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THE WAVERING ECONOMIC THOUGHT ABOUT THE LINK BETWEEN EDUCATION AND GROWTH

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JEL Classifications: E24, O40, B22, B23, I25

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Abstract

The objective of this paper is twofold. On the one hand, it provides a balanced account of both theoretical and empirical debates on the link between education and growth since World War 2. We point out the lack of a clear-cut consensus. On the other hand, we question the traditional measurements of human capital, and assess their fit to various theoretical models of growth. Subsequently, we provide a new and arguably more appropriate proxy. Using it, we document crude correlations in line with the literature, pointing out that education may not be an appropriate instrument to accelerate growth.

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1 Introduction

"Does education matter?". This was the title of a book written by a British educationalist, Alison Wolf, in the early 2000s. The subtitle was "myths about education and growth", reflecting the very heated debate at a time of political consensus on the need to expand education and especially higher education on a massive scale (Wolf, 2002). At first sight, it seems that the contribution of education to economic growth is straightforward. But it is not. On the theoretical side, the arguments in favor of the contribution of education to growth (Romer, 1990 and Lucas, 1988) alternate with more skeptical models showing that private returns to education systematically exceed social ones. These models include the theories of job market signaling (Spence, 1972), countersignaling (Feltovich et al, 2002) and the theory of overeducation (Freeman, 1976). The empirical literature, either quantitative (econometric) or historical is also somewhat divided. All this literature is quite recent, mostly developed since the 50s. It is of utmost importance to give some guidance to actual policy. However, the wavering nature of economic literature on the subject did not align with the political consensus since the end of WW2, in favor of expanding education attainment. Indeed, educational policies are quite attractive for policy makers, since they seem to kill two birds with one stone: fostering economic growth while solving social problems such as unemployment, poverty and social inequalities. Developing countries have also relied on the development of literacy and numeracy as well as on formal education to promote their own economic prosperity and to catch up with the Western economies.

The turn of the century was characterized by conflicting viewpoints concerning the link between education and growth. On one side, a revival of the theory of growth (the so-called endogenous growth literature) has led to a renewed faith in the role of human capital (either its stock or the growth of its stock) in promoting growth. Some first empirical results seemed to support this view (see Barro, 1991). On the other side, a lot of new empirical studies with better data seemed to cast some doubt on the contribution of education to economic growth (e.g. Pritchett, 2001). It was not crystal-clear that education always and everywhere contributed to growth. As such, "one size fits all" measures of expanding education systems may not be optimal across all countries. Pioneering studies as Benhahbib and Spiegel (1994) suggested that the link might be different for the richest and the poorest economies. This view was further refined by neo-schumpeterian approaches that underlined the interaction between optimal policy and the distance from the technological frontier.

The objective of this paper is to highlight the development of the empirical literature on the link between education and growth since the 50s. We also discuss the theoretical literature underpinning these empirical debates. We summarize briefly the evolution of ideas since the early developments of economic thought in the 17th and 18th centuries. We study the characteristics of proxies used in the empirical literature to measure human capital, such as schooling attainment or enrolment rates. We also stress that poor proxies may undermine the proper estimation of the precise link between human capital and growth. Consequently, we propose a new and hopefully better measure of human capital, which is the incidence of skills put to use on the labor market. This measure better aligns with the model setups of growth theories. We show that using this proxy allows us not only to replicate previous correlations from the prevalent literature, but also to shed some light on the optimality of further expanding tertiary educational attainment.

The rest of this paper is structured as follows: in Section 2, we discuss the theoretical developments from the earliest mentions of human capital to the most recent models of countersignaling on the job market. In Section 3, we introduce the heated empirical debates on the proper role of human capital in explaining growth. In Section 4, we introduce our own empirical measure to approximate human capital, and we introduce it in regressions to explain economic growth. We conclude the paper in Section 5.

2 Theoretical developments

2.1 The prehistory of the economic thought regarding the link between education and growth (1650-1950)

One has to distinguish economic practices from economic theories and empirical strategies. The Mercantilist perspectives conditioning economic policies of late Medieval City-States already showed some awareness of the importance of human resources for economic prosperity. Migrants were welcome, both in quantitative terms (in order to repopulate destroyed areas, such as in Prussia in the 18th century) and in qualitative terms (foreign craftsmen were welcomed to develop new techniques). As put forward by Pierre Deyon (1969), mercantilist thinkers were aware that an abundance of workers was good, since it had decreased the cost of labor. Some of these authors, for instance William Petty (1676), were more sophisticated. He computed the economic losses brought about by the death of English soldiers abroad, using the monetary sum of wages that those people would have earned, had they survived. More importantly, Adam Smith (1776) was a forerunner of the idea of investment in human capital, by comparing it to investment in physical capital. Education and training were viewed as costly investments increasing future productivity (both direct and indirect costs had to be incurred through foregone earnings). One can find in Smith the role of education and training in fostering individual productivity and income. One could also think that by aggregation, this investment could favor the wealth of nations, but several authors have put forward that Smith also implied a deskilling thesis, coupled with the generalization of manufacturing, and the consequent specialization of labor. In the same Classical school of economics, somewhat unexpectedly, Marx proposed the distinction between simple and complex labor (i.e. non-qualified and qualified labor). He even proposed an equation for converting hours of complex labor in terms of simple labor (using the depreciation of the cost of training during active life). One finds here the origins of the human capital production function. But as Smith (1776), Marx (1867) believed that the development of capitalism and industrialization will induce a process of deskilling, leading to the weakening of the bargaining power workers would possess.

Parallel to economic theory, there were also developments in policy-making circles, especially in Germany. Some authors (Gispen, 1989; Demeulemeester and Diebolt, 2011) have noted the far-sightedness of Prussian reformers in the early 19th century after the defeat against France (1806-1807). They identified the key causes of the defeat both in the economic organization (too much regulation) and in the education system, which they had deemed too elitist and too detached from sciences and mathematics. They did not rely on *laisser-faire* system to reform education policy, but implemented instead a “revolution from above”. Their first ideas were very modern. They thought that the curriculum should be modernized, (sciences and technology were viewed as important to favor innovation) and that access should be widened (elitism in the educational system coupled with the ignorance of sciences in the general population were considered as key causes of the backwardness of Prussia with respect to France). The gap between the education attainments of the elites and of commons should be narrowed, and the accent should be placed on natural sciences instead of classics. Some reformers also tried to imagine ways of fostering the collaboration between higher technical education and the economy (Gispen, 1989). Those very advanced ideas were not all implemented after 1815, due to financial constraints, the fears of the elite, the anti-utilitarian bias of the new Humboldtian university (and the Gymnansium), as well as the backwardness of the Prussian economy (entering the Industrial revolution only in the 1820s and 30s). List (1910, 2nd Ed.) was one of the key German economists of the 19th century thinking about the determinants of development and growth. He 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 setup of a sufficiently large market through the development of transportation networks (railways), a German custom Union, i.e. a trade policy in line with an active industrial policy (setting up a strong industrial basis through a transitory period of protectionism, i.e. the infant-industry argument). These were his proposed remedies to allow a backward economy (he meant Germany) to catch up with a highly developed one (he meant UK). Von Thünen (1875; ed. 1968) was another German economist who stressed the contribution of human capital to the wealth of the Nation[4].

With the emergence of the neoclassical school of economics, the interest for the issue of growth and development declined. If some authors, such as Marshall were in favor of public subsidization of education (to which he attached various externalities) (Kiker, 1966; Blandy, 1967), they would still not consider the concept of human capital as fruitful. Many economists prior the 60s had a tendency to view education as a durable consumption good (at least postcompulsory education, see Blaug, 1976), and they considered that income was conditioning education investments, and not the inverse.

2. 2 The 50s and 60s: revival of growth theory and the link with human capital theory.

The 1950s saw the dawn of quantitative growth theories, while human capital theory and the field of the economics of education appeared[5] in the 60s.

The simple premise of the 1956 Solow neo-classical model of economic growth was linking output to capital and labor, assuming that the production function exhibits constant returns to scale and that to each input, returns diminish. This setup guarantees a steady state level of capital and output per worker, towards which every country was believed to converge. The model is also compatible with the inclusion of indices for technology or efficiency. As Schütt (2003) summarizes: "The fundamental dynamic equation of the model relates the evolution of the capital stock to a constant rate of saving and a constant rate of depreciation. Labor and the level of technology grow at exogenous exponential rates. If there were no technological progress, growth in this model would eventually come to a halt. However the formulation of the model is chosen so as to allow increases in efficiency

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[4] "There is no doubt about the answer to the very controversial question of whether the immaterial goods (services) of mankind form a part of national wealth or not… since a more highly schooled nation equipped with the same material goods creates a much larger income than uneducated people" (Von Thünen, 1875; reed. 1968, p. 393).

[5] Teixeira (2000) considers that the "emergence of the economics of education as an autonomous field of study is usually associated with Theodore Schultz's presidential address to the annual meeting of the American Economic Association (AEA) in 1960.

to offset the diminishing returns to capital. The economy therefore converges to a steady state in which output and capital per worker both grow at the exogenous rate of technological progress. Accordingly, in the long run, economic growth is unaffected by changes in the rate of savings or population growth. Changes in these parameters alter only the level of the long run growth path, but not its slope." The theoretical breakthrough was followed up with empirical growth accounting, put forth by Solow in 1957. The assumptions of the theoretical model were kept[6], in particular that technology and development are exogenous factors. However, the results stemming from growth accounting have led economists to seriously consider the large part of growth unexplained by the change of the traditional paid factors, ie. capital and labor (Denison, 1967; Jorgenson and Griliches, 1967; Jorgenson and Fraumeni, 1992; more recently Maddison, 2007). As put forward by Teixeira (2000, p. 262), "Denison tried to identify the contribution of different productive factors to economic growth in the United States and later on in other Western countries. His work suggested that the quality of the factors was more important than their quantity. In the case of labor, education represented a major source of improving its quality, hence of improving a nation's potential for growth (Denison, 1966)". Denison (1962) pointed out that a fifth of total growth in the USA may be explained by the growth of education attainment between 1929 and 1957 (see also Diebolt, 2008). Given that much of the variance in growth was still to be explained, attention started shifting towards the quality of labor (Schultz, 1961 and 1963). The role of education in adapting to changes in the macroeconomic environment was stressed, pointing out that a better educated labor force learns new processes quicker. Subsequent growth literature started to take into account the theories of human capital, created by Becker (1964), as found also in the studies by Arrow (1962) or Uzawa (1965). Nelson and Phelps (1966) 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. This remark is a precursor to the empirical puzzle of the 90s, namely the identification of the roles played by the stock and flow of human capital in fostering growth.

2. 2. 1. The historical context

The Cold War further emphasized the focus on these determinants of growth. The competing ideology on how to best organize production made fast and effective policy changes unavoidable. The early advantage of the Soviet Union in the Space Race was an alarming shock to the West, and policymakers deduced that these aeronautical achievements were fostered by intense training of the workforce in technological fields. On the other hand, the Keynesian views tended to dominate in the Western countries, accepting the growth of public expenditures, including the ones on education (Teixeira, 2000, p. 263), and the role of the State in economic management. "In the case of education, the increase in public expenditures seem to be not only socially popular but also economically meaningful (Svennilson, 1966)." (Teixeira, 2000)

The widespread belief, as such, at this time was that education is a key element for sustained growth, not only in developed countries, but in LDC's as well. The Cold War led to the consensus that a large-scale expansion of the education was necessary, at the expense of public finances. Firms had a need for a highly trained and productive workforce, which was further accelerated by the information technological revolution starting ca. 1980 (Wren et al, 2013). The policy narrative was that education also fosters upwards social mobility and higher wages, which in turn will trickle back down through

[6] and they were quite stark. Endogenous growth models, at this point in time still to be developed, point out that research and development are costly activities, and that technology is far from exogenous.

the use of progressive taxation. Public investment in education steadily increased all throughout the 60s.

2. 3 The bleak 70s: questioning the social utility of education

Rapidly declining growth rates (halving in the USA from 4.5 to 2%) and simultaneously skyrocketing unemployment provided an adequate nest for pessimistic economic thought in the early 70s. It seemed as though the massive expansion of the 60s had not paid off. At the first sign of a considerable set of unemployed college graduates, economists were quick to paint a portrait of the "*overeducated American*" (Freeman, 1976). At the same time, the first pieces of empirics emerged, showing that private returns to education exceeded social ones (Psacharopoulos 1980, 1981, 1985). To make sense of these developments, economic thought has begun to incorporate them into theory. Growth theories were temporarily put aside with a growing interest in the cycles on academic markets[7] (Freeman, 1971, 1976). Economists started to view education as a sorting device (Arrow, 1973) or more simply as a signal of pre-existing productivity. As such the preponderant utility of education is private – agents invest in it to obtain that particular "dream job", in the context of information asymmetry about ability on the job market (Spence, 1973, 1974). As such, education, as long as it is the cheapest way to reveal information about productivity, will still be demanded.

This era of skepticism in the role of education led to the idea that the efficient functioning of the job market boils down to optimal selection of individuals by firms. It is in this era that we observe the emergence of studies on the interaction between signaling and screening. For instance Layard and Psacharopoulos (1974) observe that the private rate of return to unfinished studies is close to that of finished ones, and as such, they argue that private firm-based screening is a cheap and more efficient method of information revelation on worker type. Lazear (1977) remains stoic about the exact influence that education exercises on productivity, noting that as long as education is the cheapest way of information revelation, more able individuals invest more in it, independently of whether it increases productivity or not. Riley (1976) is considerably more optimistic about the contribution of publicly provided education to firm-based screening. Since the more educated learn faster on average, educational prescreening does a good job of "suggesting" optimal workers for tasks which require a lot of on-the-job training. Wolpin (1977), along similar lines concludes that even if education, indeed, does not increase productivity, its role in the optimal allocation of workers is non-negligible, and as such its social utility is bounded away from zero.

2.4 The Renaissance of growth theories in the 80s and 90s

The endogenous growth theories of the 80s gave new impetus to this strand of the literature (Romer 1986, 1990 and Lucas 1988). These new theories changed the exogenous growth theories of the 50s and 60s fundamentally. In earlier models, it was assumed that at the steady state, growth is only possible if exogenous technology grows. However, these models had remained silent about the source of this exogenous technological progress. Endogenous growth theory, on the other hand, explains sustained growth by investment in costly human capital, now modeled as a choice variable.

[7] See for instance Siow (1984) for a discussion of education production lags (time between enrolment and graduation). He argues that private investment decisions are conditioned on current college premia, but if unrealized upon graduation, they deter future investment – hence the alternative cycles of over- and underinvestment.

This literature can be further subcategorized by its approach to whether the stock or change of human capital matters for growth. Lucas (1988), for instance, puts the emphasis on the change of human capital, modelling it as yet another input for production. For him, human capital exerts a positive productivity-enhancing externality for all firms. As with any market exhibiting externalities, the model hinted towards the optimality of state intervention to align social and private incentives for investment. In the Lucas model, agents can devote time to work and to skill acquisition. The determinants of investment in human capital are analyzed as well as their influence on growth. Human capital here is unbounded from above, and is an alternative to technological progress, exhibiting increasing marginal returns (see Diebolt, 2008). The main determinants of growth in this model are rooted in the size of the externality that human capital exerts on production, and in the proportion of time devoted to learning. As such, convergence of growth to some common technological progress rate (Mankiw, Romer and Weil, 1992) is no longer an unavoidable feature.

The Romer (1990) model of endogenous growth, on the other hand, emphasized the role of the stock of human capital in facilitating imitation or innovation. Romer argues that a higher initial stock of human capital leads to quicker adoption and diffusion, more innovation and in turn, more growth. The theory assumes the economy is built up of three main sectors: research, intermediate-goods production and final-goods production. The level of human capital and labor supply are kept constant. "The Romer model endogenizes technological progress by introducing the search for new ideas by researchers interested in profiting from their inventions" (Jones, 2013, p. 98). "The reasons for sustained growth in this model are twofold. First there is an increasing variety of products which expands with the stock of ideas. Second… Romer assumes that there are knowledge spillovers because all researchers have unrestricted access to the existing stock of knowledge… This is why A enters into the production function of new knowledge. Moreover the linearity assumption is equivalent to supposing that the productivity of human capital employed in research increases in proportion with A… Knowledge can grow without bound and generate endogenous growth. In the steady state, capital, output and the stock of knowledge all grow at the same rate, driven by technological progress. (The equation of production of knowledge) implies that the growth rate of A depends on the amount of human capital employed in research, which, as Romer shows, is a linear function of the total stock of human capital… What this means is that a rise in the stock of human capital will permanently speed up growth" (Schütt, 2003, pp. 14-15).

Exogenous growth models were also revived at this time. Mankiw, Romer and Weil (1992) developed the so-called augmented Solow model of growth. They introduced human capital as a standalone production factor. As such, savings are now channeled into both physical and human capital. As in Solow, "because of the assumption of diminishing returns to broad capital (human and physical), measured in effective units of labor, all quantities are constant in the steady state, so that output per worker and capital per worker grow at the exogenous rate of technological change. This implies that an increase in the rate of investment in human capital has no effect on the long run growth rate of the economy." (Schütt, 2003, p. 8). The main prediction of the model is an increase of investment in human capital pushes the equilibrium level of production upwards, leading to a transitory, higher growth rate, which eventually returns to its initial level.

Table 1: Differences between models of growth including human capital

	Augmented Solow model	Lucas model	Romer model
Human capital is accumulated by…	Investing a fraction of income	Spending a fraction of time acquiring skills	Not modeled
Technology for production of human capital	Same production function for C, K and H	Separate sector for production of H using only human capital	Not modeled
Role of human capital	Input in production	Input in production of Y and H	Input in production of Y and A
Growth rate determined…	Outside the model	Within the model	Within the model
Determinant of long-run growth	Exogenous technological change	Rate of human capital accumulation	Stock of human capital
Effects of a permanent change in the variable governing the accumulation of human capital	Level effect	Rate effect	Rate effect (though not explicitly modeled)
Effects of a one-off increase in the stock of human capital	Level effect	Level effect	Rate effect

Source: Table 1 in Schütt, 2003, p. 15.

2.5 2000-2010: New era of skepticism, theories of overeducation and countersignalling

The ICT revolution of the 1980's and the relative optimism around the positive effects of education not only on economic growth in general but also on earnings created a large mass of university-educated workers in OECD countries. In particular, by 2004, around 25 percent of total hours worked by the labor force were provided by university graduates in the USA. This figure is even higher for Scandinavian countries such as Finland at 32 percent (source: EUKlems, 2007). As a comparison, the OECD average of the percentage of total hours worked by university graduates was a mere 6 percent in 1970. This monumental increase in the size of the highly educated workforce sparked heated debate akin to that of the 1970's, about the sorting role of education. Given that demand for skilled workers did not increase as fast as the supply for them, inevitably, many workers were forced into occupations that require lower credentials. The literature documents the phenomenon quite clearly, however it is split on assessing the impact of overeducation on growth.

Authors like McGuiness (2006) critique government policy of inflating graduate numbers, since he observes in his comprehensive survey of the literature that on the one hand, overeducated workers tend to be less able than their properly matched counterparts. On the other, even the capacities they do possess, they are unable to exploit fully. As such, the social and individual costs of overeducation are not trivial. The wage penalty that overeducated workers incur is documented in many studies, such as Korpi and Tahlin (2009) or Chevalier and Lindley (2009). Nevertheless, the particularity of this latter study is that it argues that even though the individual returns to overeducation are negative on the short run at least, a large pool of overeducated workers prepares the economy for the emergence of new tasks, partly arising from technological progress, and as such, is favorable for growth.

As a corollary to the consensus that overeducation imposes wage penalties at the individual level, the road was paved for the theory of job market countersignalling. These theories are in general skeptical about both the social and individual utility of education, stating that even the sorting role of education is no longer fulfilled if the job market is flooded with signals of ability that are of low quality to employers. Feltovich et al (2002) propose and experimentally test a model, where the highest ability workers separate themselves from the medium quality ones by not obtaining education at all, whereas medium quality workers invest in education for the sole purpose of separating themselves from the lowest ability types. Chung and Eső (2013) refine the model and conclude that countersignaling separating equilibria tend to happen when the average expected productivity of the highest- and lowest-talent workers (both groups being non-signalling types as opposed to the medium-ability workers) is still higher than the average productivity of medium ability agents. Araujo et al (2007) observe that countersignalling is bound to happen in practice in connection with jobs that require a starkly different set of skills that traditional schooling curriculum provides. These studies seem to be somewhat in line with the earliest policy recommendations (see for instance List (1910) presented above in this paper) that a detachment of curriculum from the needs of the industry not only takes away incentives from private investment in education, but also hampers economic growth in general.

3 Empirical analyses since the early 90s

3.1 The early consensus

The early empirical validity of the exogenous growth theorem that seemed to confirm the hypothesis that more capital (physical and human) leads to higher levels of wealth across and within countries were warmly embraced by policymakers. Furthermore, studies like Romer (1989), Azariadis and Drazen (1990) and Murphy et al (1991) seemed to have found some evidence that literacy and enrolment in certain specific studies, such as engineering, improve growth across 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.

The reason for this is quite straightforward. The empirical studies of the early-to-mid 90s, such as Benhabib and Spiegel (1994) show a positive relationship between educational attainment and growth. At the same time, articles like the one by Mankiw, Romer and Weil (1992) have confirmed the enlarged exogenous growth model *à la Solow*, estimating that indeed 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). As an extension, Mankiw et al considered a broad measure of human capital in their estimations, namely secondary enrolment rates, and have found that the inclusion of this measure helps in explaining the variation in growth levels. It follows from this result that 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).

These accumulation models receiving considerable empirical support at this stage led a simplistic way of looking at the relationship between education and growth: more human capital (growth rate of scholarly level) generates more growth. This quantitative philosophy led to the above mentioned 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 GDP *per capita* at time *t*, with the accumulated stocks of human and physical capital. If one follows the estimated coefficients obtained by Barro (1991) or Mankiw and 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 percentage point (Gurgand, 2004).

It is also at this time that we see the appearance of empirical studies evaluating the quality of education and its output bundle in terms of the precise qualifications provided. While at this time, the consensus that more education led to more growth stood firmly, some economists refined the line of questioning by looking into the deep realms of classroom work. Lee and Lee (1995) for instance, find that higher test scores in high schools lead to higher growth, both across and between countries (later studies confirm this relationship, see for instance Bosworth and Collins, 2003).

Besides the focus on quality versus quantity of education, scholars at this stage were also interested in identifying the types of skills most useful for growth. Murphy et al (1991), as also referenced above, state that "*engineers are good for growth and lawyers are bad for growth*". Whilst quite a crude conclusion, this line of reasoning calls into question the role of institutions. The thoughts of the Neo-institutional school (such as North, 1990) point out that the demand and supply for skills has to be understood within a broader institutional context. The choice of training that individuals undertake is subject to a certain path-dependency, which are typically long-standing, and reduce transaction costs whilst solving static coordination problems. However, these institutions rarely consider the long-term impact in terms of incentives. Some societies favor investment in wealth-enhancing activities, generally considered positive for growth, while others tend to put emphasis on rent-seeking preoccupations, which tend not to be as optimal socially as they might be individually (for instance training in law[8]). The key takeaway from this train of thought is that these two "extreme" institutional backgrounds perhaps require different optimal levels of educational attainment, and a mere equilibrium between demand and supply of human capital may be suboptimal (see Peters, 2011 on the New Institutional History and Demeulemeester and Diebolt, 2007 on cliometrics at large). As such, the views, at this time, confirmed both theoretically and empirically, stating that "*more education automatically creates more growth*", might not be the case for countries with *laissez-faire* institutions that favor rent-seeking. This is not to say, however, that intervention in education has always been successful. For example, both in France and Prussia, the State had established engineering schools that served mainly the needs of the civil service (or the

[8]This is not to say that lawyers are only adverse to growth. They also produce institutional devices that favor 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.

army), but not necessarily the needs of the emerging private sector (leading to new, private, institutions outside the realm of the public sector).

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).

3.2 The 90s and early-2000s: refining the consensus, stock and flow debates

Data has started to become more abundant as time passed, researchers begun to have access to panel data, which challenged the consensus that we had put forward above. Divergence in the proxies used to measure human capital and its contribution to production changed results across papers. At this stage, we observe that as a general rule, papers that use the *stock* of educated individuals or the current levels of enrolment rates as proxies remain quite optimistic about the positive effects that education has on growth. However, the newly emerged time-series dimension of data allowed researchers to look at the yearly variation of the stock of human capital (in whichever way it might be defined). These studies are, across the board, more skeptical about the growth effects on education.

This duality has made the message of empirics quite fuzzy. 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*". Indeed, influential studies like Barro (1991) or Mankiw et al (1992) that explain well the differences in GDP per capita in the context of exogenous growth models do not employ the flow of human capital, but rather its stock. Solow (1956) and exogenous growth models are not the only theoretical underpinnings that give sense to these results. As we have mentioned earlier, 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. Confirmations of these ideas, albeit under attack, have been keeping on appearing in the literature until the present day. However human capital is defined, as long as its level is used to explain growth and not its stock, the results seem optimistic. Notable studies that define human capital as labor force education attainment include, for instance, Collins and Bosworth (1996), Gemmell (1996), Bassanini and Scarpetta (2002), Kalaitzidakis et al (2001), Hanushek (2007), Hanushek and Woessmann (2008), Hanushek and Woessmann (2011). The observation that one can make in relation with these articles is that the results are independent of the geographical or historical contexts that they had studied. Another popular proxy in the literature for the stock of human capital is school enrolment rates, and they are just as effective as education attainments in explaining growth across low- and medium-income countries mostly. Keller (2006) finds a positive relationship between growth and school enrolments for 40 Asian countries, Baldacci et al (2008) find similar results for a large set of developing countries, as do Lee and Kim (2009) and many others. At this juncture, however, it is important to mention that identical studies applied to developed countries provide the first signs of caution about optimistic results. For instance, Bils and Klenow (2000) find a positive correlation between enrolments and growth, but warn that the relationship might be reverse causal. Also, the first non-monotonic relationships are documented at this time, again for developed countries, between schooling and growth, see for instance Földvári and Van Leeuwen (2009).

The fundamental shift in empirics appears once one starts to rely on the change in human capital for explaining growth rates of GDP. 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*. Collins (2003) confirms Benhabib and Spiegel's results, finding that the positive relationship between growth of human capital and economic growth is much weaker than that between the level of human capital and growth. Krueger and Lindahl (2001) point out that even if there is some growth effect of the flow of human capital, it takes time to appear. In fact, he finds that the positive influence shows up with 10-20 year lags, while higher frequency changes show no effect. Some studies go even further, and show a negative relationship between changes in human capital and growth, both across and within countries. Pritchett (2001) finds an insignificant negative relationship, while somewhat alarmingly, Földvári and Van Leeuwen (2009) find a highly robust one.

Table 2: Determinants of the growth rates of GDP: stock versus flow of human capital

	Articles	Coefficient on education	Proxy for education	Other variables
Proxy: stock of human capital	Barro, 1991	0.0181	Primary schooling rates 1960	GDP in 1960, invest-ment 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
	Hanushek and Woessmann, 2011	0.173	Years of schooling (average between 1960 and 2000)	GDP per capita in 1960, measures for cognitive skills
Proxy: change in human capital	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
	Collins, 2003	*0.53*	Average log change in human capital per worker	Growth of physical capital, educational quality
	Földvári and Van Leeuwen, 2009	-0.305	First difference of the log of human capital	Physical capital, levels of human capital

Source: Compiled by the authors and Table 11, Gurgand, 2005, p. 78. Coefficients in italics are not statistically different from zero.

Some 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). A large strand of literature follows in his footsteps in pinning down the influence that the level of development has on the link between education and growth (for historical discussions see Mitch, 1990; Demeulemeester and Rochat, 1995). 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 growth potential is often approximated as the difference between the GDP level of the developing country examined and that of the most advanced nations. "*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).

The analysis by Benhabib and Spiegel leaves no room for cross-country heterogeneity. But other analyses will confirm these intuitions. The mechanism through which initial development interacts with growth appears to be the observation that educated people adopt technological development faster (see Foster and Rosenzweig, 1996 on the Green Revolution in the Indian districts between 1969 and 1982), and that they also learn faster in general. Bartel and Lichtenberg (1987) also propose that the more recently a firm had adopted a new technology, the higher was its demand for educated labor. As such, education has asymmetric effects on growth depending on the geographical context in which it operates. For instance, Durlauf and Johnson (1995) finds that working-age secondary school enrolment mostly increase growth in countries exhibiting low initial literacy rates. Sandar and Macdonald (2009) also find that tertiary enrolment rates increase growth, but again, only in low- to medium-income nations. As Krueger and Lindahl (2001) state: "*education is statistically significantly and positively associated with subsequent growth only for the countries with the lowest level of education*".

These empirical contradictions, as outlined, led to a need to define more systematic and less erroneous datasets (De la Fuente and Domenech, 2002). As for the explanation of the phenomenon that growth rates of education do not explain GDP growth as well as the stock of education does, Gurgand (2005) notes 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*". With this in mind, a few empirical papers, which are, by the way, more the exception than the rule, show that there is a positive between growth rates of education and GDP (for instance De la Fuente and Domenech, 2002). This new avenue of research also advocated for finding better proxies. For instance, the average schooling attainment of a country might be convenient, but it is quite restrictive. First of all, a given number of years of education may contain more skills in one country than in another, and, perhaps more importantly, the mere stock reveals no information on how the stock of education is put to use on the labor market. In the section below, we propose a solution for this latter problem, and we observe in the literature that there have been attempts at adjusting empirically for differences in the quality of education. 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. Barro and Sala-i-Martin (2004) also note that the relationship between the stock of education attainment and growth weakens once test scores are added to the regression.

Another pioneering approach allows for the possible heterogeneity of the impact of education on growth contingent on the level of initial development (in the spirit of Benhabib and Spiegel (1994) and economic historical intuitions). The use of a concept of distance to the technological frontier within the framework of endogenous growth models has been developed by the so-called neo-schumpeterian approach *à la Aghion* (see Aghion and Howitt, 1998, 2005).

3. 3 The neo-schumpeterian approaches

Aghion and Howitt (1992) developed a neo-schumpeterian endogenous model of growth with destructive creation. The main idea is that the succeeding innovator captures the market and replaces the incumbent monopolist, reaping all the monopoly rents, which underlines the necessity of investment in R&D. When making her investments, she takes into account the time during which she is expected to hold monopoly before succumbing to yet another challenger. As such, the innovation link to growth is stressed here, and, *in fine*, also the link between human capital and growth, through the number of employees assigned to research (as in Romer, 1990). On the basis of the philosophy of this first paper, the neo-schumpeterians have explored a whole array of issues (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 focus on the differences between imitation and innovation, as well as on the capacity of countries to pursue one or the other. This strand of work contains a critique of the *"one-size-fits-all"* policy. The authors propose that both activities use both unskilled and skilled labor, but that innovation is more intensive in its use of skilled labor. For poorer countries, further away from the production possibilities frontier, imitation is more profitable, and so is the development of primary and secondary education. This train of thought puts into question the causality of some of the correlations found between enrolment rates and growth in developing countries (see for instance Tsai et al, 2010). An important implication of the neo-schumpeterian school of thought is that since education favors imitation, its role, and especially its growth levels are insignificant for rich countries closer to the frontier, since their main preoccupation is innovation, as also hinted at by Nelson and Phelps (1996). 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. Holding human capital constant, the capacity of human capital to foster growth resides in the development level of the nation. For countries near the technological frontier, the catch-up potential is reduced and therefore innovation matters much more. As such they conclude that the highest qualifications (the "*top of the top*"[9]) matter much more for developed

[9]For a recent survey on the importance of human capital for growth, see Hanushek and Woesmann (2007).

countries than for developing ones. This prediction seems to have some empirical validity (see for instance De la Fuente and Domenech, 2002 or Vandenbussche et al, 2006).

Vandenbussche, Aghion and Meghir (2006) observe a strong positive correlation between an interaction variable, consisting of the proximity towards the technological frontier and the proportion of adults with higher education degrees. This confirms the idea that the proportion of people with higher education degrees is more important for countries close to the technological frontier. For countries with the most high-skilled workers, the lagged effect of the distance to the technological frontier appears less negative than for others. Accounting for country group-level non-observables, one obtains a threshold, above which the impact of education is positive on growth.

These ideas were the main motivators of vivid EU-wide policy debate. As pointed out by the Lisbon Strategy, the transformation of the Union into the most competitive knowledge-based economy is of utmost importance. A series of policy papers were supporting these policy goals (Sapir Report for the European Commission in 2004; Cohen and Aghion report, 2004). However, as we introduce below, it is conceivable that economies are constrained by a certain absorption capacity or a human capital absorption frontier, which puts an upper bound for reasonable production of human capital for developed countries.

4 Proxies matter: human capital employed on the job market and growth

We have introduced the notion that empirical evidence is quite wavering when it comes to providing a clear conclusion on the nexus between education and growth. Given the multiplicity of theories linking the two, this is hardly surprising. Furthermore, it would seem that the empirical results are quite vulnerable to identification strategies, especially the establishment of a clear positive link between education and growth. We have shown that studies use either the flow or stock of total educational attainment, enrolment rates, test scores and to a lesser extent, education spending to account for human capital accumulation. Flow and stock variables provide radically different estimates, as documented in Table 2. As we have put forth above, the explanations for this puzzle are numerous. Some researchers blame the low quality of the data (Portela et al, 2004), and that educational attainment is measured in an erroneous way. Pritchett (2001) believes that human capital not put to its most efficient use is the reason why the change of human capital does not seem to explain growth so well. Földvári and Van Leeuwen (2009) advance the rather attractive idea that the growth of human capital requires the human capital-producing sector to become larger, and as such, resources are channeled away from the GDP-producing sector, meaning that at some point, growth is hindered by the growth of human capital. Finally, the neo-schumpeterian school argues that empirics are fuzzy because not all types of human capital are equally useful for all types of countries. Authors note in particular that developed countries benefit the most from the expansion of their tertiary education sector.

On the other hand, the positive correlation between the level of human capital and growth is rarely questioned, following the Romerian train of thought, namely that a higher initial stock of human capital leads to more innovation, which in turn leads to more growth. We argue here that there may be fundamental measurement error problems in the empirics around this field. In order to properly explain variation in production growth, one would ideally measure the level or change (as the researcher desires) of human capital contemporaneously put to use in the labor market. However, even educational attainment in the general population remains a noisy proxy of this, whereas schooling enrolment rates and test scores might take a decade or more to manifest themselves as production increasing factors. Indeed, in all capital accumulation models, human capital intervenes *at time t* to produce output *at time t*. Hence the use of, say, schooling enrolment rates in countries undergoing an education reform is particularly worrisome, if current human capital actually *employed* on the labor market falls short of enrolment.

We suggest a possible proxy, thus far neglected by the literature. The EU KLEMS Growth and Productivity Accounts give a country-year level measure of the hours worked by high-, medium- and low-skilled employees as a percentage of total hours worked. We are especially interested in the incidence of high skilled individuals on the labor market. Both the yearly change and the level of this variable may be useful in predicting growth. We also take into account medium skilled workers in alternative specifications, but neglect low-skilled incidence as a measure of human capital, since this is the stratus of workers education policy universally tends to minimize (through, for instance, the gradual increase of minimum schooling requirements). High-skilled workers are defined as having obtained a tertiary degree, medium-skilled workers possess higher-secondary education or some technical certificate, while low-skilled individuals include all others. The hours worked by these three groups as a percentage of total hours worked provides us with internationally comparable measures. Since we can track the measures for each country-year, we arguably have a decent chance at approximating the level of human capital as intended by theoretical models of growth, since we obtain a measure of the incidence of human capital actually put to use in production.

Naturally, no proxy is without its setbacks. The measure we introduce here does not necessarily measure the entire stock of human capital, but rather gives a way for us to track, through time, an equilibrium outcome on the labor market, which, naturally, depends on demand as well. However, demand may change independently of supply or education policy (through technological change for instance). We also do not account for the actual *occupations*. The proxy remains silent on the inefficient use or the low quality of human capital. As Fodor (2016) points out, there remains heterogeneity in this aspect across countries, so the proxy is to be interpreted with care.

However, we are optimistic that this measure fits theoretical models well, and as we outline below, the correlations between this proxy (both its level and change) and growth are more or less in line with the entire strand of empirical research thus far. The level is correlated with real GDP per capita growth *across* countries, and its change is correlated *negatively* with growth within countries, which is out of line with some, but not all papers emerging in the field.

To document these correlations, we use an unbalanced panel of 13 developed[10] OECD countries, observed from 1970 to 2004. Table 3 gives an overview of our proposed proxy to measure employed human capital. The proportion of high-skilled hours worked as a percentage of total hours has grown much faster throughout this period than real GDP per capita, and also much faster than medium-skilled incidence. This underlines, as point out earlier in this paper, that education policy in this period was mainly preoccupied with the expansion of tertiary education in developed countries. Simple x-y "workhorse" regressions ran but not reported here, with average real GDP per capita growth as the dependent variable and the human capital measures as explanatory variables provide highly significant coefficients, positive for high-skilled and negative for low-skilled incidence. This

[10] USA, United Kingdom, the Netherlands, Belgium, France, Spain, Germany, Austria, Italy, Finland, Sweden, Denmark, Japan. The hours worked by different skill groups as a percentage of total hours have only been collected for these countries.

observation, albeit crude, seems to be in line with the Romer growth model, as we outline earlier in this paper.

Table 3: Descriptive statistics

	Real GDP per capita average growth	High-skilled hours worked[11], average growth	Medium-skilled hours worked, average growth	High-skilled hours worked, initial level	Medium-skilled hours worked, initial level
USA	2.11	2.69	0.34	12.88	52.28
UK	2.17	9.05	1.53	1.07	41.51
Netherlands	1.83	2.96	-0.05	14.27	65.58
Belgium	2.23	3.13	2.18	7.29	33.25
France	2.02	3.83	1.44	5.95	46.69
Spain	2.45	4.14	6.13	7.90	7.30
Germany	1.21	2.78	0.37	3.94	55.98
Austria	2.39	3.76	1.11	5.56	50.88
Italy	2.06	3.48	0.11	3.91	83.52
Finland	2.46	3.27	2.77	11.76	17.98
Sweden	1.73	5.02	0.77	8.52	60.93
Denmark	1.65	4.26	1.59	2.94	44.32
Japan	2.43	3.60	1.38	7.13	41.69

Source: OECD and EU KLEMS. Please note that all numbers are in percentage terms. The initial year of observation is 1970, except for Belgium, France, Spain, Austria, Denmark (1980), for the Netherlands (1979) and for Sweden (1993). The last year of observation is 2004 for all countries.

Given the multiplicity of theoretical work, our objective in this section is not to test any particular theory, nor do we replicate any particular empirical piece. What we aim to achieve is a proposition of a proxy, to be used in future empirical work, which also takes into account the demand side of the labor market. Schooling enrolment or test scores, even schooling attainment focus only on the production of human capital, with little attention to how this human capital is put to use. This is why we have felt that it was necessary to given an account of signaling, screening and overeducation theories, which point out explicitly that the market might have an absorption capacity, above which the production of new university graduates is counterproductive. As we show below, simple correlations between this measure of human capital and growth are in line with previous findings in the literature. As such, we see no obstacle for its use in empirical studies. Please note that at this stage, we are not concerned with establishing a causal link, and as such, our empirical strategy remains minimalistic. We establish two main correlations: the level of human capital explains growth *across* countries, while the growth of human capital is negatively correlated with growth *within* them. Consequently, we estimate, using panel-corrected standard errors OLS (taking into account contemporaneous correlation between panels and the relatively large time-dimension of our data, to which this method is more appropriate than standard OLS)

$$g_{i,t}^{Y} = \alpha_i + \beta_1 H_{i,t} + \beta_2 g_{i,t}^{K} + \gamma d_t + \varepsilon_i \quad (1)$$

to establish the cross-country correlation, and

[11] As a percentage of total hours. This is also valid for the rest of the variables in this table.

$$g_{i,t}^{Y} = \alpha_i + \beta_1 g_{i,t}^{H} + \beta_2 g_{i,t}^{K} + \rho d_i + \varepsilon_t \qquad (2)$$

to establish the within-country correlation, where $g_{i,t}^{Y}$, $g_{i,t}^{H}$ and $g_{i,t}^{K}$ denote the growth rates of real per capita GDP, human capital and physical capital, respectively and d_t and d_i are period and country dummies. Our human capital measure in baseline specifications is the percentage of hours worked by high-skilled individuals as a percentage of total hours, but we also estimate the above equations with human capital defined as high- and medium-skilled joint incidence. As controls, we include the volume indices of information and communications technology capital[12] in the financial, real estate and other business services sector, which is the heaviest user of such capital, and as such, the measure provides an upper bound on this capital growth. This is done to account for the human capital demand-shifting effects of the ICT-revolution that takes place at this period (Wren et al, 2013). We also include total social expenditure to account for public versus private incentives to invest in human capital, noting that welfare states with higher levels of social expenditure have a tendency to finance education at all levels publicly (Wren et al, 2013).

Table 4: Regression output

Growth of real GDP per capita						
High-skilled hours worked as perc. of total	0.02[b] (0.01)				0.02 (0.01)	
High- and med-skilled hours worked as perc. of total			-0.003 (0.004)			
Growth of high-skilled hours worked as perc. of total		-0.06[a] (0.01)				-0.2[a] (0.04)
Growth of high- and med-skilled hours worked as perc. of total				-0.17[b] (0.07)		
Growth of physical capital			0.46[a] (0.11)	0.32[b] (0.13)	0.51[a] (0.09)	0.38[a] (0.13)
ICT Capital (volume indices)			-0.004[a] (0.001)	-0.00 (0.00)	-0.003[a] (0.001)	-0.00 (0.00)
Total Social expenditure			-0.002 (0.01)	-0.23[c] (0.11)	0.01 (0.02)	-0.18[c] (0.11)
R^2	0.41	0.04	0.38	0.14	0.38	0.17
Dummies	Year	Country	Year	Country	Year	Country
N	364	357	209	208	209	208

The dependent variable in all specifications is the growth of real GDP per capita. Bracketed figures show panel-corrected standard errors. The superscript a denotes significance at the 99%, b at the 95% and c at the 90% levels. The number of observations drops in the last four columns, since reliable physical capital growth data is only published since 1985 by the OECD.

As apparent from Table 4, the growth of human capital, independently of its definition, correlates strongly and negatively with economic growth. This is in line with the literature discussed in previous sections, which almost unanimously finds that the change in human capital, be it schooling attainment, schooling enrolment or any other proxy, is either insignificant in explaining growth or shows a negative correlation with it. The level of human capital seems to show a positive correlation with growth, although this seems (using this crude identification strategy) fragile to changes in specification.

[12] Source: Groningen Growth and Development Centre

What we have shown is that there exists a measure that manages to reproduce some findings in the empirical literature on the link between education and growth, while arguably approximating human capital better in the sense pinned down by capital accumulation models. The negative correlation between the growth of human capital and growth of GDP is somewhat alarming, especially if further research concludes that it is causal. The correlation is in line with signaling and overeducation theory as discussed above, and clearly points towards the conclusion that some newly produced (or employed) graduates cannot pull their own weight in terms of contribution to growth (since we control implicitly for population, explicitly for physical capital growth). Therefore, overinflating the education sector (both secondary and tertiary, as it seems) may be a path to walk down upon with extreme caution. First, referring to the thesis with which we start this paper, the link between education and growth, as apparent from the literature and these crude estimations, is not as straightforward as previously understood. Second, we point out the need to develop micro-founded growth theories that take into account the sorting role of education, which may be at peril, especially if the growth of human capital (or at least the growth of credentials) happens through the "watering-down" of requirements and standards. It is important to note that these types of analyses, especially our crude correlations given above, do not settle the empirical stock versus flow debates, stemming from the seminal study of Nelson and Phelps (1966). The two measures tell different stories, although one might argue that the stock of human capital, given the already high growth-explanatory power of its *initial level*, is more of an institutional variable. Founding country-specific schooling reforms, especially schooling expansion efforts on a perceived (or misperceived) notion that the growth of human capital fosters growth may however be misguided, as also pointed out by decades of empirical evidence.

5 Conclusion

The link between education and growth is not as immediate as previously understood or assumed. In fact, theories of growth tend to remain silent about education itself. Human capital does, nonetheless, enter production functions, and a central question in the literature is the optimal quantity of investment devoted to human capital accumulation, which is generally interpreted as investment in education and training. In practice, however, substantial expansion of education attainment usually happens as a "revolution from above", more often than not as a reaction to exogenous shocks, such as conflicts and rapid technological change. Such periods of alarming need for highly-skilled workers were accompanied by optimistic growth theories. Take for instance the Cold War and the Solow growth model with its empirical complement, growth accounting. Much of the unobserved variance in growth attributed to the role of education led to a massive expansion of secondary and tertiary education in developed countries. The endogenous growth theories of the 80s and 90s were also emerging in a historical context of rapidly changing technology (the information technological revolution). Nevertheless, when education investments do not pay off on the short- to medium-run, the wavering economic thought quickly descends into lethargy. Skepticism appears, and the social utility of education is questioned, firm to worker sorting and the role (or failure) of education in facilitating this process is examined.

Empirical evidence certainly does not help much in smoothing out these alternating cycles of optimism and pessimism. The initial evidence on the positive link between education and growth (apparent mostly from using the stock of education as a proxy) was quickly contradicted by studies relating the change in human capital to the change in growth. Papers that show a robust positive correlation between these two variables are rare in the literature, especially when observing developed countries. As a reaction, studies emerged that examined the role that quality of education plays for determining growth. We have shown that the findings that have dominated recent empirical literature may be reproduced by measuring human capital as the proportion of educated workers employed. We argue that this measure may approximate the contemporaneous human capital input better than schooling attainment, enrolment or schooling quality. Even though we do not claim causality, we caution policy reforms of further mass expansions of higher education.

In conclusion, the forthcoming direction this strand of research may take is unclear. On the one hand, job market polarization and the disappearance of medium-skilled tasks pushes individuals to invest in educational credentials. On the other hand, we deduct from the literature that credentials themselves are not good predictors of growth. However, there is still the open question of the link between early childhood education and growth. No piece of literature concludes that human capital itself is negligible to growth. As such, the question may be the optimal placement of human capital accumulation within the lifespan of individuals. Be that as it may, the one to one correspondence between education and human capital, and the use of the former to approximate the latter, may soon disappear.

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