandro (2012), The Longevity of famous People from Hammurabi to Einstein, CORE Discussion Paper 2012/52.

De la Croix D. and O. Licandro (2013), The Child is Father of the Man - Implications for the Demographic Transition, *The Economic Journal*, **123**, 236-261.

Diamond J. (1999), Guns, Germs, and Steel: The Fates of Human Societies, W. W. Norton & Co.

Durlauf S. and D. Quah (1999), The new empirics of economic growth, In: John B. Taylor and Michael Woodford, Editor(s*), Handbook of Macroeconomics*, Elsevier, **1**, 235-308,

Easterly W. (2001) *The Elusive Quest for Growth, Economists' Adventures and Misadventures in the Tropics*, MIT Press.

Engerman S. and K. Sokoloff (2002), Factor Endowments, Inequality, and Paths of Development among New World Economies, NBER Working Paper No. 9259.

Feenstra, R., R. Inklaar and M. Timmer (2013), The Next Generation of the Penn World Table available for download at www.ggdc.net/pwt

Galor O. and O. Moav (2002), Natural selection and the origin of economic growth, Quarterly Journal of Economics, 117, 1133-1191.

Galor O. (2011), Unified Growth Theory, Princeton University Press.

Hansen G. and E. Prescott (2002), Malthus to Solow, *American Economic Review*, **92**, 1205-1217.

Kindleberger C. (1996), *World Economic Primacy 1500-1990*, Oxford.

Koepke N. and J. Baten (2005), The biological standard of living in Europe during the last two millennia, *European Review of Economic History*, **9**, 61-95.

Lee R. and A. Mason (2006), What is the demographic dividend, *Finance and Development*, **43**.

Lindh, T., and B. Malmberg, (2007), Demographically based global income forecasts up to the year 2050. *International Journal of Forecasting,*

Maddison A. (2001) *The World Economy, a Millennial Perspective*, Paris.

Malthus T. (1798). An Essay on the Principle of Population. London: Johnson.

McGrattan E. (1998), A defense of AK growth models, *Federal Reserve Bank of Minneapolis Quarterly Review*, fall 1998.

Mokyr J. (2012), *The Enlightened Economy. An Economic History of Britain 1700-1850*, Yale University Press.

Nordhaus William (1996), Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggests Not, in *The Economics of New Goods,*T. Bresnahan and R. Gordon, editors, University of Chicago Press, 27-70.

Solow R. (1956), A Contribution to the Theory of Economic Growth, *The Quarterly Journal of Economics*, **70**, 65-94.

van Zanden J.,J. Baten, P. Foldvari and B. van Leeuwen (2014), The Changing Shape of Global Inequality 1820–2000; Exploring a New Dataset, *Review of Income and Wealth*, **60**, 279-297.