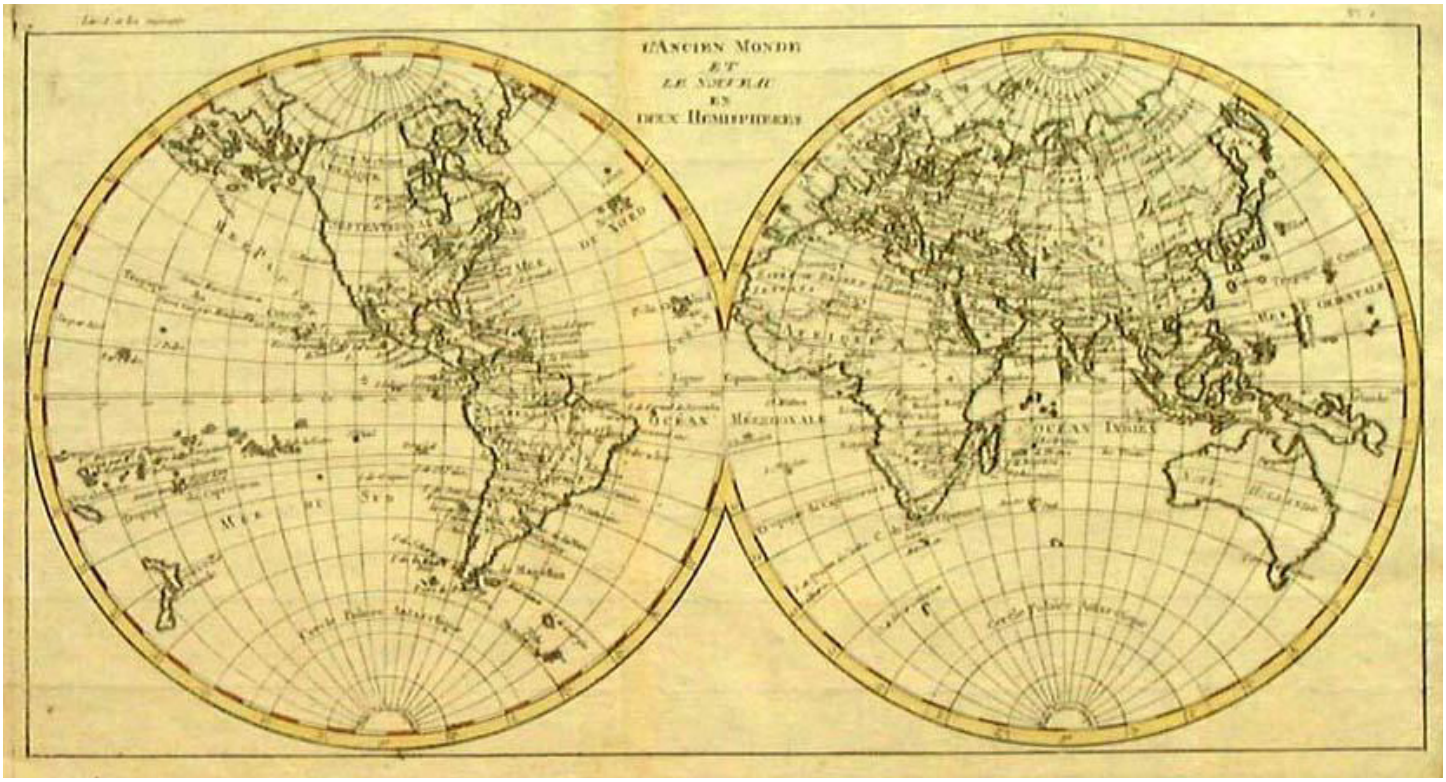

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Education and Economic Growth: From the 19th to the 21st Century

Executive Summary

The research summarized in this article shows that schooling is necessary for industrial development. The form of schooling that emerged in the 19th century generates specific cognitive, behavioral and social knowledge that are critical ingredients for the way industrial societies organize:

- production and consumption
- daily life in cities and nations
- the size and fitness of the population for work
- the creation and use of knowledge.

Therefore, it is documented that:

- Schooling is a necessary but not sufficient condition for the spectacular feats of industrial development in the 20th century.
- The intricacy of the relationship between schooling and the industrial form of economic growth is confirmed by the technical economics literature.
- Economists have demonstrated that both individuals and societies gain from the investments made in schooling.

That education is an essential ingredient of prosperity is at once obvious and contentious. Obvious because any person able to read this text knows what a difference it makes in their lives to have gone to school, to have learned to read, write and calculate. Contentious because when social scientists try to "prove" that education is a cause of economic growth it turns out to be quite difficult to decide which came first, the chicken or the egg. What is more, even the basic terms such as "what is education" and "what is prosperity" become vast and cloudy terrains for the technical experts like economists, sociologists, education specialists and policy analysts.

This article offers one way of arriving at a single overarching generalization about the relationship between education, defined as the classroom school system that has been the predominant way of organizing formal education throughout the 20th century, and economic growth, defined as the monetary aggregate GDP (gross domestic product) that is used widely by economists and the press to measure the economic performance of industrial societies. Over the following pages it is argued that the specific form of education system, characterized by universal compulsory classroom schooling, is an indispensable component of an industrial growth society. This is a broader, more historically grounded hypothesis that aims to encompass the wide range of economic, social and political reasons for associating education with growth. It is a hypothesis that rests on clarifying the role of one specific way of organizing learning, universal mass compulsory classroom schooling and the preponderant kinds of knowledge that emerge from this process, with the creation of one particular form of prosperity, typically summarized by the metric of gross domestic product (GDP).

The hypothesis is that making investments in all the elements of a school system (teachers, buildings, text books, information technology, curriculum, supervision, testing, etc.) and then forcing young people to attend them (i.e. give up the income they might otherwise earn) is a necessary but not sufficient condition for expanding the gross domestic product of an industrial society. To be clear, the massive systems of universal compulsory schooling pioneered in the 19th century and "perfected" as well as extended to post-secondary education in the 20th century do not encompass all human learning—far from it. What people learn and know, the practices that are informed and inspired by experience and reflection, arise from all kinds of human activity. However the argument here is that the specific cognitive, behavioral and social knowledge, that is the basic result of a specific form of schooling introduced in the 19th century, played and continues to play a crucial role in spectacular feats of industrial development.

Economic Growth

There can be little doubt that the performance of industrial societies has been nothing short of amazing when it comes to generating monetary wealth. As Angus Maddison (2001) shows in his publication: The World Economy—A Millennial Perspective, GDP per capita in industrial nations exploded from around 1,000 US$ in 1820 to over 21,000 US$ by the late 1990s. Figure 1 below, also from Maddison (2007), provides a detailed global breakdown for the period 1950 to 2003. The evidence is overwhelming.

Where industry triumphed so did GDP growth. In Western Europe GDP per capita jumped from just over 4,500 US$ to almost 20,000 US$. In Japan the leap was even greater, from around 2,000 US$ in 1950 to over 20,000 US$ in 2003. With the exception of China, where the recent growth spurt is impressive when seen from the perspective of such a low starting point, those parts of the world where the development of industrial society either stagnated or declined show much lower growth rates of GDP per capita.

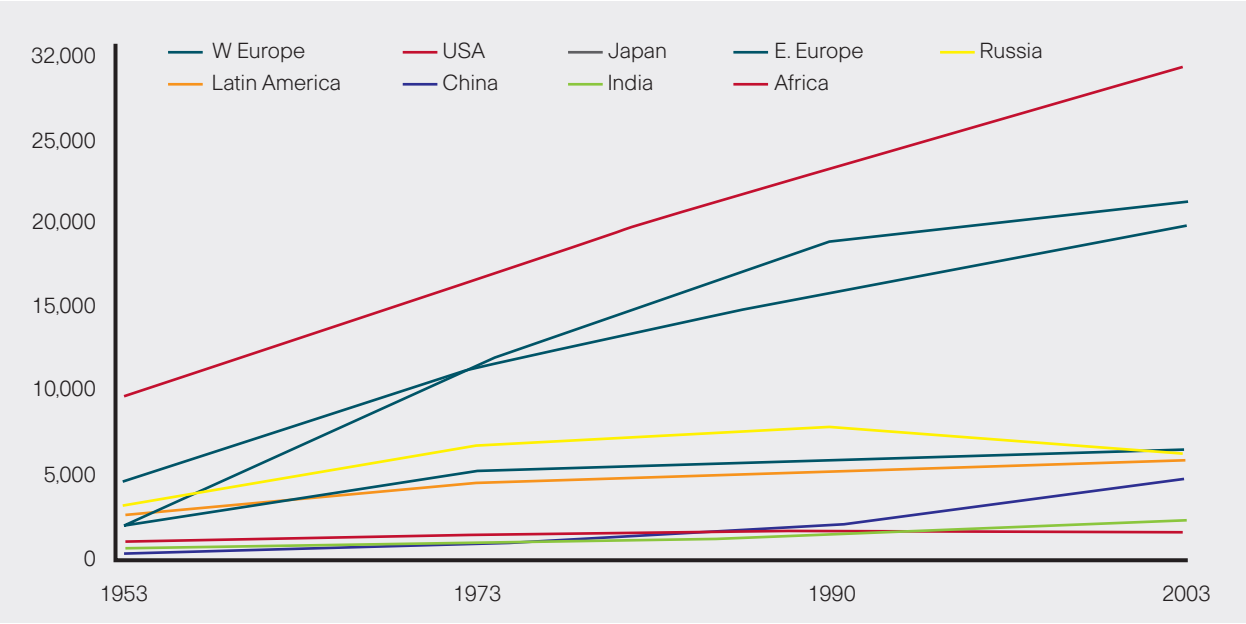

Figure 1: Growth of per Capita GDP: the World and Major Regions, 1950–2003. Level in 1990 Internationl PPP $
Source: This chart is based on data from: Angus Maddison, Chapter 7, Table 7-3, Contours of the World Economy, 1-2030 AD, Oxford University Press, 2007, forthcoming. www.ggdc.net/Maddison

Education Growth

A similarly spectacular expansion of participation in education as measured by school enrolment rates can be seen over the same period. Historical estimates for the year 1900 put participation rates in primary education at under 40% of the corresponding age group in most parts of the world, except North America, northwestern Europe and Anglophone regions of the pacific, where the rate was 72% (Cohen and Bloom, 2005, p. 10). Now, more than a century later the "net enrollment rate"—which is a stricter definition of participation—shows that most of the world is above level of the "high education" regions at the dawn of the 20th century. Figure 2 shows that by the early 21st century (2004) every part of the world had achieved, at a minimum, the level attained by the most industrialized countries at the start of the 20th century and most far exceeded the levels of a century earlier.

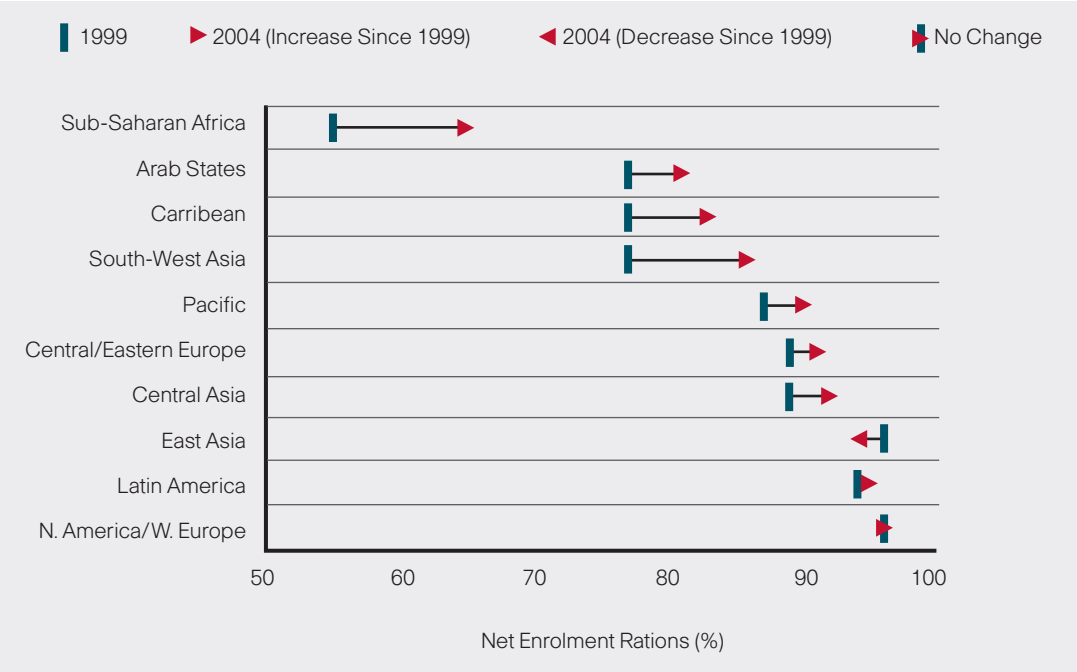

Figure 2: Net Enrolment in Primary Education Worldwide 1999 to 2004
Sources: Education for All, UNESCO, 2007, p. 1.

Of course, as is underscored by the important efforts to realize the United Nations Millennium goals of Education for All, there is still a long way to go. The 2007 Report (UNESCO, 2006) indicates that worldwide, in 2004, 781 million adults (one in five) still do not have minimum literacy skills and that close to 77 million children of school age are not enrolled in school (Table 1).

	1999	2000	2001	2002	2003	2004
Not in Primary School	110,244	107,852	105,307	107,395	101,038	91,032
Not in School	98,172	94,787	92,379	93,824	86,828	76,841

Table 1: Estimated Numbers of Children Out of School 1999–2004 (thousands)
Source: UNESCO, Education for All, 2007, p. 28

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Looking at the degree of educational attainment in terms of the average number of years of schooling for the adult population—a measure that tells how many years of schooling have been accumulated—shows that in OECD countries the average stands at just under 12 years (Figure 3). Worldwide progress is being made towards this level but as UNESCO reports there are still many parts of the world where the obstacles are very significant—including problems with enrolment rates, gender inequality, and school quality (UNESCO, 2006, p. 64).

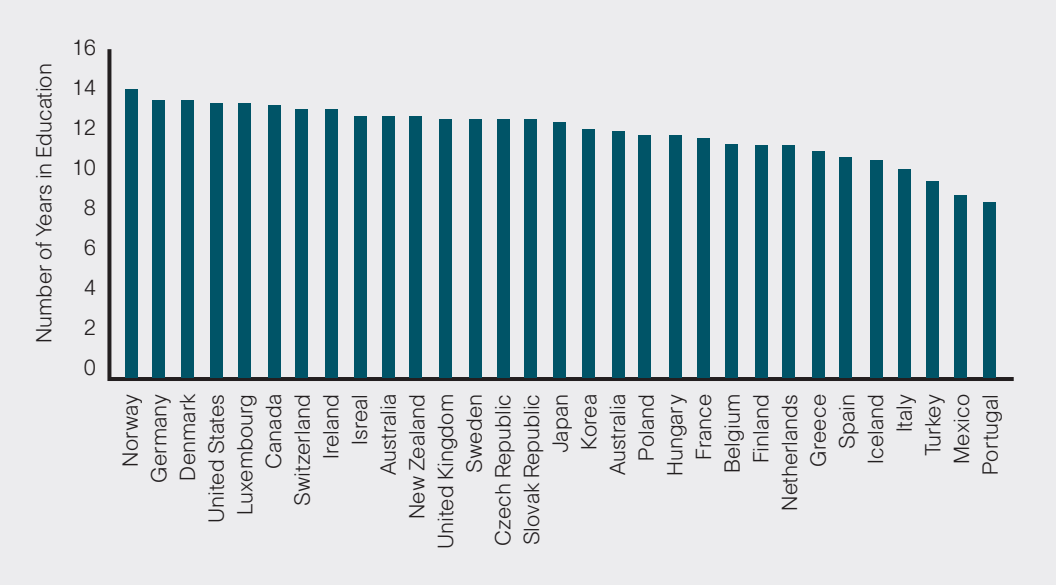

Figure 3: Educational attainment of the adult population: average number of years in the educational system for the OECD countries 2004.
1. Year of reference 2003.
Countries are ranked ind ecending order of average number of years in the education system of 25-to-64 year-olds.

Source: OECD, Education at a Glance, 2006, p. 28.

The Overall Argument

As the previous two sub-sections indicate, there is strong evidence from the recent past that economic growth has been accompanied by growth in both spending and participation in schooling. Economists, as reported in a brief overview in the next section, have examined this association quite carefully and come to the conclusion that, through a variety of different avenues and in a number of different ways, investment in school systems does have a strong economic pay-off. This is an important conclusion that is highly relevant to individual, corporate and government decisions regarding investment. For all spheres of decision making there is good evidence that the rate of return is high, even relative to other investment opportunities.

However, the two main components of this relationship—schooling and income growth—are both very specific, even narrow ways of looking at two broader questions: learning and well-being. Indeed neither GDP nor schooling emerged full-blown on to the stage of history. There were many experiments, many reactions and much reflection before today's familiar indicators and institutions gained universal currency. It may seem like a long-forgotten historical story, but measures of national income like GDP are the result of protracted economic and intellectual processes. In the same way that universal compulsory schooling did not always exist nor did it become a fixture of social life over night. GDP and schooling, each in its time, was a radical idea, perhaps more radical than any of the policy initiatives that are commonly debated today.

Now, however, it is becoming clear that the way we think of learning and economic wealth are changing. There is little controversy over the observation that the many kinds of knowledge acquired through industrial era schooling are only part of what a person knows. Equally accepted is the notion that industrial wealth as measured by GDP is only part of overall societal wealth. Such conclusions may seem obvious as attention shifts to concerns about quality of life, community caring, the environment and other often non-monetary aspects of people's lives. But this recognition also underscores the historical specificity of these ways of looking at the world around us. And it also signals that the construction of basic ways of doing things, like schools for learning, and measuring things, like GDP for wealth, are time specific.

Neither schooling nor national income accounts were prescient constructs, built with a foreknowledge of how each would serve to facilitate the achievements (and failures) of industrial societies. On the contrary, history is too rich and complex, the future too unknowable, for anything but ex-post accounts of the "inherent" logic of choices in the past. Even though it is now clear that both metrics, years of schooling and GDP, are particularly well suited to the way production, consumption and, in a general way, daily life are all organized in industrial society. It would be wrong to see either as eternal or self-evidently useful. Hence what will serve in the future must remain an open question. Part of being open to such questions involves situating, on the basis of hypotheses and analysis, why and how relationships like that between years of schooling and GDP exhibit particular patterns over particular periods of history and phases of socio-economic development. In other words, as discussed in the next section, the analysis of the relationship between years of schooling and GDP offer important insights precisely because these concepts depended on and contributed to the emergence and evolution of industrial society.

With the objective of understanding the relationship between school systems and economic growth, this paper is organized around the hypothesis that there are four roles or functions that schooling (a specific form and content of learning/knowledge) performs (more or less well in different places at different times) in industrial society (a specific but evolving way of organizing and defining wealth creation). Thus, from an economist's perspective, universal compulsory schooling systems play a role in the constant and on-going process of industrialization in four broad and essential ways:

1. Diffusing and inculcating the organizational attributes of industrial methods of production and consumption;
2. Diffusing and inculcating the organizational attributes of anonymous urban life, mass-citizenship and the administrative state;
3. Augmenting the size and fitness of the population available for increasing the division of labor in industrial work and life; and
4. Improving the overall societal capacity to produce, accumulate, depreciate and diffuse knowledge.

The importance of these attributes for the functioning of industrial society, at a minimum as a transaction space (product and labor markets), is often overlooked. Today we take for granted many of the basic attributes that make the functioning of industrial societies more efficient, including the simple fact that:

- most people speak and read a common language;
- the majority of people are punctual (on-time) and respect authority (obedient);
- people find it routine to cooperate with strangers at work and in their local community;
- adults can participate in the labor force without putting their children at risk and children do not compete with their parents in the labor market.

These conditions did not always pertain in today's industrialized societies. And, as is painfully obvious, these conditions do not currently pertain in many parts of the world where basic social order has broken down. The point is not to argue that some sort of ideal uniformity or dictatorship is necessary. Rather the point is that historical processes have created the conditions for open transactions and high levels of interdependency, diverse expressions of freedoms and internalized responsibilities. And that by understanding the enabling and limiting role of schooling in this process of social evolution current decisions can be put in context.

This paper focuses on the role of the industrial form of schooling, invented in a burst of creativity and experimentation that marked the industrial revolution, in creating the awareness, acceptance and reflex expectations for many basic attributes of industrial work and life. The hypothesis is that the universal and compulsory classroom method of schooling is such a critical ingredient for the transition from both agricultural to industrial production and from rural to urban life because it is a highly effective means for achieving the four functions outlined above. In other words the pay-off from a specific way of organizing learning is linked to a specific way of organizing economic and social activity.

Obviously one of the underlying assumptions behind this way of looking at the relationship between years of schooling and GDP growth is that societies change over time. For the arguments presented here a further assumption has been made, that the industrial economies that have had the highest rates of GDP growth over the last two centuries exhibit a compositional form of change. This is a form of change where leading sectors, with leading skills (for example recently IT) attract investment and generate jobs, while declining sectors with failing markets (for example in the past horseshoes) become not only less important in the overall share of output but also lose influence over the expectations and behavior of society.

Figure 4 is one way of illustrating how compositional change transforms the economic landscape. Again, it is not some prescient plan cooked up and implemented implacably by some all powerful authority that gradually marginalized agriculture. Indeed in many ways agricultural society maintains its presence through the long-arm of the seasonal cycle and the farm subsidies that still shape many choices today. Nevertheless, what did happen is that industry grew, along with the overall pie, such that gradually the industrial forms of organizing production, consumption and every-day life became predominant.

Figure 4 makes no pretension at predicting the future. On the contrary, its imaginary trends are intended to clarify the historical specificity of the main hypothesis of this paper. Specifically, that the role of particular institutions (schools) are connected with specific ways of organizing society (industrial) and that the synergies between the two come out of a process of compositional change. Consequently it is not unreasonable to expect the congruence or synergy of institutions related to a virtuous circle of reinforcing behavior, competencies and expectations to shift over time as the composition of socio-economic activity changes. Accepting this proposition then helps to provide insights into why simple macro-economic returns to more years of schooling, as analyzed in the technical economics literature below, seem to be declining as countries get further along the path of industrial development.

Why bother to do this? Because it is the contention of this paper that putting the relationship between schooling and economic growth into this kind of long-run historical perspective offers insights into why this relationship changes over time and from place to place. Societies differ across time and across space, so it is only to be expected that the relationship between this specific form of learning (schools) and a specific form of growth (industrial) will also differ. The question is in what ways. This article only begins to explore this question, largely by showing how powerful schooling has been for industrial growth.

The following text is divided into two sections. Section 1 offers a selected overview of the immense and highly technical economics literature on the relationship between education and economic growth. Section 2 looks at each of the four areas where schooling contributes to the evolution and wealth creating capacity of industrial society and then concludes very briefly by considering an imaginary extrapolative scenario of spending on schooling systems to 2030.

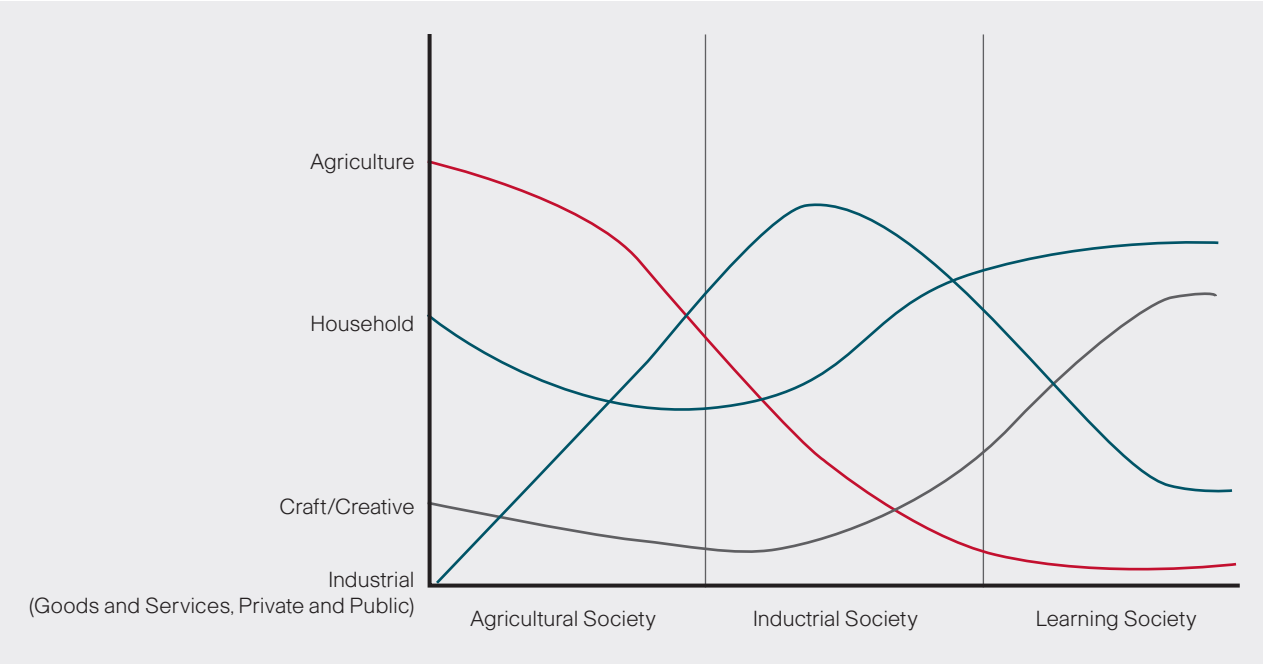

Figure 4: Imagining Changes to the Composition of the Sources of Total Value Production
Source: Riel Miller, Xperidox

Section 1—Education and Economic Growth

The relationship between economic growth and education has been one of the central threads of economic analysis. Both Adam Smith in the 18th century and Alfred Marshall in the 19th century, two important figures for the economics profession, addressed the question of how individual investments in "education" influence the wealth of nations. Throughout the 20th century, as Krueger and Lindahl (2001) point out in their survey of these issues, modern professional economists have been attempting to develop empirical estimates of the relationship between education and economic growth. Some of the most famous names in late 20th century economics made their reputations studying the question of individual returns to investment in education. Jacob Mincer (1974), Gary Becker (1964) and a long list of researchers inspired by their work have produced hundreds of books and papers.

Much of this literature is highly technical in the sense that it uses formal econometric models to test hypotheses using empirical data. Some highlights of this impressive work will be sketched below, but the bottom line is that the economic evidence supports the view that both public and private returns to investment in education are positive—at both the individual and economy-wide levels. The vast technical literature on this subject can be subdivided into two general areas:

a. The micro-economic literature looks at the relationship between different ways of measuring a person's educational achievement and what they earn. Most studies show consistent results for what can be called the private or personal pay-off from education. For individuals this means that for every additional year of schooling they increase their earnings by about 10%. This is a very impressive rate of return.

b. The macro-economic literature examines the relationship between different measures of the aggregate level of educational attainment for a country as a whole and, in most cases, the standard measure of economic growth in terms of GDP. Once again, most studies find evidence of higher GDP growth in countries where the population has, on average, completed more years of schooling or attains higher scores on tests of cognitive achievement. However, as will be explained in somewhat greater detail below, given the diversity of national experiences, particularly over time, it is hard to settle on one figure for the rate of return at a social level.

The rest of this section treats each of these areas in turn.

a. Micro-economic evidence on schooling and income.

> Each additional year of schooling appears to raise earnings by about 10 percent in the United States, although the rate of return to education varies over time as well as across countries.
> —Krueger and Lindahl (2001)

The micro-economic literature has, for the most part, studied the relationship between two specific variables: the number of years of schooling and wages. Picking these two indicators is generally justified along two lines. One is that analyzing these two variables can provide insights into the basic economic hypothesis that people who go to school (number of years) are more productive (earn higher wages). The other justification is that data on years of schooling and wages are available for study while other indicators are not. There are a myriad of difficulties with testing this main hypothesis using these variables, leaving aside the fact that any data set will have errors and/or fail to capture the underlying causal factors that a social scientist is trying to isolate.

One of the difficulties is how to distinguish between the impact of differences in innate ability and of schooling when it comes to the incomes people earn. In other words, it could be true that people who go to school longer are just more able in some way that is unrelated to schooling. In which case it could mean that variable that measures the number of years a person spends in school just captures differences amongst people related to their innate abilities and not something that is actually influenced by what happens to that person while they are in school. The fact that the variable for more years of schooling is correlated with higher income could simply mean that people who are more able earn more - in which case schooling does not really matter.

Other similar types of problems arise from the use of years of schooling and income to test the hypothesis that more education makes a person more productive. For instance more years of schooling may just represent another more important factor in the determination of income, like social differences related to parental background; or the fact that specific communities have access to specific networks (plumbers instead of bankers); or certain social groups have particular ways of speaking, dressing, behaving, etc.. Alternatively there may be a social or signaling bias that leads to giving higher wages to people with more years of schooling (credentials like high school diplomas, university degrees, etc.) despite the fact that these people are not actually more productive (Bowles, Gintis and Osborne, 2001). In this case the problem with the economic research is not only that years of schooling may be unrelated to productive capacity but also that productive capacity may be unrelated to earnings.

However, on balance the economic literature has been able to take into account most of these difficulties and as depicted below in Figure 5 from Krueger and Lindhal (2001, p. 1104), the longer a person goes to school the higher their earnings. In addition, recent work has been able to take advantage of advances in data collection to move beyond the quantitatively biased measure of years of schooling to look at the arguably more qualitative and accurate measure of cognitive achievement (Hanushek and Wößmann, 2007). While the time spent in school may or may not be related to acquiring knowledge or status that has a bearing on earnings it seems logical to think that a person's score on a test of cognitive achievement should have a bearing on how productive they are in the economy. Although, as noted in the introduction, it is important to recognize that notions of cognitive achievement and the relationship of such "skills" to productivity also change over time.

Hanushek and Zhang (2006) look at the evidence for a positive relationship between test scores and income. Their results, presented in Figure 6 below, show that in places like the US and Chile the rate of return for higher test score results is roughly in line with findings from other studies on the returns for additional years of schooling, around 10%. Their estimates of the relationship between an individual's years of schooling and income are somewhat lower after adjusting the basic equation to include literacy test scores.

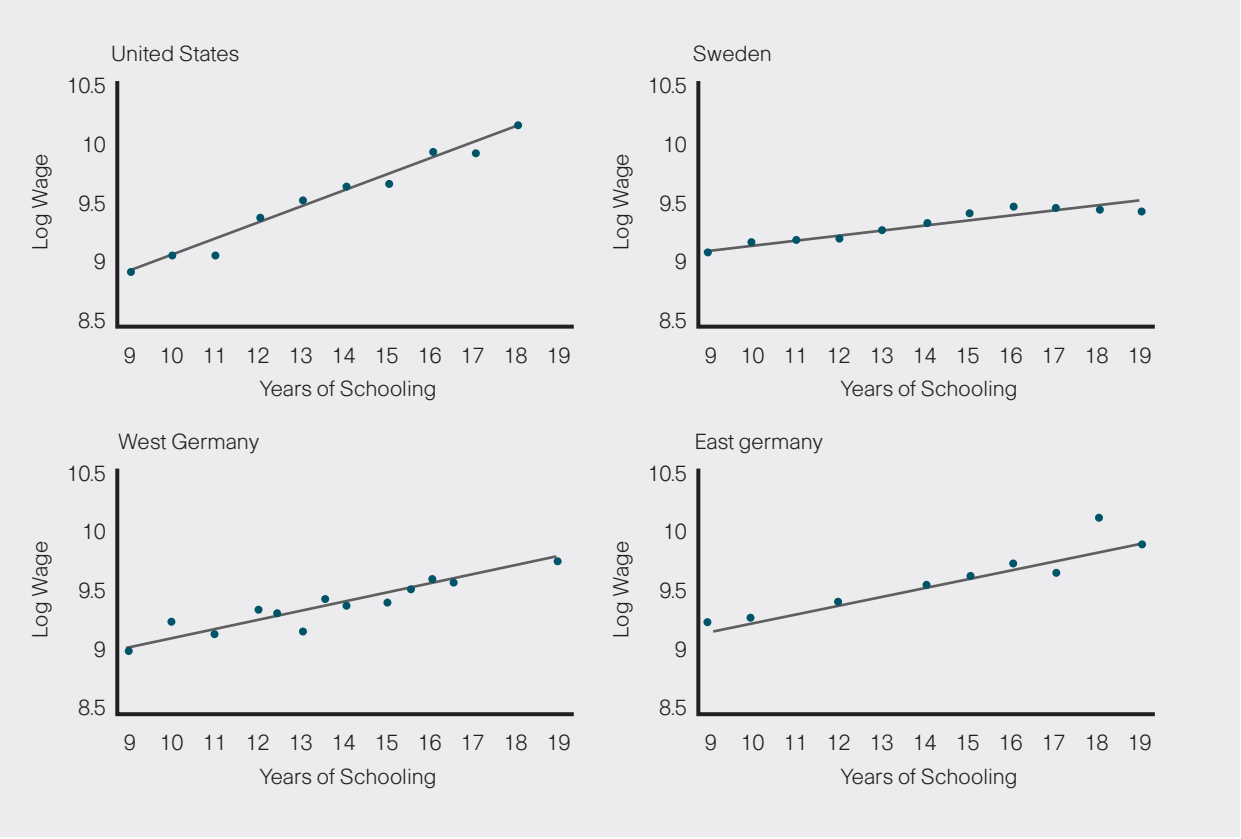

Figure 5: The Relationship between Years of Schooling and Wages for Four Countries Unrestricted Schooling-Log Wage Relationship and Mincer Earnings Specification
Source: Krueger and Lindhal (2001, p. 1104)

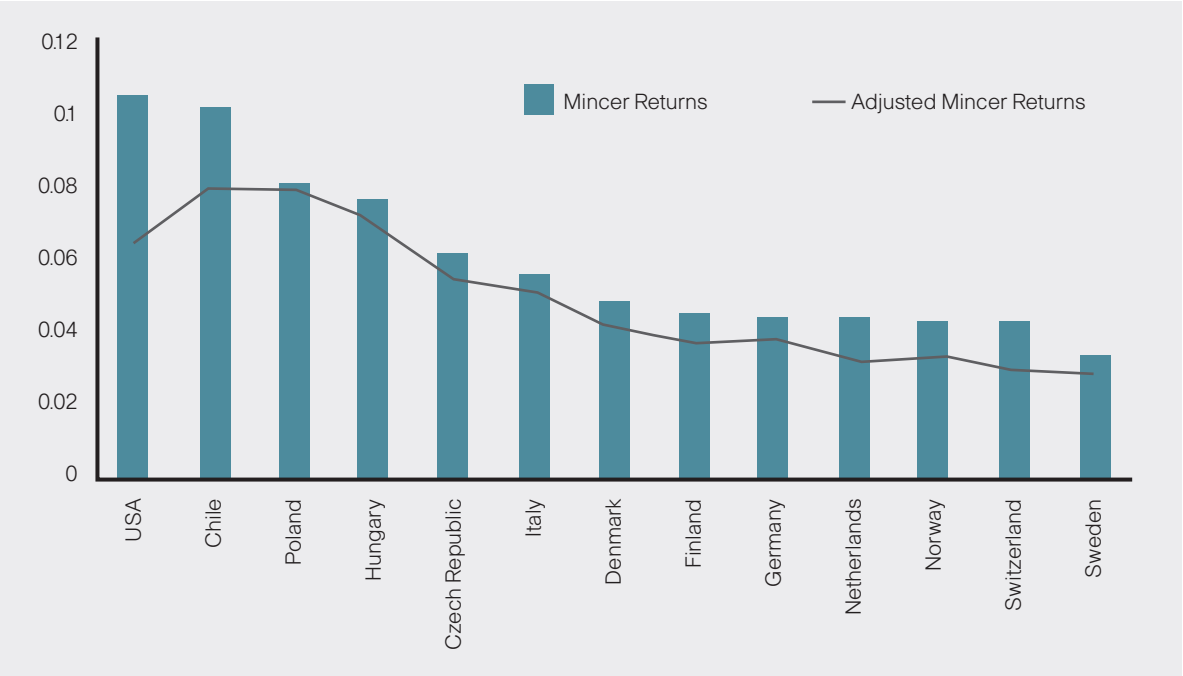

Figure 6: Returns to School Attainment, International Adult Literacy Survey
Source: Hanushek and Zhang (2006)

Finally, for the micro level evidence, Figure 7 from the OECD confirms the basic message regarding the measured relationship between specific levels of educational achievement, in this case a university-level degree that follows on directly from high-school, and what a person earns.

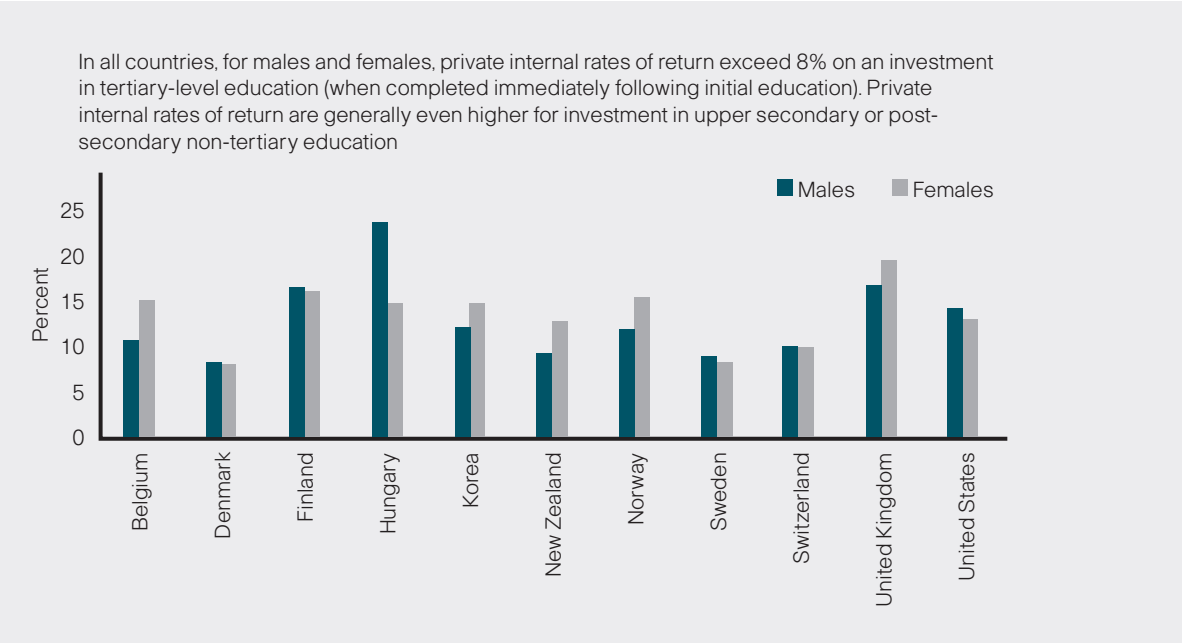

Figure 7: Private internal rates of return for university level achievement in OECD countries
Source: OECD, Table A9.6. See Annex 3 for Notes (www.oecd.org/edu/eag2006).

Despite the apparent strength of these findings it is important to note that there are also strong reasons for questioning what exactly is being measured and if there are not other factors that might account for the positive relationship between years of schooling and earnings. As Hanushek and Wößmann (2007) point out, the relationship between school quality and test scores is not all that straight forward since other factors like parental background and location may be even more influential on test outcomes than years of schooling or school quality. Indeed one of the main challenges to the econometric analysis is to disentangle the factors that account, in different contexts and in different points in time, for differences in both the levels and changes in the levels of cognitive test outcomes.

Furthermore, even if the link between schooling and what people know when measured by mathematics or literacy tests can be nailed down, there is still an important open question about how wages levels are determined. As Bowles, Gintis and Osborne (2001) point out, there is good evidence that:

... a major portion of the effect of schooling on earnings operates in ways independent of the contribution of schooling to measured cognitive functioning. Correspondingly, the contribution of cognitive functioning to earnings is substantially independent of schooling (p. 1151).

What this means is that the relationship between schooling and economic success remains evident, but the question of why is not as clear. Certainly, to conclude this brief look at the micro-level debates, both years of schooling and levels of cognitive achievement are associated with higher earnings for individuals. However, discerning the specifics of when and where the returns are higher or lower remains difficult due to the complexity of each individual's circumstances. History matters and the reasons why an engineering degree pays better than a teacher's diploma change over time, along with the economic, social and political conditions. As discussed in the next sub-section societal or macro-economic analyses provides a different vantage point on why at specific points in time, in certain places and for particular groups of individuals, the returns to investments in education may be higher (or lower).

b.Macro-economic evidence on schooling and economic growth.

The OECD Growth Project estimated that in the OECD area, the long-term effect on output of one additional year of education in the adult population generally falls between 3 and 6%.
(Education at a Glance, 2006, p. 154).

As discussed briefly in the introduction, a more educated population improves economic growth in a wide variety of ways. Most of the technical economics literature, anchored in a specific model of production where output (Y) is a function of inputs capital (K) and labor (L) and using different theories of the economic growth , looks at three basic links between schooling and growth (Hanushek and Wößmann, 2007, p. 23). One, building on the micro-economic analyses outlined in the previous sub-section, sees the causal chain flowing from schooling, to skills, to greater worker productivity, to increased growth of national income (or at least potential growth, since there may be unemployment at the macro level that reduces actual growth). The second link flows from the role of education in enhancing innovation in the economy as a whole and is related to what economists call endogenous theories of growth. The third picks up on the innovation dimension but more from the diffusion than creation perspective, seeing an educated population as crucial for the spread of new processes, products and technologies.

Unlike the micro-economic analyses discussed above these studies do not try to relate the number of years an individual spent in school to their income but rather tries to assess the aggregate level of education in the society as a whole to aggregate national income (level and/or growth rates). In the literature this is called the social as opposed to the private return on education. Here again, like with the micro-level research there are important definitional issues related, once again, to questions such as the quantity versus quality of schooling and is an economy comparable over time as it changes, for instance from one where heavy manufacturing plays a lead role to one where lighter high-technology industries and the service sector are more important. What then can be concluded from this voluminous literature?

Studies that compare different countries over a period of time, such as the study by Barro (2002), that looks at 100 countries from 1960 to 1995, show results as in Figure 8. What this figure shows is that "years of school attainment at the secondary and higher levels for males age 25 and over has a positive and significant effect on the subsequent rate of economic growth" (Barro, 2002). This can be interpreted to mean that if the average number of years of upper level schooling for this particular group increases by one year then the rate of economic growth increases by 0.44 percent per year. These are powerful results since an increase in economic growth of almost half a percent will have a large impact on the total GDP of a country over time. This is one of the reasons that education has been treated as such a positive investment for governments.

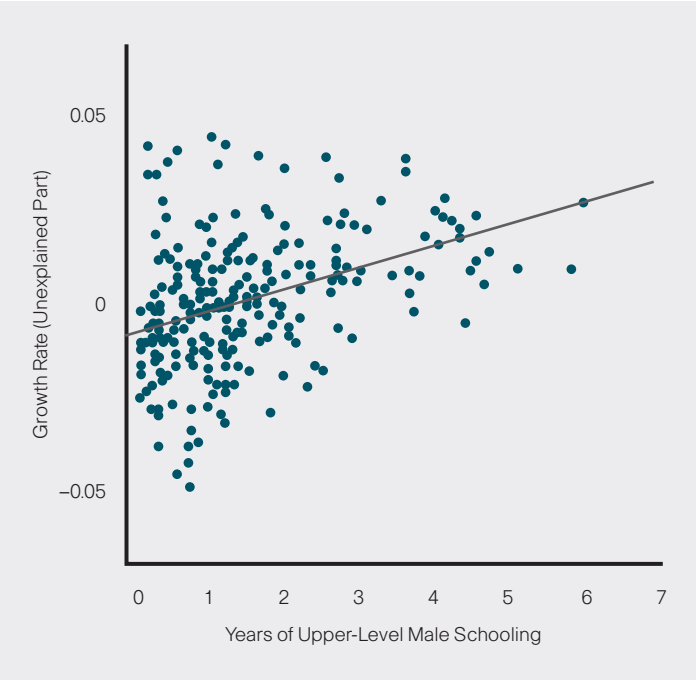

Figure 8: Growth rates and years of schooling for men age 25 and over
Source: Barro, Robert J. (2002), "Education as a Determinant of Economic Growth." Edward P. Lazear (ed.) Education in the Twenty-first Century, Palo Alto, The Hoover Institution, pp. 9-24. [Note the term "unexplained" part means that aspect of growth that is not already "caused" by factors other than education, like capital investment.]

However, as has already been noted, there are a number of unresolved issues raised by these studies. Some economists have questioned the quality of the data being used to make the calculations (Krueger and Lindahl, 2001) and others have focused on the basic causal thesis that underpins studies based on number of years of schooling across time and countries. This questioning was fueled by empirical findings, like those of Bils and Lenow (2000) that showed that:

"...the channel from schooling to growth is too weak to plausibly explain more than one-third of the observed relation between schooling and growth. This remains true even when we take into consideration the effect of schooling on technology adoption. Thus our primary conclusion is that the bulk of the empirical relationship documented by Barro and others should not be interpreted as reflecting the impact of schooling on growth." Mark Bils and Peter J. Klenow, American Economic Review, Vol. 90, No. 5, Dec. 2000, p. 1177.

Spurred on by these controversies recent developments in the technical economics literature, in part made possible by new data sources on cognitive achievement, have opened up some new insights into the relationship between schooling and economic growth. What is particularly fascinating is the contrast between the earlier work based on years of schooling (levels or rates of change) and the results provided by attempts to account for the quality of what people know. Hanushek and Wößmann (2007) take this approach. Their findings, depicted in Figure 9 below, show a significant impact of improved test scores on economic growth after controlling for the initial level of GDP per capita and for years of schooling, for a sample of 50 countries for the period 1960 to 2000.

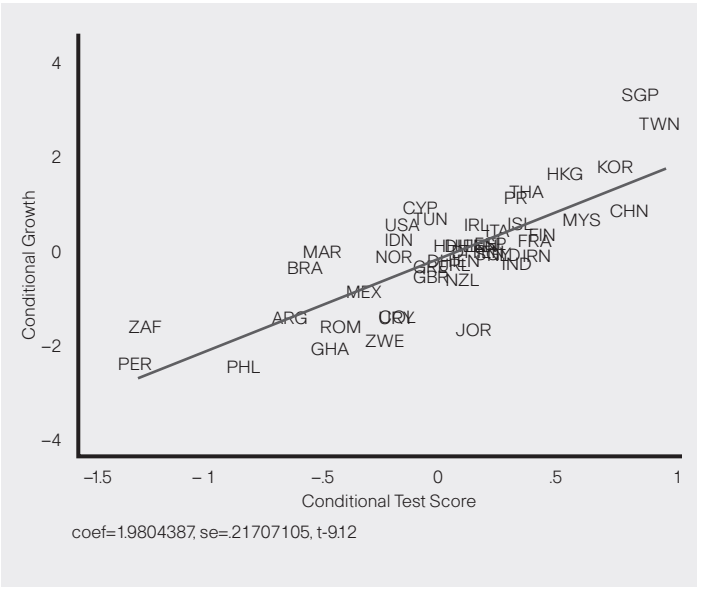

Figure 9: Adding Cognitive Achievement to the Growth Equation
Source: Hanushek and Wößmann, 2007, p. 33.

The consensus of the existing studies is that education does make a difference for the growth of national income but that it is a complicated picture that depends on how different aspects (quantitative and qualitative) of both the economy and education system interact. As the OECD recently summarized:

> "The research indicates that literacy scores, as a direct measure of human capital, perform better in growth regressions than indicators of schooling. A country able to attain literacy scores 1% higher than the international average will achieve levels of labour productivity and GDP per capita that are 2.5 and 1.5% higher, respectively, than those of other countries." (OECD, Education at a Glance, 2006, p. 155)

Does the kind of education matter?

The technical economics literature presents intriguing if somewhat difficult to interpret results. Many results look to be consistent with the hypothesis that different phases of industrial development privilege different aspects of what might be generally understood as human capital. There is evidence that "countries with relatively more engineering college majors grow faster and countries with relatively more law concentrators grow more slowly" (Hanushek and Wößmann, 2007, p.41). This means that the kinds of graduates and the kinds of occupations that are dominant in one society over another changes economic performance. Explaining this correlation is another challenge. It might be due to a more fundamental change in the way growth, particularly increases in productivity are achieved in a society that is moving towards a higher priority (and share of spending) on qualitative as opposed to quantitative aspects of life (services not goods). It might be some other factors that still need to be explored. However it does seem reasonable to expect that the structure of the economy as well as the role of the education system in shaping the structure (mix) of skills in the economy can be more or less well matched to different socio-economic contexts, such as early or advanced industrialization.

On the face of it, for instance, there is an interesting association between the growth take-off in China and the rate of investment in graduating engineers. Figure 10 shows recent data on the trend in engineering and technology PhD degrees of the United States, China and India. Of course it is important to keep in mind that these rates are absolute numbers, not representative of the comparative quality of the graduating PhDs, and that it will take many years for per capita convergence. Furthermore, the nature of global flows of sourcing and ideas may be changing so that the links between occupations and economic activity at a local level may be changing as well. Certain systemic "weak signals", meaning phenomena that could signify a significant pattern under different conditions, like co-production or the "democratization of innovation" (Von Hippel, 2005) might even shift the economy away from the industrial way of dividing conception and execution. This could mean that the role of engineers, or designers in a more general way, would change as well.

Once again, it is important to keep in mind that the relationship of particular skills and institutions to wealth creation can change over time. The role of engineers in the industrialization take-off in China or India may not necessarily follow the pattern experienced by today's wealthy industrial countries. Indeed the expansion of engineering talent on a global basis combined with the ability to inter-connect on a global basis could accelerate the marginalization of the old industrial innovation model by increasing the efficiency of technical design that is able to service DIY (do it yourself) and other forms of co-production.

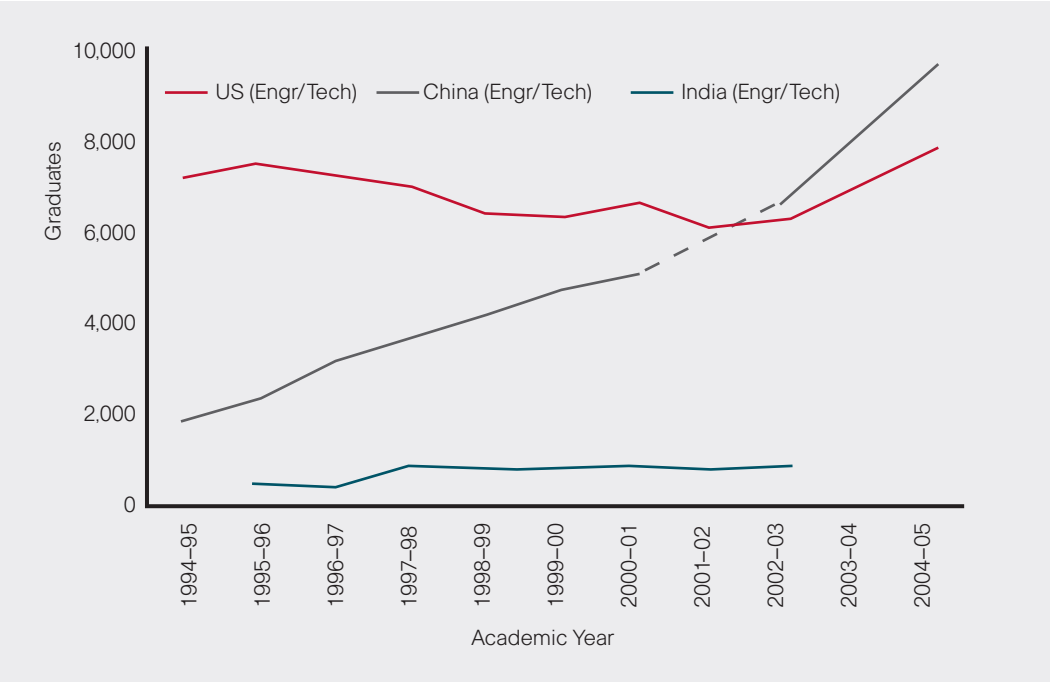

Figure 10: Ten-Year Trend in Engineering and Technology PhD Degrees in the United States, China, and India
Source: Wadhwa et. al. (2007) http://www.issues.org/23.3/wadhwa.html . Note: 2001-02 Chinese data (hashed line) from the Ministry of Education represent a significant outlier and were removed from the analysis.

Conclusions from the technical literature

The contrast between earlier econometric work, done without the benefit of more recent efforts to collect data on the qualitative aspects of what people know (cognitive achievement tests), shows a fascinating paradox. One that suggests that there may be an important difference in the way schooling impacts on economic growth depending on what might be called the stage of industrial development. Not much formal work has been done to test this hypothesis, but contrasting the results from the analyses of the effect of number of years of schooling on growth with those that try to capture cognitive achievement does suggest that the pay-off from inculcating the population in the basic behavioral aspects of industrial society declines over time.

In effect there is evidence from the econometric literature that shows a falling off of the macro-economic impact of years of schooling as countries become wealthier. But, once the studies adopt cognitive measures of achievement—ones that are not necessarily exclusively based on schooling but reflect the broader context for learning specific cognitive skills—then the high pay-off returns. The latter evidence may still not capture knowledge society dimensions of learning since most of the cognitive tests remain fairly narrowly focused on industrial era skill sets. However the paradox remains—in certain cases years of schooling has high rates of return and in others cognitive achievement.

Following this line of thought suggests that it is important to take into account the differences that distinguish, for instance, a sub-Saharan country struggling to establish basic socio-economic foundations from an Eastern European nation entering the European Union. In the case of Eastern Europe the highest returns may be at the secondary and tertiary levels of education, while in the less developed nation there may be a very high payoff—not just in income—from primary schooling. Indeed there is considerable evidence from the development literature, regarding the importance of increasing girl's participation rates in primary education, that underscores how differences in stages of economic and social development can alter the impact of schooling (UNESCO, Education for All, 2005).

Of course it is important to take into account not only differences across time in the same place but also across places at the same time. For example the much higher returns to advanced levels of schooling in developed countries can lead to an exodus of people from poorer countries. Or, it could be argued, an unmerited (from a rate of return perspective) investment in higher education by places where the really big payoff is from primary schooling. However, from a longer-run perspective it is difficult to draw conclusions in this area. For instance, the long-run implications of "brain drain" are far from clear since the direction of flow and level of return can change as a country moves through different stages of development. A case in point is the important role of highly schooled individuals returning to India and China in recent years because the boom conditions offer even greater rewards. Equally pertinent is the experience of countries like Canada that were able to leverage links to England and the United States to build up a strong post-secondary system. Furthermore, in the context of global knowledge sharing the role of an international network of students studying in foreign lands may be more important than is currently recognized.

From a more general perspective, there is overall agreement that more and better schooling is an important way to improve economic growth. Figure 11 below portrays one version of this argument by showing how school reforms that improve cognitive achievement can payoff for economic growth. The logic of Figure 11 rests on the causal chain from school reform to better cognitive results—meaning an improvement in the test scores for the population as a whole over time—to economic growth. In Figure 11 Eric A. Hanushek estimates the returns from the introduction of school reforms that improve test scores. He argues that school reform takes time to have an impact on the test scores and to become influential on economic performance overall. Figure 11 below shows the very significant gains in percentage of GDP arising from school reform. The faster the impact of the reform on cognitive test scores the larger the impact on GDP.

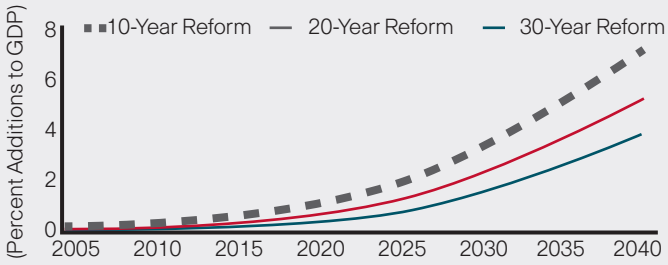

Figure 11: Possible Growth Dividends from Schooling Reforms that Improve Cognitive Achievement.

Source: Hanushek, "Finance and Development, IMF, June 2005, p. 17

However, even if there is a direct link between specific types of school improvement and better test scores, there is still much that remains to be explained in terms of how test scores relate to economic performance. Certainly progress is being made in broadening the coverage of empirical analyses to include more factors and potentially offer evidence that helps to deepen the connection to major historical changes. Still it is important to keep in mind that the metrics being used so far, despite recent improvements, remain quite restricted.

Section 2—Schooling, the Emergence-Evolution of Industrial Society and the 21st Century

> In the eighty years or so after 1780 the population of Britain nearly tripled, the towns of Liverpool and Manchester became gigantic cities, the average income of the population more than doubled, the share of farming fell from just under half to just under one-fifth of the nations output, and the making of textiles and iron moved into the steam-driven factories. So strange were these events that before they happened they were not anticipated, and while they were happening they were not comprehended.
>
> —D. N. McCloskey, "The Industrial Revolution in Britain 1780-1860: A Survey," in Roderick Floud and Donald McCloskey, The Economic History of Britain since 1700

The social order around us everyday springs up each morning seemingly of its own accord. But everyone knows that our complex societies follow millions of familiar and largely accepted patterns. We do not reinvent social order from scratch at dawn. It is also very clear that there are societies that lose the thread or no longer trust the pattern of yesterday because it did not work through lack of basic success in providing the minima of life or the minimum of what people believe is important. Social breakdowns, in many forms, exist all around us. Social change is not the same as social breakdown, although sometimes change can provoke such breakdowns. The last few centuries have illustrated this many times in the revolutions, wars and crises that shook the world.

More pertinent in our day, as thinkers as diverse as Angus Maddison (2007), Francis Fukuyama (1999), William Baumol (2004) or William Easterly (2001) have all argued, is the difficulty of making the voyage from one kind of society to another. Chinese, Indian and Brazilian peasants are making this kind of voyage everyday, in the millions, as they leave their rural lives to move to the city

a. The role of the 19th century 'school system' in the transition to industrial society

What does this system do that is so crucial for industrial society and the kind of economic growth that is typical of industrial society?

1. Diffusing and inculcating the organizational attributes of the factory.

> "Attempts to reform British and American society from the 1830s on in what we now label the Victorian era were a monumental success. The impact on social capital in both societies was extraordinary, as masses of rude, illiterate agricultural workers and urban poor were converted into what we now understand as the working class. Under the discipline of the time clock, these workers understood that they had to keep regular hours, stay sober on the job, and maintain minimal standards of decent behavior." (Fukuyama, 1999, p. 268)

Key issues here are:

a. punctuality, obedience to non-fealty/non-divine authority,
b. faith in an external hierarchy of knowledge, acceptance of the pre-determination of tasks and objectives,
c. common language,
d. shared codes of group behavior in the workplace, acceptance of strangers,
e. basic definitions of collective-interests and self-interests.

2. Diffusing and inculcating the organizational attributes of anonymous urban life, mass-citizenship and the administrative state.

> "Among the Nandi an occupational definition of time evolved ... at 5:30 in the morning the oxen have gone to the grazing ground, at 6 the sheep have been unfastened... In Madagascar the time might be measured by 'a rice cooking' (about half an hour) or 'the frying of a locust' (a moment). The Cross River natives were reported as saying 'the man died in less than the time in which maize is not yet completely roasted' (less than fifteen minutes)."
>
> —EP Thompson, 1967

Key issues here are:

a. common language, capacity to find essentials like: a place to live, a job, food through written non-familial/non-tribal sources,
b. shared codes of group behavior in contexts like factories or urban agglomerations (punching-in, commuter train schedules, etc.)
c. acceptance of strangers,
d. facilitates articulation and expression of demand for mass-consumption and welfare state services by universalizing the experience of "outsourcing" formerly family-only or local-only functions—expands sphere of legitimacy/trust for material and immaterial, and
e. accepting/believing in the myths, codes that bond people to the national form of cooperation-interdependency.

3. Augmenting the size and fitness of the population available for increasing the division of labor in industrial work and life.
   a. increases the inter-changeable wage-labor ready proportion of the population for both goods and services production,
   b. relieves parents of working-day child-minding responsibility.
4. Improving the overall societal capacity to produce (acquire and invent), accumulate (maintain/remember) and depreciate (forget, denigrate) knowledge.
   a. increases the supply of workers with high cognitive and research capacities,
   b. alters the rates and methods for the diffusion of knowledge in society,
   c. provides a structure for creation and retrieval of knowledge.

The historical record and the evidence collected by social scientists are less definitive regarding the link between industrial society and either economic growth or social well-being. There are important examples of well schooled, mostly industrial societies – perhaps most prominently the former Soviet Union and China but also parts of Latin America – that failed to match the growth rates of Europe, Japan and North America. Mass compulsory schooling systems, even ones that generate relatively high rates of literacy, are not enough. Crucially it is how the specific behavioral and cognitive attributes generated by industrial schooling is used that is one of the main distinguishing features between the unstable, low growth industrial societies and the more stable, higher growth ones. Institutions (other than schooling), events and values are major factors shaping the way different kinds of knowledge are used and the economic payoffs associated with that use. Well schooled people working in a centrally planned economy do not perform as well as those working in more open market-welfare or mixed economies.

b.Education in the 21st Century

The 20th century was the education century. For the first time in human history the majority of the world's population learned to read and write (Cohen and Bloom, 2005). The introduction and spread of universal compulsory schooling, the daring and innovative mass education systems pioneered in the 19th century, made this happen. The 20th century also demonstrated that universal compulsory schooling is indispensable for economic prosperity and social well-being in an "industrial growth society" (IGS).

For the 21st century the verdict has not yet been pronounced. What we do know is that there are signs in the world around us already that point to an even more significant role, and potential payoff from investing in learning, although not necessarily always in schooling. This paper concludes with an imaginative scenario, a simple extrapolation of education spending worldwide to the year 2030. This kind of projection is familiar, it simply asks the question: what if existing patterns continue.

Global Education Spending to 2030

If it is expected, as many people do, that in the early decades of the 21st century the entire world will converge to the industrial model pioneered by countries like England, the United States, France, Japan, etc. in the 19th and 20th centuries. Then it is also to be expected that industrial era mass schooling systems will grow as the huge populations of the developing world reach the education levels of the developed world.

Equally if not more significant for education, particularly from a financial investment perspective, is the race amongst developed nations to increase the average number of years of schooling (including post-secondary education) of their populations. This race reflects, in many cases, the belief that a more innovation and creativity driven economy is the only (or at least most obvious way) to stay at the top of the value-added pyramid in the emerging globally integrated industrial mega-society. As a result many politicians and policy advisors are pushing even greater investments in education.

To provoke thinking about what such developments in the field of education might mean Figure 12 presents a non-predictive scenario (an imaginative story) of education spending to 2030. This model uses recent estimates of education spending along with projections developed by Angus Maddison for overall global economic growth to extrapolate education spending to 2030. Three sources of additional growth in enrolment and spending are assumed to build the model for this story: a) an expansion of participation rates in post-secondary, b) realization of the "Education for All" objectives that would bring an even larger share of the world's population into school, and c) efficiency improvements in the delivery of education (due to a combination of technological change, developments in cognitive science and reform of the school process) such that the average per pupil cost of education does not increase even though quality does (in other words it is assumed that technology and organizational change will improve).

Taking this overall positive environment for education spending over the next twenty years and using GDP projections from Angus Maddison (2007) produces Figure 12 below. This implies a massive absolute increase from roughly 1.78 trillion 1990 PPP dollars in 2003 to 3.35 trillion in 2030. However, this might be seen as a conservative estimate since the model used to imagine this outcome assumes only a very modest increase in the share of national income devoted to education. The calculations that underlie Figure 12 assume that education spending levels (in percentage of GDP) will gradually converge to 6% GDP as we near 2030. Currently, North America and Western Europe average 5.7%. For the estimates presented here it is assumed that developing countries will catch up and that there will be a slight increase in OECD average. Should there be a slower rate of productivity increase in the education sector without impinging on higher demand, i.e. people are willing to devote a larger share of their income (via private or public avenues) then the share of education could be more important than 6%.

Figure 12 shows the now familiar rise of China and India along with the repositioning of Western Europe. Nevertheless, it is crucial to keep in mind that in relative terms—on a per capita basis for instance—there is still a huge gap between the core OECD areas (Western Europe, North America and Japan) and the rapid growth economies of the 21st century. Like with the average number of years of school attendance, which only grows slowly as the share of younger people who have attended school longer become a more important share of the overall population, it takes time to close the gap when the starting point is very low. Furthermore, as noted previously there are important issues around quality (for instance on China's engineering graduates see: Wadhwa (2007)) and what is the actual contribution of years of schooling to economic and social change.

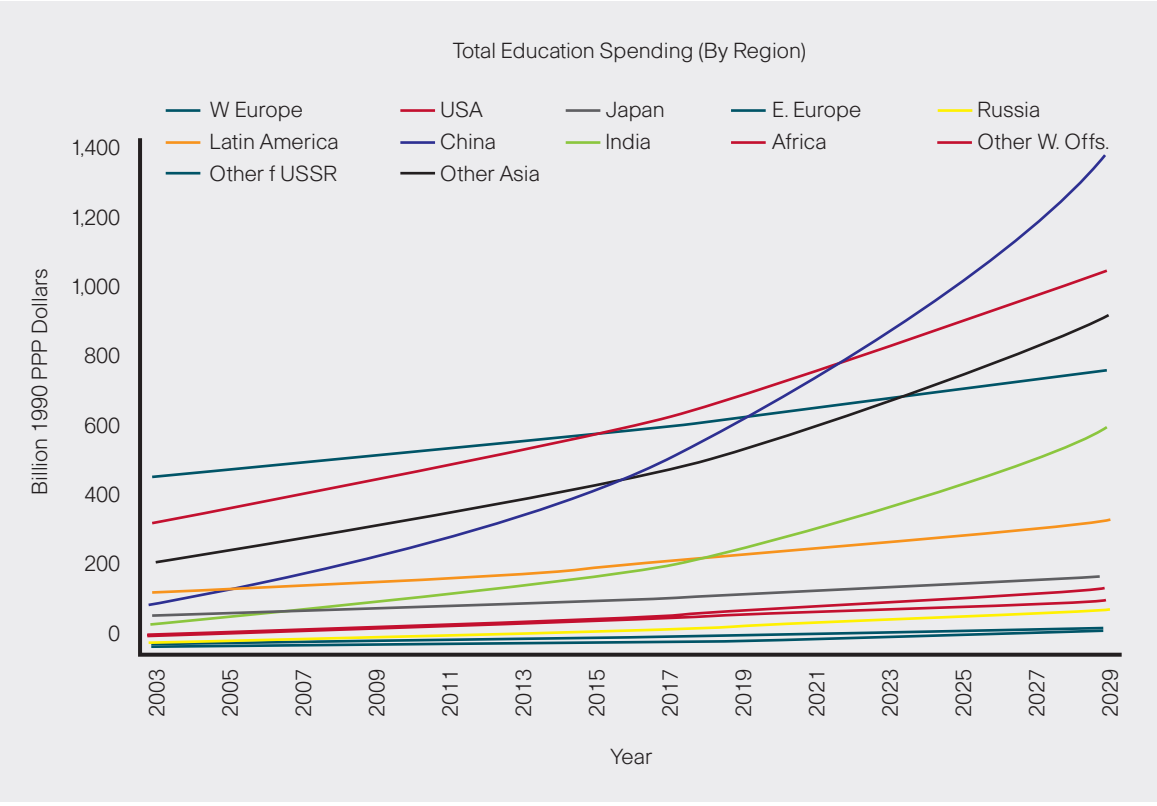

Figure 12: Imagining the Future of Education Spending by Region—An Extrapolation to 2030
Source: Riel Miller and Carl Schoonover, authors calculations.

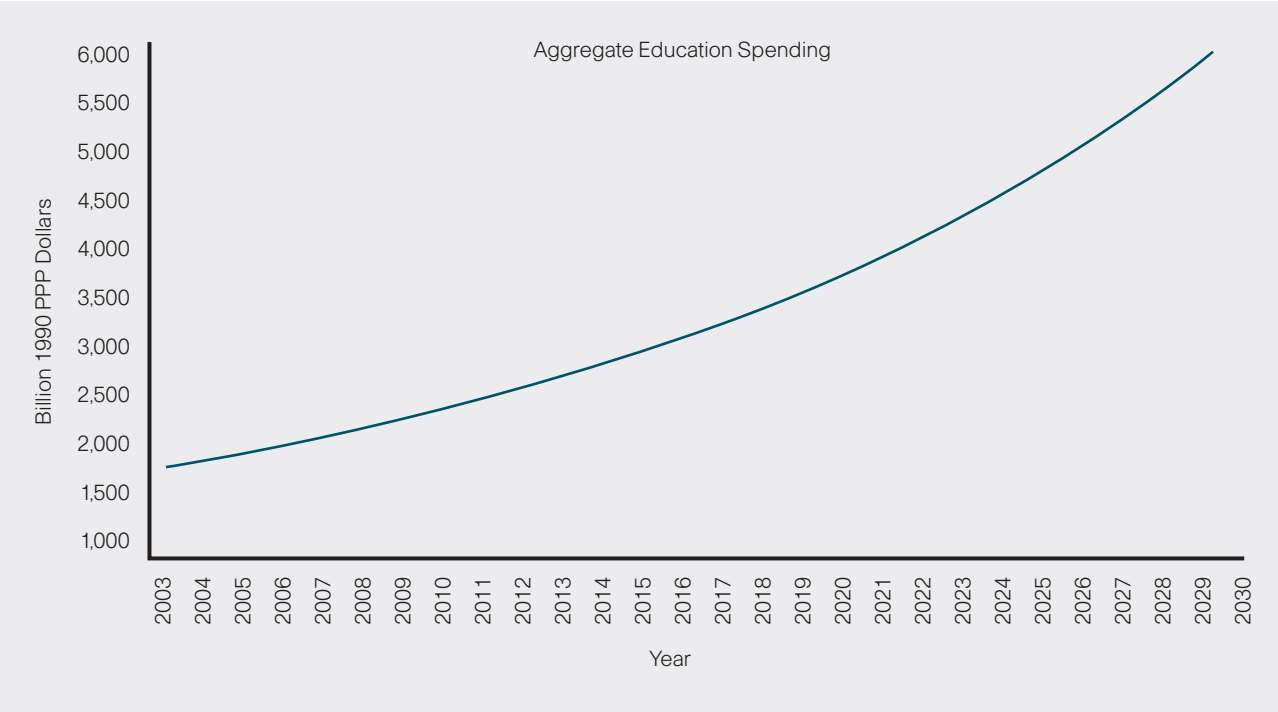

Figure 13: Imagining the Future of Education Spending Worldwide—An Extrapolation to 2030
Source: same as in Figure 12.

Still, taken that education will be whole, the amount of spending is impressive and certainly means that education as a will be a very dynamic part of global, regional and local economies. With spending close to 6 trillion there will be significant activity in areas like:

- teacher training and salaries;
- educational infrastructure like libraries, schools, etc;
- processes of educational management and reform;
- teaching tools like books, computers, networks and software; and
- the time spent (and earnings foregone) by parents and young people.

Furthermore, it is clear from the vast literature on both education reform (Miller and Bentley, 2003) and the future of universities and research (Akrich and Miller, 2006) that the transformation of this sector towards greater personalization and co-production—if it occurs— will entail major efforts in all parts of today's school systems. If supply side constraints emerge, such as finding a sufficient number of qualified teachers, then there will be even a further need for innovative responses in the areas of recruitment, training and teaching methods. Management methods, organizational models and in general the incentives/disincentives that alter how schools work can also be expected to strive to make the change to "best practice".

What this extrapolation does not tell us about is the extent to which the old school systems, including the "massification" of post-secondary education, will really continue to predominate as the most important or most prominent source of learning. It is worth remembering the observation from the technical economics literature that "the share of human capital wealth in the aggregate wealth of the United States during 1948–1989 was ... 'estimated at'... around a remarkable 93 percent" (Palacios-Huerta, 2003). If the signs of an emerging learning society signify a new socio-economic system (Miller, 2003b, 2006a) then industrial style schooling, with its huge custodial role that interferes with learning efficiency and its authoritarian requirements for testing/classroom behavior, etc., might gradually become marginal.

Right now there is no way to tell if there will be either the changes in the composition of the economy or in the role of schooling. What we do know from the past is that when the how, what, when and where of wealth creation changes then so too does the way learning is produced. This means that it is possible that the strong positive relationship between what people know and the wealth and well-being of society, already evident from the industrial era, could become even clearer in the future.

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