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**Abstract**: *»Bildung und Wachstum: Welche Verbindungen für welche Politik?«*. The relation between education and growth is not an easy topic. At the turn of the century a vague of skepticism reawaked due to empirical evidence concerning a weak link between education and growth in the developed countries. A new emerging literature on the political economy of educational reforms should help economists in the design of policies that are both optimal (conducive to growth) and politically acceptable.

**Keywords**: education, growth, economic policy.

## Introduction

The contribution of education to economic growth could appear at first sight as one of the most well-established causal link in economics. It is not actually that true. Around the turn of the century, a real scepticism arose concerning the contribution of education to economic prosperity, followed by a counter-offensive of new theoretical ideas. There is a real debate. If on the one side a series of policy papers nourished by new trends in the growth literature (as the new so-called neo-Schumpeterian approaches, see Aghion and Howitt, 1998) supported the idea that our higher education systems should be mobilised in order to foster economic growth and economic competitiveness (see the Sapir report, 2003 or the Aghion and Cohen report in France, 2004), other papers developed a more sceptical view (Pritchett, 2001; Krueger and Lindahl, 2001). The aim of this short survey is to shed light on this complicated debate, the more so that the more sceptical arguments have received widespread attention and media coverage (at least in the UK) through the publication of books popularising some aspects of the debate (as *Myths about Education and Growth*, by Wolf, 2002). If one considers the history of economic thought (or economic ideas), it is clear that those debates are not new. As put forward by Blaug (1985) during the 80s, phases of optimism alternated with phases of pessimism regarding the relation between education and growth. This is the reason why in

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the first part of this paper we propose a rapid survey of the main ideas that one can find in the last 200 years of economic thought, before turning to the more contemporary debates, both theoretical (variations on the theme of endogenous growth theory) and empirical. The latter are especially important as they have jeopardized the theoretical consensus on the mechanical link between education and growth. We will particularly analyse the most recent ideas developed by economic theoreticians about the growth processes, i.e. the so-called Neo-Schumpeterian approach. In this view, higher education receives a key role in explaining sustained growth rates in the most developed economies (close to the technological frontier, assimilated to the US economy). Those theories (that seem empirically validated, see Vandenbussche, Meghir et Aghion, 2006) tend to modify the traditional viewpoint of economists, as their traditional growth theories led too easily to the same policy recommendations for all countries irrespective of their level of economic development ("one size fits all policies"). The Neo-Schumpeterian approaches tend to show that the optimal education policy (and other policies as well) vary depending on the level of economic and technological development proxied by the distance to the technological frontier. These theories formalise a message already well known by economic historians (Mitch, 1990) and can reconcile the mixed empirical evidence concerning the link between education and economic prosperity put forward by the recent studies. Last but not least, we also try in this paper to cover the literature on educational reforms (the political economy of educational reforms). It is not indeed sufficient for economists to determine the optimal education policies to foster growth; it is also necessary to understand the conditions which will ensure that those (supposedly) optimal policies will be adopted. The partial failure of the Lisbon agenda in several European countries (but not all of them, see the counter-example of Scandinavian countries) should lead us to think more carefully about the actual behaviour of policy makers.

## 1. A Rapid Overview of the Main Ideas Concerning the Link between Education and Growth in the History of Economic Ideas (1700-1914)

Sometimes, policy debates and actual policies are well in advance of economic theorisation. It was particularly true during the 18th century and early 19th century. During the 18th century, enlightened despots of Prussia (for example) fostered the migration of qualified craftsmen (as Protestants and Jews expelled from catholic countries), showing their awareness of the key importance of human resources, of skills and competencies in promoting their economic development (and by the way their political power). In the economic literature per se, the concept of human capital, its analogy with the concept of physical capital, its link with the wage level and the level of economic development,

appeared during the 17th and 18th century as well. William Petty, a mercantilist author, suggested a very simple way of assessing the economic value of human life through the sum of incomes earned along the active life (as a proxy for production), in order to assess the loss incurred by the death of English soldiers. More centrally, Adam Smith (1776), in his famous *Wealth of Nations*, exposed the formal analogy between the investment in human and physical capital, and presented education as one form of investment increasing future productivity (and therefore wages) but incurring costs to acquire it. Even if historians of economic thought diverge on this point, one can suggest that Adam Smith implicitly put forward the two basic ideas of the theory of investment in human capital that will be formalised some 200 years later: the role of education and training as determinants of individual productivity and by the way incomes; and implicitly, through aggregation, their roles as determinants of the wealth of nations (even if Smith also stressed that the passage from craftsmanship to manufacture was accompanied by a process of deskilling of average workers). Besides this first intuition coming from the Classical School of Political Economy and assimilating human capital (acquired through education and training) to a mere factor of production (as the physical capital), opening the way to those approaches of economic growth stressing the role of the *accumulation of human capital* in driving the growth process, another view emerged at the beginning of the 19th century. Put forward by Prussian bureaucrats dealing with the reform of the national education system after the defeat of 1806-1807, it stressed the importance of the *stock* of human capital itself on the capacity of the population to adopt and assimilate new technologies. After its defeat in 1807, Prussia launched a vast array of reforms, in order to modernise its economy (its backwardness was viewed as one cause of the military defeat) (Gispen, 1989). Concerning education, if the actual reforms put in practice after 1815 did not make justice of the fruitfulness and variety of ideas put forward during this period, it is nevertheless interesting to stress the modernity of the debates at the time, echoing very contemporary concerns. First, Prussian bureaucrats saw a link between military defeat, economic backwardness and low levels of education (especially for the mass of the population). Too rigid regulations were accused of hampering the development of the economy as well as too an elitist system of education (and too far away from the sciences and useful knowledge). For the Prussian reformers an institutional re-design was necessary and only the State could engineer it (one can find here the idea of institutional path-dependence, making abrupt change difficult, even if institutions are ill-designed; see North, 1990). They thought that a curriculum reform was urgently needed, and that natural sciences and technology should receive more weight in order to foster adoption of new technologies and innovation. They also stressed the importance of democratising access to the educational system in order to promote economic efficiency. The conjunction of a very classically educated *élite* with a mass of the population either not or ill-

educated (ignorance of sciences and techniques) led (for them) to economic and military backwardness. A Prussian official, Kunth, clearly summarised the main points of this argumentation in a Report published in 1816: *On the Education of the Manufacturing and Trading Class* (Gispen, 1989). He stressed the need to close the gap between the education of the mass of active citizens working in the economy and the one received by the *élite*, to change the curriculum, making it less centred around the Classics and more centred around the natural sciences, as well as making it more open to everybody. Democratisation of secondary education and curriculum reform should help in restoring economic prosperity. They even put forward the idea of creating institutions aimed at favouring the linkage between educational institutions and the economy, and favouring the transformation of technological innovations into marketable products (all this well before the take-off of the Prussian economy). These ideas were however well in advance to the Zeitgeist (especially after 1815, when the French defeat led to an anti-utilitarian bias in educational policy, with the development of the Gymnasium and the Humboldtian university, as well as to an elitist one – the more so that the Prussian State was considerably indebted and had few means to foster a full democratisation of secondary education) as well as to the actual state of the Prussian economy (take-off not before 1820-1830). It is nevertheless interesting to stress the novelty of the ideas put forward at the time.

During the 19th century, few innovations emerged concerning the analysis of the link between education and growth. List (1910, 2nd ed.) nevertheless introduced the key role of education (in relation with the manpower requirements of a nascent industry) and (targeted) migrations (needs for new skills and competencies not yet developed at home), besides the setting up of a sufficient market size through a marked development of transportation networks (railways), a German custom Union, i.e. a trade policy in line with a volunteering industrial policy (setting up of a strong industrial basis through a transitory period of protectionism, i.e. infant-industry argument), in his proposed remedies to allow a backward economy (he meant Germany) to catch up with a highly developed one (he meant UK). A decade later, Marx also innovated by stressing the heterogeneity of labour force (simple and complex labour, i.e. skilled and unskilled), as well as a modelling exercise of the production of skilled manpower through the use (as inputs) of skilled and unskilled labour (Marx, 1976, 3rd ed. in French). We find here a remote forerunner of the human capital production function. With the emergence of the Neo-Classical School of Economics (after 1870), the interest for growth issue declined markedly. If some English neo-classical authors as Marshall were in favour of public subsidies for education (he saw some key linked externalities), they nevertheless did not see the concept of human capital as fruitful. Even more, some economists will in 1914 tend to consider education as a mere (durable) consumption goods (Wicksell…), implying causality links running from income to

education rather than the reverse. The period of the so-called 30-years war (1914-1945) with its succession of wars and economic crises was not really favourable to concerns for the long run (and therefore not for the contribution of education to economic growth). One should nevertheless note that some works were carried out concerning the links between education and the labour market (unemployment of graduates), as well as new thinking and modelling perspectives on growth.

## 2. The 50s and the 60s: a Period of Optimism Regarding the Contribution of Education

The 50s were characterized in economics by the re-emergence of growth analyses and the development of human capital theory. In 1956 Solow (and Swan) introduced the neo-classical model of economic growth that echoed in a sense the Ricardian model: a model with accumulation of factors of production, decreasing returns with ultimately the end of the per capita growth. Only an exogenously determined growth rate of technological progress can support sustained long run growth rate (the saving behavior affecting only the level of output *per capita*). The following year, Solow (1957) complemented this theoretical breakthrough with an empirical methodology called growth-accounting approach (grounded on the same assumptions as the theoretical model, i.e. two costly factors of production, labour and capital, the other ones not being paid[1]; factors of production remunerated at their marginal product), that led economists to become aware of the fact that only a small part of the growth progress could be attributed to the growth of factors conventionally measured. A growth residual will be interpreted in various ways (exogenous technological progress, but also education…), not always with a high degree of rigor (not to speak of measurement errors). The specific historical context, besides the mere internal evolution of the economic thought, played certainly a key role in the new awareness of the importance of these other determinants of growth. In a Cold War period characterized by the ideological conflict and competition between two antagonist blocks and also conflicting views on how to best organize productive activities to generate material well-being, the early Soviet successes in the spatial race (Sputnik, 1958) led Western leaders to become aware of the key importance of large amounts of human resources trained in technology. The large-scale mobilization of the skills of the population in the context of a planned economy seemed to pay off. Empirical researches also led economists to stress the link between education, productivity and wages (see Mincer, 1958

[1] This is of course a stark assumption. Research and development are at the basis of technological progress and are clearly costly activities. Endogenous growth models will later on take this point into account.

and the first attempts to measure the rate of return of educational investments). More directly linked with growth issue, Schultz (1961, 1963) will stress the importance of the quality (education) of the manpower in the process of economic development (idea that education will matter the more so that the overall macro-environment is changing, because education increases decision-making abilities as well as the ability to learn new things). He especially showed that in the case of agricultural workforce in LDC's. But it is Gary Becker (1964) that will first formalize explicitly the notion of investment in human capital (with analogy with investment in physical capital, as Smith did in 1776), using the tools of the modern microeconomics. Human capital can be defined as all the skills, competencies, knowledge and abilities embedded in individuals and allowing them to be more productive. The latter can be acquired either formally (through education) or informally (experience, learning by doing), voluntarily (it is the main assumption of many models) or involuntarily (in the case of learning while doing, role of experience). This investment incurs a cost (foregone earnings and direct costs) but will increase individual productivity, and by the way the level of earnings. By aggregation it will lead to higher national product (growth). This concept of human capital was first used to account for many stylized facts in labor economics (determinants of earnings, people with higher degrees earning more money; hierarchy of wages depending on the level of education, i.e. accumulated human capital, concave age-earnings profile, income distribution; see Mincer, 1958; Ben-Porath, 1967), but also in the growing growth theory literature (Arrow, 1962; Uzawa, 1965; Nelson and Phelps, 1966). We can find in the latter, already in the 60s, the main debate that will dominate the profession during the 90s, for example the respective role of the stock or the growth of the stock of human capital in the growth processes. A large empirical literature developed also the growth-accounting methodology put forward by Solow (1957) and contributed to establish a widespread belief in the key role of residual factors (technological progress, education) in explaining growth performances (see Denison, 1967; Jorgenson and Griliches, 1967; Jorgenson and Fraumeni, 1992; for more recent surveys see Maddison, 2001, 2007). All these developments certainly contributed to diffuse a strong belief that education constituted a key necessary condition to sustained economic growth especially in rapidly evolving and highly-technologically developed economies, but also in LDC's. All this theoretical and empirical literature as well as the political context of rivalry with the Soviet-Union led during the 60s to a large consensus regarding the need to largely expand education systems with massive expenses of public funds. Firms expected a better trained and more productive workforce, young people hope to benefit from higher wages and an upward social mobility while the States believed that the massive public investments will pay off later on in terms of higher growth (and taxes in systems where progressive tax rates were widespread). The level of public expenditures devolved to education (as well as the percentage of a class age

going on with higher levels of education) continually increased during the 60s. In Western countries there was a massive expansion of higher education.

## 3. The "*black 70s*": Years of Skepticism

As soon as the early 70s, a vague of skepticism regarding the economic and social benefits of this massive expansion of educational systems emerged in a context of economic crisis (especially after 1973 and the first oil shock). In a context of declining growth rates (they halved after 1973, from 4-4,5% to 2%), the massive investments of the 60s did not seem to have paid off as expected. Unemployment rose everywhere in the West, including among graduates, to the point that some authors as Freeman wrote about the "*overeducated American*" (Freeman, 1976). Doubts emerged about the relevance of such educational investments. Empirical studies as those carried out by Psacharopoulos (1980, 1981, 1985) at the World Bank, tended to show that the private rates of investment were systematically superior to the social ones (regarding higher education). More theoretical analyses embodied these concerns in the hardcore of economic theory. Growth analyses faced a slowdown – economists turning rather more towards the analysis of cycles in academic markets[2] (Freeman, 1971, 1976). In these analyses, it is not only the level of education that affects wages but also expected wages that influence educational (and career) choices. Other researches, echoing sociological debates (as the credential theses), tended to view education as a screening device (Arrow, 1973) or more simply as a signal of pre-existing productivity (education here is not assumed productive, as was the case in the human capital theory), that candidates for jobs can acquire to get better chances on the job markets in a context of asymmetric information between employers (hiring candidates) and prospective employees (Spence, 1973, 1974). In such models, education could perfectly be demanded while it involved private benefits but without any social benefits (unless one assumes that one cannot find a less costly way of identifying productive individuals). It is also interesting to note that a concomitant skepticism emerged among sociologists concerning the virtues of education in reducing social inequalities. Various approaches (more holist and socio-linguistic as Bourdieu and Passeron, 1970, or more systemic as Boudon, 1972) tended to show instead that educational systems reproduced social inequalities and that changing this situation was either difficult (if favoured social groups design the system, as in Bourdieu and Passeron) or illusory (due to more systemic causes, as the very

[2] Cobweb models were developed where first enrollments at university are assumed to be influenced by expected relative wages, while there is a production lag between the entry and the time of graduation (supply and demand conditions influencing the equilibrium wage of graduates). This leads to cycles and movements of over- or under-investments in specific fields of studies. See Siow, 1984 for a full-fledged analysis for the Law schools.

structure of educational systems, organized as trees with nodes where choices have to be made, and where less favored groups than to self-select in less rewarding orientations due to cost-benefit calculations by the families).

## 4. The 80s-90s: Optimism Back Again

The 80s saw the revival of a vivid growth theory literature with the pioneering works of Romer (1986, 1990) and Lucas (1988). This is what has been called endogenous growth theory to compare it with the growth theory of the 50s and 60s which was an *exogenous* theory of growth as growth rates per capita could only peter out unless one introduces an exogenous growth rate of technological change (not explained in the model). The new growth theories will try to explain sustained growth rates by making the investment choices in human capital (in the 60s the human capital literature was mostly disconnected from the growth literature) or in R&D endogenous. All these activities were now considered as economic because they entail costs (they are not free) and will generate benefits. These new growth theories can be divided into two categories depending on whether the stock or the accumulation of human capital matters for growth. In the latter case, human capital is just considered as *another factor of production, whose accumulation is good for growth*. In his seminal paper, Lucas (1988), for example, developed this philosophy, adding just an externality linked with the average level of human capital in the population (making all firms more productive, ceteris paribus). This externality introduced a gap between the decentralized and centralized equilibriums, rendering some state intervention desirable to narrow the gap between the individual and social calculations concerning the optimal level of human capital. The other philosophy of growth models stress the role of the *stock of human capital* (capitalizing in a sense on the pioneering paper by Nelson and Phelps, 1966) in the process of imitation or innovation (a higher stock of human capital leading to a higher rate of adoption, diffusion of existing technologies or innovation, leading to growth) (Romer, 1990).

These early developments of the endogenous growth literature were mainly theoretical. The first empirical studies of the early 90s tended to confirm the positive role played by education on economic growth (Barro, 1991), even if the theoretical underpinnings of such exercises were not always the new endogenous growth paradigm. One can indeed think about the positive role of education to growth through the lens of an enlarged exogenous growth model *à la Solow* considering a broad measure of capital including human capital, where the accumulation of factors of production exerts a steady decreasing positive impact on production due to decreasing returns (so that at one point it is no more rewarding to accumulate further than what is necessary to compensate for depreciation of existing capital) (Mankiw, Romer, and Weil, 1992). In this model, like in the Solow one, the only source of growth (besides popula-

tion growth) is technological change whose rate of change is considered exogenous. If all economies face the same growth rate of technological progress (because technology is available everywhere at no cost), they will end up by growing at the same rate (this is the famous convergence debate) but their level of wealth can still diverge. For example, if specific economies allocate every year more resources to education, they will have a bigger stock of education than the others and they will produce more (Gurgand, 2005).

At this period (mid-90s), it is mainly an accumulation model that seemed to receive an empirical support: more human capital (growth rate of scholarly level) generates more growth. This is also a quantitative philosophy supporting policies aiming at expanding educational systems and the number of graduates (as during the 60s). As stated by Gurgand (2005): "if produced wealth, Y, depends mechanically (with a given technology) upon the stock of human capital E, then, ceteris paribus, a country whose stock E grow more rapidly will also grow more rapidly".

A very simple empirical strategy to test this relation consists in relating at time t GDP *per capita* with the accumulated stocks of E and K (physical capital) at this stage:

$$\log Y_t = m + a.\log E_t + b.\log K_t$$

Taking first differences one obtains the (approximate) growth rates of the variables:

$$(\log Y_t - \log Y_{t-1}) = a.(\log E_t - \log E_{t-1}) + b.(\log K_t - \log K_{t-1})$$

If one follows the estimated coefficients obtained by Barro (1991) or Mankiw et. al. (1992), the shift from a participation rate at secondary level from 50 to 100% (approximately the one observed in the French education system from 1960 to 1985) should have increased the growth rate by one point of percentage (Gurgand, 2004). In many countries, this led to a renewed faith in the necessity of expanding the participation to secondary and higher education. In France for example, Chevènement proposed at the late 80s that 80% of a class-age get the *baccalauréat*, i.e. the degree consecrating the end of high school and opening the doors to higher education institutions (Deer and Demeulemeester, 2004). Various policy memoranda (e.g. the White Paper by the European Commission called Learning and Teaching in the Information Society, 1995) called forth important reforms in a sector now viewed as central for the competitiveness of nations.

Reforms were not only viewed in terms of a quantitative expansion but also qualitative changes. In the economic literature as well, new concerns of a more qualitative or institutional nature emerged. Economists as Murphy, Vishny and Shleifer (1991) demonstrated that not all disciplines are equally worthwhile in terms of contribution to growth. They even comment their econometric estimations by noting that "*engineers are good for growth and lawyers are bad for growth*". On a more theoretical perspective, the views of the Neo-Institutional

school (as North, 1990) led economists to re-think the link between supply and demand of human capital. They remind us that the demand for specific skills and competencies cannot be thought *in abstracto* but have to be understood within a broader institutional context, i.e. a set of rules of the game, informal and formal norms influencing behavior and choices and that have partly been inherited from the past due to path dependence. These rules were often designed a long time ago to solve static coordination problems, reduce transaction costs, but without considering their long term impact in terms of incentives to perform such or such tasks. Human societies have adopted a huge array of distinctive institutions to solve rather similar problems, but their long run impacts were different. Institutions do indeed have an impact on growth through the incentives they create (both for individuals and organizations, those groups of people emerging to put forward and advance their specific interests given the specific sets of rules they face). In some societies, adopted institutions were such that they promote wealth-enhancing activities, leading to a demand for human capital in this direction favorable for growth. On the contrary, in other societies, institutions will favor rent-seeking activities, leading people to invest in non-productive but nevertheless individually remunerative activities (and skills) as theology or law[3]. In the long run those societies will have lower growth rates (even if at each period of time demand and supply of human capital perfectly clear). This neo-institutional perspective tends to show that history matters, and that the analyst should take the precise institutional context of a country into account. *Laisser faire* solution (regarding investments in human capital) can be non-optimal simply because the overall institutional framework favors more rent-seeking than wealth-enhancing activities. This philosophy of research led to a revival of systemic or economic historical approaches, enlightened by economic theory or game theory while paying attention to the more traditional institutional approaches of the traditional historian (see Greif, 1997 on the New Institutional History and Demeulemeester and Diebolt, 2007 on cliometrics at large). These approaches have allowed economists to enrich their originally very crude view on the link between human capital (and education) and growth, based upon simplistic growth models (very aggregate and suggesting only "*one size fits all policies*"). One key message of those new historical approaches was indeed that the mere equilibrium between supply and demand of human capital may not be optimal. Historical studies (Guagnini, 1993) have shown that the slow development of an academic engineering education in England at the end of the 19th century could be traced back to both the anti-utilitarian bias of the established academic institutions (as Oxford and

[3] This is not to say that lawyers are only adverse to growth. They also produce institutional devices that favour economic activities as well. But this is a question of balance and a society cannot afford to induce all its investments in human capital in this sole direction, as wealth has to be produced.

Cambridge) and the anti-academic bias of employers who favored more "*on the job training*" forms of education even if experts rapidly perceived the shortcomings of such an approach to face the competitive pressure of new emerging industrial powers as Germany (the latter having developed a very comprehensive set of engineering schools with the support of the State, see Demeulemeester and Diebolt, 2008; Gispen, 1989). If the *laisser faire* attitude of the English authorities can have played a negative role in these developments, historical studies have also shown that where the State intervened, it was not necessarily optimal. For example, both in France and Prussia, the State had established engineering schools that served mainly the needs of the civil service (or the army), but not necessarily the needs of the emerging private sector (leading to new, private, institutions outside the realm of the public sector). One key message of these historical approaches can be that mere supply-side approaches ("*increase the stock of human capital and get automatically higher growth*") are not necessarily optimal. It can be useful to produce engineers but the state of the economy should be such that it employs the graduates (the demand of human capital had to be taken into account; other policies – industrial one, for example – may be complementary to human capital policies), the institutions should be favorable to growth enhancing activities. State interventions can help as *laisser faire* solutions cannot guarantee a necessary institutional change for example (even if at the same time too precise monitoring of the development process by the State can be harmful to growth, simply because it does not possess the relevant precise information to make the best decisions). Some economic historians have also suggested a non-linear relation between human capital and growth as threshold have to be attained (e.g. economic and technological, but it can also be a certain density of graduates in the country) before the development of education can promote growth (see Mitch, 1990). If early theoretical works (Azariadis and Drazen, 1990) have introduced this idea of threshold, the idea will receive considerable new attention by the Neo-Schumpeterian approaches of economic growth (Aghion and Howitt, 1998).

## 5. The 90s and Early-2000s: the Consensus under Attack

We have already put forward that the first empirical analyses of the early 90s (where the growth rate of the stock of human capital was approximated by schooling rates) tended to confirm the belief in the positive role of expanding education (Barro, 1991; Mankiw, Romer and Weil, 1992). Mankiw, Romer and Weil used the same database as Barro (1991) but in a traditional Solow model (1956) context including this time human capital (they introduce human capital accumulation through the use of schooling rates). For them, the differences in terms of savings, education and population growth explain the differences in GDP *per capita*. Their classical model with exogenous technological change and decreasing returns seems to better explain international variations of output

*per capita* than the newly developed endogenous growth models. Barro and Lee (1993) studied the success rates in education of the adult population at different levels (population without education, with primary education, secondary education and higher education) for 129 countries between 1960 and 1985 and concluded that education produces direct positive effects on the growth rates of GDP.

However, some criticism began to appear concerning the virtue of the massive expansion of higher education (in pure quantitative terms, without deeper concerns on the composition of this expansion, for example). The model of accumulation that was part of the consensus was now under attack, thanks also to the availability of new and better data concerning the stock of human capital. If the first estimations approximated the growth of the stock of human capital using schooling participation rates (Barro, 1991; Mankiw et al., 1992), other papers were now using a direct measure of this growth of education in the population (approximated by years of schooling) (Benhabib and Spiegel, 1994; Pritchett, 2001). Changes appeared: statistically significant coefficients for the variable education did not appear when one used these better proxies. For Benhabib and Spiegel (1994), the *growth rate of human capital* measured by the average years of schooling in the active population was *no more* a significant explanatory variable of the *growth of output per capita*. However the levels of human capital seemed to play a key role in explaining growth rates of output *per capita*. It was therefore no more possible to consider human capital just as another factor of production, because the latter assumption implies that it is its growth rate and not its level that should explain the growth rate of output *per capita*.

The message that comes from those empirical studies was rather fuzzy. If the first empirical analyses seemed to confirm the link between education and growth in the context of an accumulation model, they used a rather crude proxy of the growth of human capital (schooling rates). As soon as one relied upon a direct measure of this growth, this effect disappeared (and tended to be linked to the change of proxy for the variable education). As put forward by Gurgand (2005, p. 79), "the best measure does not allow us to put forward a link from the growth rate of the education level to the growth rate of GDP in the context of an accumulation model".

We already note in this review that older papers as Nelson and Phelps (1966) had suggested that it was the stock of human capital itself rather than its growth rate that might positively impact growth, through its effect on imitation, adoption and diffusion of new technology. More recent papers in the spirit of endogenous growth literature also gave a key role to the stock of human capital in the growth rate of technological change (innovation) and by the way in the growth rate of the economy (Romer, 1990). More empirical studies will give some credibility to this thesis, with an underlying debate on the differentiated role of education (human capital) on growth depending upon the level of de-

velopment attained by the country (for historical discussions see Mitch, 1990; Demeulemeester and Rochat, 1994). One should note here the key importance of the pioneering paper by Benhabib and Spiegel (1994) that showed that in the richest countries the stock of human capital, i.e. the direct effect of education, tends to play a key role on innovation and therefore growth whereas in the poorer countries there is a catch-up effect. The latter effect is approximated using a catch-up potential variable as the gap between the income *per capita* of the country and the one of the most advanced economy. "The estimated effect of education is then proportional to this gap: a positive coefficient confirms that education fosters growth the more so the catch-up potential is big" (Gurgand, 2005, p. 80).

Table 1: Determinants of the Growth Rates of GDP, Models of Accumulation

| Articles | Coefficient on education | Proxy for education | other variables |
|---|---|---|---|
| Barro, 1991 | 0.0181 | Primary schooling rates 1960 | GDP in 1960, investment rate, share of public expenditures, political stability, deviation vis-à-vis PPP index |
| Barro, 1991 | 0.0225 | Secondary schooling rates 1960 | |
| Mankiw et al., 1992 | 0.233 | Log of secondary schooling rates in percentage of the adult population (average 1960-1985) | GDP in 1960, investment rate |
| Benhabib/Spiegel, 1994 | *-0.059* | Growth rate of the average number of schooling years in the active population | GDP in 1960, growth of capital stock |
| Pritchett, 2001 | *-0.38* | Growth rate of the average number of schooling years in the active population | GDP in 1960, growth of capital stock |

Source: Table 11, Gurgand, 2005, p. 78. Coefficients in italics are not statistically different from zero.

Table 2: Determinants of the Growth Rate of GDP, Innovation and Adoption Models

| Education variable | All countries | 1/3 richest | 1/3 poorest |
|---|---|---|---|
| E | *-0.0136* | 0.0439 | *-0.0736* |
| E x (Ymax/Y) | 0.0011 | *0.0003* | 0.0012 |

Source: Table 12 in Gurgand, 2005. The education variable E is measured by the average number of years of education in the active population (averaged on the period); the other variables present in the regression are GDP in 1960 and the growth rate of the stock of physical capital. Estimation standardised by population size. The coefficients in italics are not statistically significantly different from zero.

The analysis by Benhabib and Spiegel is interesting even if it used very imperfect data, and even if it remains rather crude (based upon stylized relations leaving no room for the country heterogeneity). But other analyses will corroborate their intuitions. It seems indeed true that better educated people can benefit more from technological change (see Foster and Rosenzweig, 1996 on the Green Revolution in the Indian districts between 1969 and 1982), or that more educated people learn faster (see Bartel and Lichtenberg, 1987, showing that demand for skilled manpower is higher the more recent is the technology introduced in the firm). An implicit idea here is that education does not exert the same effect in all contexts, and that this effect could change depending on the level of development or whether the country/firm faces or not a period of technological change. Krueger and Lindahl (2001) put forward in their survey that "education is statistically significantly and positively associated with subsequent growth only for the countries with the lowest level of education".

Considering all these puzzling developments in the empirical literature, two avenues of research unfolded. *The first one* tried to set up better data sets, more systematic and with less errors (De la Fuente and Domenech, 2002). One can wonder indeed whether the empirical evidence in favour of this imitation/innovation model rather than an accumulation model was not simply a statistical artifact. All econometricians know that a large measurement error on a variable risks to weaken artificially its correlation coefficient with other variables. Gurgand (2005) put forward that

> the noise around the education variable weakens the observed link with GDP as the measurement error can make E bigger or lower independently from GDP. This phenomenon becomes even worse when one uses growth rates of E as measurement errors compound.

This could perfectly explain why the estimation results of the link between the growth rates of education and GDP are less good than the ones observed between the mere stock of education and growth. Empirical works have been carried out following this line of thought, obtaining a renewed confirmation of the link between growth rates of education and GDP (De la Fuente and Domenech, 2002 on OECD countries). A complementary way of dealing with the problem is to find better proxies to represent human capital. The measurement of the education level of populations through the use of schooling years is at the same time convenient and restrictive (for example: how seriously compare the quality of a given number of years of education between two countries?). Analyses have been carried out to explicitly take into account *real* skills and competencies. For example, Hanushek and Kimko (2000) used survey data on sciences and mathematics test scores (as the standardized tests of IEA or IAEP; see the OECD Pisa studies). They use them to build indexes combined with the active population (by comparing the precise realization dates of those tests with the age structure of the population). They obtain significant results as the countries where people have the best test scores also faced higher growth rates from

1960 to 1990. Coulombe and Tremblay (2006) have also tried to proxy the skills and competencies of the manpower directly rather than use the education proxies.

*The second avenue of research* consists in integrating directly in the theoretical structure a possible heterogeneity of the impact of education on growth depending on the level of development (capitalizing on Benhabib and Spiegel results and economic historical intuitions). The use of a concept of distance to the technological frontier within the framework of endogenous growth models will be developed by the so-called Neo-Schumpeterian approach *à la Aghion* (see Aghion and Howitt, 1998, 2005).

## 6. The Neo-Schumpeterian Approaches

Aghion and Howitt (1992) developed a Neo-Schumpeterian endogenous model of growth with destructive creation. In this seminal paper, the succeeding innovator captures the market and replaces the incumbent monopolist, reaping all the monopoly rents, a powerful incentive to invest in R&D indeed. He/she is himself in a contestable position, and in his/her calculations he will take into account the expected period during which he/she will keep his/her monopoly power before being replaced by new innovative entrepreneurs. These authors give to innovation a central place in explaining growth processes, and it is linked to the share of the manpower affected to research activities (as in Romer, 1990, but the latter did not introduce the idea of creative destruction). On the basis of the philosophy of this first paper, the neo-schumpeterians have explored a whole array of issue (see the textbook by Aghion and Howitt, 1998), including education. In a more recent paper, Vandenbussche, Aghion and Meghir (2006) have built a model (accompanied by an empirical test) where they stress the importance of either imitation/adoption or innovation activities depending on the level of development of the countries (one finds here a critique of the "*one size fits all policies*" implied by the older models). Both activities use skilled and unskilled labor, but the former is more intensive in unskilled (less educated) workers whereas the reverse is true for the latter (higher education degrees are more important for innovation). For countries far away from the technological frontier they show that as adoption of existing technologies are more central (more remunerative), the development of primary/secondary education is of utmost importance (not so much higher education). On the contrary, for countries at or near the technological frontiers, innovation matters much more and therefore higher education becomes central for growth. This paper contributes to solve the debate around the apparent less important role of education for more developed economies (or, that education matters more for lagging countries). A simplistic view was that as education favors the adoption of existing technologies, the role of this variable becomes less important the closer the country is from the technological frontier (Nelson

and Phelps, 1966). Vandenbussche, Aghion and Meghir (2006) stress that the sources of technological change are actually dual: imitation and pure innovation (the latter being more important for the advanced countries). Technological advances result from a mix of imitation and innovation (as in Benhabib and Spiegel, 1994 or Acemoglu, Aghion and Zilibotti, 2002). For them, it is not solely the distance vis-à-vis the technological frontier that matters for a country but also the composition of its stock of human capital. If, *ceteris paribus*, the increase of the stock of human capital is always favorable, on the other hand, keeping its level constant, the capacity of human capital to favor growth depends both on the distance to the frontier and its composition, as stated above. For countries near the technological frontier, the catch-up potential is reduced and therefore innovation matters much more (and so qualified manpower, high-level human capital). In their empirical analysis the authors approximated the distance to the technological frontier by the ratio of total factor productivity in the country under study and the one observed in the US. For our advanced economies it would be no more the increase of human capital *lato sensu* that matters most but the highest levels ("*top of the top*"[4]). Econometric analyses on the refined databases (as the one of De la Fuente and Domenech, 2002: 22 OECD countries from 1960 to 2000) (panel data) tended to confirm this idea (Vandenbussche, Aghion and Meghir, 2006).

The positive sign on the variable of interaction between the proximity towards the technological frontier and the proportion of adults with higher education degrees confirms the idea that the proportion of people with higher education degrees is more important for countries close to the technological frontier. One also notes that for countries with a higher proportion of skilled workers (with higher education) the lagged effect of the proximity to the frontier on growth is less negative. The introduction of dummy variables to account for specific (non-observable) country groups effects (close either geographically or institutionally) on growth in regression 2 (table 3) leads us to define a threshold level (above which one gets a positive impact of higher education on growth) of a productivity level bigger than 60% of the frontier level.

Aghion will diffuse such ideas with key policy implications in a series of memoranda and policy papers (Sapir Report for the European Commission in 2003; Cohen and Aghion report for France in 2004…). This will foster a vivid policy debate (not to speak of the influence on the so-called European-wide Lisbon Strategy aiming at transforming the EU in the most competitive knowledge-based economy in the world up to 2010). Two natural questions arise: is this Neo-Schumpeterian approach unquestionable? Is it feasible in pure political terms?

[4] For a recent survey on the importance of the higher levels of human capital for growth see section 2.4.1 in Minne et al., 2007. Besides some econometric discussions, Hanushek and Woesmann (2007) demonstrated a strong impact of the latter on growth.

Table 3: Equation of TFP Growth

| Variable | Regression 1 | Regression 2 |
|---|---|---|
| Proximity | -0.17 (.044) *** | -0.31 (0.063) *** |
| Fraction (% of adults with tertiary degree) | 0.134 (0.06) ** | 0.427 (0.146) *** |
| Proximity x Fraction | 0.629 (0.29) ** | 1.06 (0.28) *** |
| Dummies for countries (groups) | - | Groupes |
| Threshold | -0.213 (0.11) | -0.403 (0.052) |

Source: Table 4 in Vandenbussche, Aghion and Meghir, 2006, p. 114. Methods: instrumental variables (IV).

## 7. An Unquestionable Approach?

If an empirical validation was included in the Vandenbussche, Aghion and Meghir (2006) paper on OECD data, one could nevertheless question the very aggregate, macroeconomic approach (with underlying unrealistic assumptions, as underlined by Aghion and Howitt themselves). They can easily lead to mechanical policy responses such as expanding higher education (for example at the PhD levels). One can wonder which types of degrees should be precisely promoted to foster growth (in the line of Murphy, Vishny and Shleifer, 1991). These approaches are very supply-side, thought in a long run perspective. The time span for policy makers can be shorter and adjustment can take time (including risks of short run overeducation problems). The demand side is partly ignored. One could wonder whether an education policy should not be thought simultaneously with other (industrial) policies. The Aghion and Howitt framework (2005) allow them to address the issue of optimal institutions or policies one at the time but not simultaneously. Here again, we can only stress the potentials of more economic historical (Sanderson, 1999; Fox and Guagnini, 1993…) or systemic approaches (Finegold and Soskice, 1988; Finegold, 1999) (see above). It is the more true that the empirical analyses too often focus on very contemporary periods (e.g. since the 60s). However, the robustness of an economic argument should be checked in the long run. If we turn to economic history we can only note that the correlation between high levels of education and sustained growth was not always evident during the 19th century (performance of the British or Belgian economies without even primary compulsory education before the beginning of the 20th century; and high performance of agricultural economies and export-countries as Argentina or Australia prior the WW1). One can of course question the relevance of high investments in human capital (especially at the university levels) for supporting technological innovation and growth during most of the 19th century. Some authors as well as contemporary observers tended nevertheless to think that it was only with the second industrial revolution (chemistry, electricity, cars…) that technological education began to matter. During this period the UK faced fierce economic competition with Germany and the US (both countries characterized by in-

creased efforts vis-à-vis their education systems), and a lot of British authors accused the deficient organization of the British system of educating its *élite* (as well as the absence of academic technological education) as one of the factor contributing to the British economic decline (Guagnini, 1993, p. 27). The successes of Germany and the US during the same period tend to support in a sense the Aghion theses. Both countries invest a lot in their higher education systems. Germany developed a network of *Technische Hochschulen* to train a large number of engineers urgently needed (Gispen, 1989), while in the USA academic institutions faced deep transformations between 1870 and 1914 (Donovan, 1993), leading some authors to suggest that this element should be taken into account besides technological change and the emergence of the Modern Business Enterprise in explaining the strong rise of TFP from 1872-1906 – see Demeulemeester, 2009). As already put forward, the idea that a high skill strategy alone could lead to sustained growth should be mitigated by the importance of other complementary policies as well. The example of communist economies (as the Soviet-Union from 1917 to 1991) that invest massively in their human capital but within a context of suboptimal policies in other domains should be clear to all economists.

## 8. An Approach that is Politically Feasible?

It is not because economists demonstrate that specific policies or reforms are necessary that they will necessarily be implemented. Reforming education systems means also reforming institutions, and we have already stressed that it is difficult due to path-dependence (not to speak of vested interests opposing change). In a world of benevolent dictators, it can be easier (as we have shown in the context of the Prussian higher education at the early 19th century with no universal suffrage and a large discretion left to those in powers, even if like in other European countries in the 19th century, the *élite* itself could be divided), but even if initial reforms are feasible, the subsequent changes cannot remain so easily under the central authority's influence (for the Prussian case see Demeulemeester and Diebolt, 2008; Gispen, 1989). In most 20th century countries, education systems are run by the State so that any reform implies the democratic process. A new literature arises therefore on the *political economy of educational reforms* (Gradstein, Justman and Meier, 2005).

We already stress in this paper that during the 19th century some countries (as UK) had suffered from the lack of responsiveness of their education systems to economic needs, and that even if various actors were aware of this situation, change was difficult (and slow) to be implemented. We stressed the *laisser faire* context in England, with very few interventions of the State, and key actors determining demand and supply of human capital very reluctant to change their perceptions and usual ways of educating e.g. engineers (Guagnini, 1993). Formal engineering education was both dismissed by employers prefer-

ring on the job training and universities not interested in applied dimensions of science, and developed only very slowly, even if the country as a whole suffered from increasing competition from countries having reformed their own educational systems. This lack of reactivity in terms of education reforms is a kind of leitmotiv in the British economic history (Sanderson, 1999). This is not to say that in all circumstances actors ignore their interests and that a *laisser faire* system could not work sometimes. In France, long before the formal institutionalization of the Ferry's Laws, primary education diffused, both in terms of supply (building of schools) and demand (increasing participation rates). The higher returns to education let families, local authorities and firms invest in education well before the intervention of the central state (Diebolt, Jaoul and Martino, 2005). On the other side, when the State directly intervenes and sets up new institutions, it is not always optimal. Sometimes (as in Prussia in the early 19th century) new institutions are established too early and do not respond yet to economic needs. They can also be ill-designed or simply designed to respond to the sole needs of the Army or the civil service. The private sector had to establish new schools outside the realm of the State. Some optimal combination of private initiatives and (publicly controlled) competition (as between federal states in the new united German Empire after 1871) could lead to better results. Recent researches (Galor and Moav, 2006, Galor, forthcoming) show that when productive complementarities between physical and human capital exist, as was the case in England during the second wave of Industrial Revolution, capitalists can support reforms to increase the human capital of the workers (even without universal suffrage) as was the case with primary education in England during the second half of the 19th century. Other studies, more centered on 20th century examples, tend to show that the elaborative structures (decentralized or not, see Archer, 1982) are very important in explaining success or failure (and also the types of reforms more likely to succeed). Deer (2003) and Demeulemeester (2009) have compared England and France from 1980 onwards and showed how the centralized nature of the French educational system rendered reforms difficult (so the necessary preliminary move towards decentralization and creation of competition between universities) while in England the network of autonomous universities were more likely to be driven by the State (especially when they mainly rely upon public funding and that the latter is reduced and increasingly made conditional to the attainment of specific objectives set by the State).

## Conclusion

The relation between education and growth is not an easy topic. Various logical structures (growth models of various types) can be envisaged to think about this relation mathematically, stressing either human capital as just another factor of production whose accumulation accounts for growth (impact in the

transitory dynamics for exogenous growth models; permanent impact in the case of endogenous models of accumulation as in Lucas, 1988) or the stock itself of human capital as a facilitator of imitation, adoption, diffusion or even innovation of new technologies. Various empirical strategies have been designed in order to test the relevance of those various theoretical models and to assess the degree of importance of the stock of human capital or its growth on the growth rate of the economy. Problems of data reliability and quality but also the nature of the proxy used led to lots of debates. At the turn of the century, in the early 2000s, a vague of skepticism reawaked due to empirical evidence concerning a weak link between education and growth in the developed countries. The idea that education might not exert the same impact on growth depending on the distance of the country to the technological frontier gained some credentials. First suggested by empirical studies (Benhabib and Spiegel, 1994) and economic historical studies (Mitch, 1990), it received considerable attention by pioneering researchers in the philosophy of Neo-Schumpeterian growth models (Aghion and Howitt, 1992, 1998, 2005). In a recent paper, Vandenbussche, Aghion and Meghir (2006) have demonstrated that for countries closer to the technological frontier, higher education will contribute more to growth than lower levels of education, as innovation (intensive in high-skilled workers) is the key thing for those countries (imitation is no more an option). Confirmed by an econometric analysis on OECD countries, the implicit message for the most advanced economies is that they should develop mainly their higher education systems (and its top tiers). This message is of course rather vague (what about the time dimension? the specific skills and competencies to develop? what about the risks of overeducation in the short run if the economic structures are not sufficiently developed to hire such top graduates?). Moreover the political feasibility of such long run policies in democracies (characterized by a short-medium time horizon for politicians) is not evident. A new emerging literature on the political economy of educational reforms should help economists in the design of policies that are both optimal (conducive to growth) and politically acceptable.

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