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Human Learning and Modern Economic growth: What is the Connection?

Gianpaolo Mariutti

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GianPaolo Mariutti*

Abstract

This article connects economic growth and human learning in historical perspective. It does so by confronting figures for almost two centuries (1820-1990) of GDP per capita and formal learning (mainly literacy) for a group of countries (19) that are nowadays rich. In the last decades of this long period, the selected sample has been enlarged including also nowadays poor countries. Some regularities emerge from the empirical evidence. Human learning has become an essential factor of economic growth. It was not so at the beginning of the Industrial revolution, in the first decades of the XIX century. As time went by, it has moved from being a sufficient factor of economic growth, to a necessary factor of growth. This means that there no countries nowadays rich in income that were not before rich in literacy. Among other things this offers interesting hints to look critically and creatively at the theories of economic development and growth.

1. Human learning, income and economic growth

1.1. Introduction

This article attempts a connection, in a historical perspective, between economic growth (Gdp per capita) and human learning (literacy). The investigation covers almost two centuries, both the XIX and the XX century, for a number of countries that belong roughly to the nowadays developed world, with a possible extension of the sample for the last decades of the period. The analysis makes use of data, but it keeps it manageable with a descriptive approach, without cranching sophisticated, but sometimes blurred, statistical tests.

The study focuses on the existence of an underlined trend relationship between the variables, while disregarding the analysis of short-term oscillations. Accordingly, data are analyzed

*University of Verona, *Department of Economics*, Email: gianpaolo.mariutti@univr.it

between certain key-years, and the two phenomena of economic growth and human learning are measured annually on average over periods lasting one decade or more.

For most of the two centuries, the available statistical base is not sufficient to draw a more precise picture. This for two reasons:

- First the statistical base for such a long time is limited in terms of available information both in its time and its space dimension. Data is tipically affected by missing values as much as one moves back into the past, and it is restricted geographically to few confined cases belonging to the "Western" world[1].
- Second, even within the available limited data, there is an overall quality problem due to a lack of homogenization, standardization, and reliability of the sources, aggraveted in our case by the necessity of making an international comparison between countries.

Therefore the statistical information are subjected to a degree of uncertainty that suggests caution. And caution implies to face squarely the problem. Namely, to stop asking questions that realistically this kind of data are not prepared to answer. Accordingly, this article advocates a responsible treatment of the statistics, leaving a certain space to more general historical considerations. This is done in an attempt of maximizing the sensible use, and limiting the abuse, of statistics on economic growth and human learning.

2. Statistical base, criteria and reference

The pitfalls in the quality of data, the doubts about its reliability, the lack of completeness, and the difficulties of making from them robust international comparisons would require a careful consideration of the sources used, and the criteria adopted for selecting both the sample, and the time-span, with its sub-periods. However, since the same statistical base has been already discussed elsewhere (Mariutti 2001, 2014), and studied for the same period of time, we shall concentrate here only on the essential information, so to make the article self-contained, and offer a sufficient framework to assess the significance - and limitations - of the results.

The arc of time analyzed covers almost completely the XIX century and XX century. It starts in the 1820, when the continental Europe increasingly began exposing itself to the Industrial revolution, following the example of forerunner Britain. It ends in 1990, just before the political and geographical changes caused by the break of "Berlin wall". This means that, for instance, Germany's data refers to the territory of the ex-Federal Republic of Germany, and not to the territory of the present (and pre-Second World War) Germany. More or less the same contrivances has been made for other countries that have seen profound changes of territory (and population) during the two Centuries - evaluations are always referred to the country borders as they apper at the end of the whole period.

1. Ironically this includes also Japan in the Far East and Austrialia and New Zealand in the Far South-East due to their past - and present - economic and political linkages to the proper "West".

As it has been already observed, the long run connection between the variables will be studied in terms of trends, disregarding short term oscillations. Accordingly data are collected and confronted in some key-years, lasting one or more decade. The splitting of the whole period into sub-periods, followed two criteria:

- one was dictated by the constraints of data. This is particular true for the (mainly first) decades of the XIX century, when the statistical information was limited. Data is available usually at the beginning of the decades (for instance 1820, 1850, 1870), and only sporadically for other individual years. To limit missing values therefore our choice makes virtu out of necessity. Namely, the selection of the key-years has not been always a deliberate choice, but it has been sometimes a constrained due to data availability.
- the other criterion attempted to circumvent the oddities of history. Whenever possible, the chosen key-years, among which the whole period has been divided, were made in order to minimize the disruption provoked by some historical events. For instance, against a common habit that does the opposit, in our analysis the key-years were set before wars and not just after them (hence 1913 was preferred to 1920, and 1939 preferred to 1950, or worst 1940). Not doing so would generate distorted results with the risk of treating as growth what may be just a recovery or a reconstruction process. It must admit that the criterion does not work equally well for all cases, since not all countries have been exposed to all and the same events. For instance the (Civil) war in Spain broke out before 1939, and not after it as occured with most of the other countries. In any case, when these adverse effects will emerge, they will be mentioned in the foregoing discussion.

The sample of countries analyzed during the whole period is restricted to19 countries, classified nowadays by World Bank (2015) as developed countries in terms of income per capita and with levels of literacy no longer reported by Unesco's statistical yearbook (1998), given their closeness to the maximum rate. It includes forthteen European countries, four ex-colonial countries of Europe, and one Asian country, Japan. The sample obviously is not rapresentative of the whole world economy of the period. It is howover sufficiently rapresentative of the part of the world that was exposed already in the XIX century to the Industrial revolution (some of the countries at the very beginning of the XIX century, others at the very end of it). This limited cases have been expanded in the second part of the XX century.

Starting from 1960, when more statical information was made available, the selected sample has been integrated with an extensive sample. Hence in the two sub-periods 1960-1973 and 1973-1990, the 19 cases have been enriched with more than other 100 countries (105 to be precise) belonging both to the poor and developed world alike. Apart of being helpful, this integration was also necessary, due to the increasingly lack of variance in one of its variables (literacy), as time moved on. Also the statistical base of the extensive sample, during the thirty years 1960-1990, has been already discussed elsewhere (Mariutti 2001), and we do not deal with it in detailed here. Its short-term results emerged there will be poured in our long run analysis, at some point in the second part of this work.

Throughout the article the analysis will be carried out with a systematic use of charts. To make the analysis more transparent, given that countries for the whole period are limited in number, we follow the convention to label them directly with the abbreviation of the national plates. How these countries are classified? Adopting an already used convention, countries are splitted into two groups, for each of the two main variables, income and literacy, as follows:

- ***DY_t countries*** (*Developed Income countries*) are those which levels of income per capita (in PPP and at constant prices) are above the line of 50 per cent of GDP per capita of the richest country at time, t;
- ***LY_t countries*** (*Less developed Income countries*) those which levels of income per capita stood below the above threshold at time, t;

- ***DL_t countries*** (*Developed countries in Literacy*) those which are above the line of 50 per cent of the literacy rate at time t;
- ***LL_t countries*** (*Less developed countries in Literacy*) those that stood below the above threshold at time, t.

Each country therefore, in each key-year, will belong at the same time to two groups: one for its level of income and the other for its level of literacy. The scale of both type of groups spans from 0 to 100 per cent. There is a difference, however. The table of income per capita is set in relative terms --the richest country of GDP per capita is normalized to 1, in each key-year, and the other countries are re-scaled accordingly. Not so for the literacy rates, that are left in their original state[2].

Before proceeding with the graphical analysis two points must stressed.

First, it should be emphasized the way we have selected the smaller sample to avoid false expectations. By statistical necessity we chose countries that at the end of the period were all developed —developed both in income (DY) and literacy (DL). By construction, therefore, our sample will witness cases of catch up, but never cases of falling (far) behind. History, unfortunately, knows also accounts of this second type, but, typically, cases of failure are not so well documented as cases of success —winners still rule (and write) history. The above limitation has been stemmed just at the end of the period by the introduction of the bigger sample. It includes both cases of success as well as cases of failure. Its advantage is to increase variance and meaningful comparisons. The disadvantage is to change the composition of the sample through time, which weakens the coherence of the analysis.

Second, a justification should be given about the different time lag in comparing literacy and income in the attempt to make a causal connection. By observing that the first phases of modern economic development have been typically slower[3], the analysis starts with a time lag of 50

2. However, with the exception to the very first sub-periods, also the liteacy scale can be interpreted in relative terms, since some countries already in the XIX century were very close to 100%. Hence the possible normalization to 1 will leave the literacy rates unchanged.

years between initial conditions of literacy and achievements of income. This lag will be shortened as the analysis moves towards the XX century. For this reason Figure 1 and Figure 2 in the next sections present data using the sub-periods 1820-1870, and 1897-1938.

3. The long run connection

3.1. The XIX century

The potential links between economic growth and human learning can be connected - as many social phenomena - in two ways: more income causes more learning, as well as vice versa. In the following pages, however, the focus is on the second type of connection. Namely, whether there exists some support in the data to the claim that human learning is an important factor of economic growth.

Figure 1 will assist us in this attempt, for the first part of the XIX century. It is split in three panels: one - the upper panel - showing a static picture and two - centre and lower panels - showing a dynamic overview. In fact, the former is a snapshot of the situation of both literacy and income in a precise key-year, 1820, the beginning of the period. If we introduce the convention of delimiting the two axes with the dividing line of 50 per cent, we notice the following.

First, the range of variation at the beginning of the modern economic growth was quite limited for both income and literacy, at least if compared with the situation that we face nowadays. The range of variation for both variables spans only 60 per cent of the scale —for income there exists a bias towards the DY group since there are no countries that fall behind 40 per cent, while for literacy there is more balance between LL and DL countries, being the countries distributed rather uniformly between 20 and 80 per cent literacy ratios.

Second, in contrast with our present perception, we notice important differences in the relation between the two variables. Nowadays a quick look at the data will show that all LL countries are also LY. Not so two centuries ago for the Western world: the upper panel shows that the great majority of LL countries belong to the DY group - being Japan and the Finland the exceptions.

Third, still contrary with the present international situation, in which many DL countries are still LY, here we have no cases of this sort —all DL countries not only are DY, but they usually held a level of income above the sample average of 67 per cent.

The conclusion, therefore, runs somewhat different from the one we could outlined nowadays data. Namely, at the beginning of the XIX century, countries in the DL group are at the same time, in the DY one. However, not always those countries that occupy the top of the scale of the

3. For instance, the average annual rate of growth in GDP per capita of the selected sample has been around 1% in the XIX century and about 2% in the XX century (see for details, Mariutti 2014).

first group end up on the top of the scale of the second group. On the other hand, those countries in the LL category maintained an uncertain position in terms of income —two of them were below the borderline of 50 per cent, but all the others kept a position above it.

Given what we already know about income, it is not difficult to offer a logical explanation of this behaviour. Our sample shows in 1820 levels of income within a limited range of values, and biased towards the DY category. The correlation with literacy (or for the matter with any other variable) cannot but reflect this fact. To put the matter in quantitative terms, the select sample in 1820 is more or less equally divided between LL and DL countries. In terms of income, however, only twelve per cent of cases (2 out of 17 countries) fell in the LY category. As a result, there must be some LL cases in the DY group.

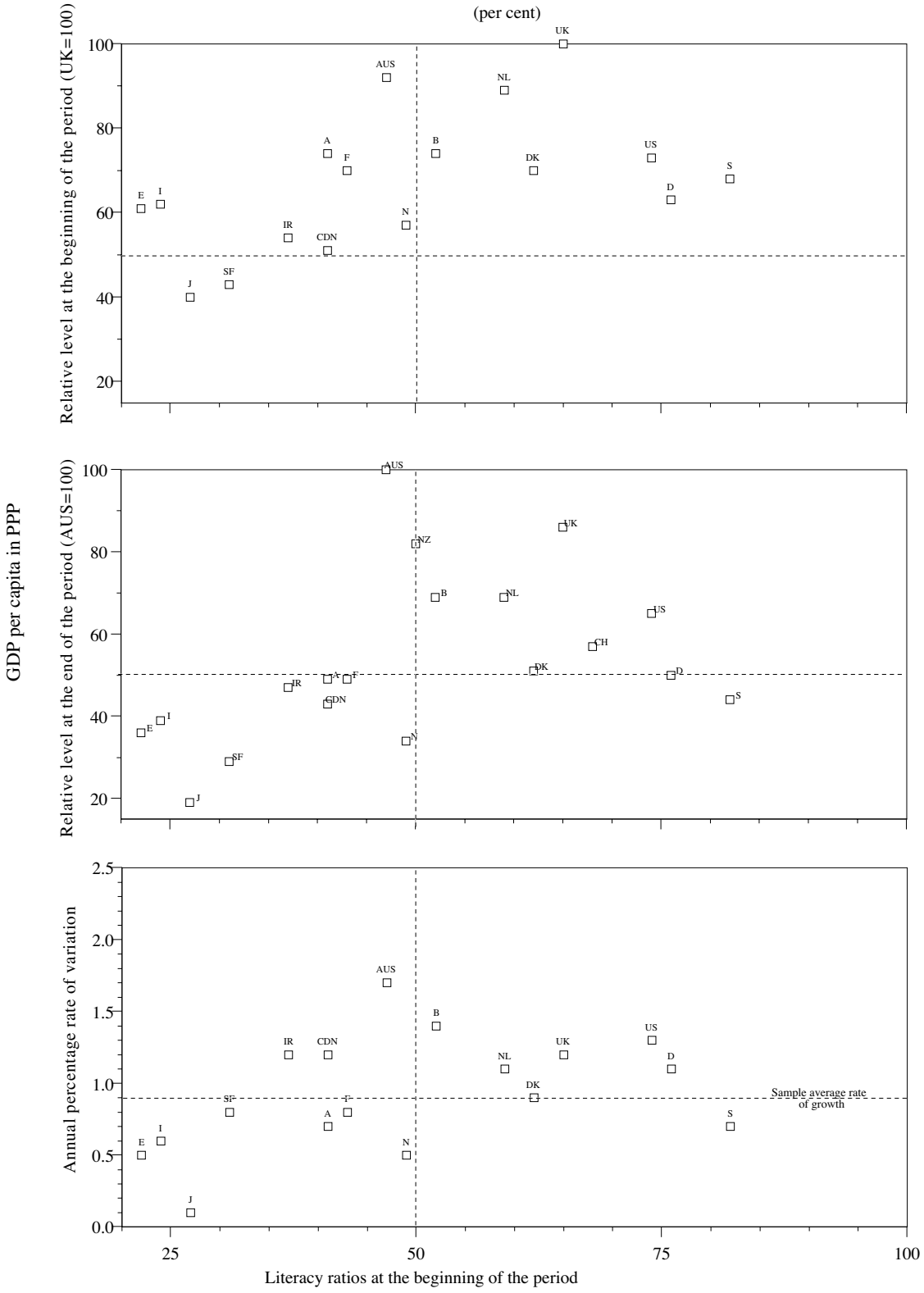
It remains to be seen if this statistical feature is only the result of the way we selected our sample or if there is also a historical explanation behind it. In support of the historical explanation one may for instance argue that countries in 1820 were grouped together in terms of income because the modern economic growth was still a relatively new phenomenon. We know that in the past big differences in the old form of national wealth, though possible, were rare.[4] Therefore, the uniformity of levels of relative income in the upper panel tends to represent just a general feature of early (or for some countries pre-) industrialization. The observation that the upper panel gives us is that the few countries, with their income below average (i.e. our two LY countries) were both from the LL category. Obviously, given the overall relationship one would be still interested to know what happens to the other LL countries in the following decades. Did literacy matter in deciding which country took advantage —and which country was precluded from— the modern economic growth that spread in the Western world during the XIX century?

The central panel contributes somewhat to an answer. It offers a dynamic view, by comparing the initial level of literacy (i.e. the same data of the upper panel) with the relative level of income fifty years later. Concerning the above question, these are the results.

We notice, first, that the two LL countries that were already in the LY group at the beginning of the period dropped further in their positions, and by the 1870 they occupy the very bottom of the scale —a scale that now extends its range of values from 19 to 100 per cent. Most importantly, however, is the observation concerning the other LL countries that in 1820 were in the DY group. By 1870, they all felt in the LY category, with the exception of Australia, and somewhat of New Zealand —the latter just positioned in the borderline of 50 per cent. With the exclusion of these cases, one observes that there are no LL countries in 1820 that belong to the DY category in 1870. Admittedly, in this context there are situations that come close to the borderlines. One may mention the case of France, Austria and Canada, which occupy a position in the LL

4. See for instance Maddison (2007).

Figure 1. GDP per capita and its rate of variation in 19 countries, 1820-1870, according to the initial level of literacy (GDP data for New Zealand and Switzerland not available in 1820)



Sources: Own elaborations from Maddison (1995) and from various sources for literacy: Cipolla (1977), Flora (1983-87), Mitchell (1989, 1993a, 1993b) Unesco (1964-1998) and U.S. Bureau of Census (1960).

group in 1820, though very close to the 50 per cent dividing line of literacy. But, one may notice that, similarly, they also occupy positions in 1870 very close to the 50 per cent dividing line of income.

Apart these borderline cases, one must stress the following point. After 50 years of modern economic growth, the LL countries were by and large unable to maintain the pace of economic growth experienced by the leading DL countries. Spain, Italy, but also Japan, Ireland, and Finland, all poor in literacy, fell dramatically behind in terms of relative income. The drop of almost 20 points of the minimum level in the scale of relative GDP per capita testifies this point quite clearly.[5]

There is then the consideration concerning the DL group. We observe that the majority of countries that are developed in literacy in 1820 are still well developed in income in 1870. This is something different from the situation analyzed between 1960-1990 for an extended sample (Mariutti 2001). In that context, the majority of DL countries in 1960 were still in the grouop of LY in 1990, not in the group of DY. What emerges in both cases seems heavily affected by the initial conditions, altough with a different correlation —in 1820 all DL countries were DY. Given these initial conditions, an evident surprise in this context is rather that not all DL countries in 1820 remained DY in 1870. For at least one case, in fact, there is a clear exception, and it is a remarkable exception, because Sweden is the country with the highest literacy rate, and yet one of those cases that dropped to very low positions in terms of income. Germany is another dubious case worth mentioning. It is the second most developed country in literacy, and yet it occupies only the border line of 50 per cent in income. Therefore, according with our figures literacy starts to show signs of becoming a necessary factor of growth, In fact almost all the LL countries dropped below the borderline of 50 per cent of relative income few decades later. At the same time, however, literacy seems to lose the feature of being a sufficient factor of growth, since there are some DL countries that are unable to kept their position of DY countries.

To clarify further the relation between literacy and economic dynamics, the lower panel relates the average annual rate of growth of the per capita GDP in the period 1820-70 with the level of literacy still at the beginning of the period. It becomes therefore a summary of the first two panels, by showing explicity the economic performance of countries between the two key-years.

5. A counter critique could be raised from the fact that in the year 1870, the horizontal axis of the central panel is distorted by the presence of Australia, which position on the top of the scale, forces all the other countries to have a lower relative income that they would be without the presence of Australia. This observation, though acceptable, is unable to change the overall phenomenon we have described. In fact, if we exclude Australia and give the crown of leader to the second classified in the income table (*i.e.* setting United Kingdom =100), we would have resulted still with a drop of relative income for those countries mentioned above. Therefore, the presence of Australia has only the effect of amplifying the result, rather than reverting its conclusion.

Before commenting it, we must notice from the income tables that our sample does not include in XIX century cases of average negative rates of change in income, and therefore, these low variance in the economic behaviour will limit our analysis as compared to a sample that would have included cases of success as well as of economic failure.

Nevertheless, the average rates of growth still show some variance, and therefore, there exists some room for analysis. To help the task, we draw the horizontal line at 0.9 per cent —the sample average annual rate of growth of GDP per capita. Studying the position of countries in relation of this line reveals the following.

First, the majority LL countries have a rate of growth below average, while the DL countries have generally a rate of growth above it. The only countries that do not conform to this observation are Australia (and to a lesser extent, mainly due to profound changes of population) Canada and Ireland, which have rates of growth much higher than one per cent.

Second, concerning the DL countries, all of them except one case, show a rate of growth above the sample growth average. There are in this category of relatively fast economies noticeable examples, such as Belgium, United Kingdom, Netherlands and United States, which show in this 50-year period annual average rates of growth well above one per cent. However, the exception that breaks the rule, is not less relevant, since Sweden is the leader nation in terms of literacy, but it is also one of the slowest economy with an annual rate of growth of 0.7 per cent.

The above two observations bring us to the third one. If one considers the sample as a whole one would confirm the existence of a direct positive relation between initial conditions of literacy and future performance in economic growth. Yet, the result is marred by the presence of few outliers.

Specifically, the two most noticeable cases we mentioned, Australia and Sweden, are clearly outside the cluster of points formed by all other countries. For this reason they deserve a closer examination that I shall developed in the next sub-Section.

3.2. Two clear outliers: Australia and Sweden

If one reconsiders what has been said about Figure 1, centre and lower panel, one must realistically face also the challenge raised by at least two outliers —Australia among the LL category and Sweden among the DL one. Is there any plausible factor that explains their behaviour?

Australia —as it is the case of Canada, which appears as outlier in the lower panel of Figure 1— is one of European off-shore colonies. Its conditions, above all in terms of population, changed dramatically in few decades since the beginning of our period (see Maddison 2007). Due to these dramatic changes, the initial conditions of literacy appear far less relevant for the economic performance of the country in the following fifty years than otherwise would have been. The premises upon which we have build the graphical relationship between literacy and income, in fact,

is that through time literacy conditions change at a slower rate than economic conditions. Yet, the high flows of immigration experienced by Australia undermines the validity of such a premise. Strictly speaking, in the interval 1820-1870 the dramatic changes of population undergone in this country, made its initial conditions far less relevant in predicting future behaviour —our graphic representation simply misses to highlight the presence of these fast-changing demographic conditions during the XIX century.

There exists also a second factor, which may explain its high rate of growth. I refer to the fact that Australia (and in general Oceania and North America) was endowed for all the XIX century of a quantity of unexploited natural resources, so that at this early stages, its economic growth seems more a result of this exploitation, than a result of industrial activities. It resembles, in other words, the example experienced in recent times by oil-export countries. The only difference, here, is that in the following decades, the off-shore colonies of Australia (and Canada) raised consistently their levels of literacy, while in the Middle East Arabian region this has occured in the recent decades to a far lesser extent.

* * *

About Sweden, the other outlier, the answer seems more intriguing, though not new (Sanderberg 1973). First, we should notice that according to the following reasoning the low performance of Sweden is hardly surprising. A common historical pattern to observe, and that persists still nowadays, is that countries that are DL and LY at the beginning of a period may well be still LY at the end of the period. High literacy is a precondition of economic growth, not a garantee of obtaining it. Sweden did not show a negative rate of growth during the XIX century. It just did not grow at the same pace of the other more dynamic economies. The fact, however, that such a *relatively* poor economic performance comes from the leader country in terms of literacy requires some further thoughts. Why was Sweden so culturally sophisticated already at the beginning of the XIX century and yet still unable to grow in economic terms as fast as the others?

Looking more closely to the history of the country (and to the other Scandinavian countries present in our sample, such as Norway and Finland, see Figure 1), it appears obvious that Sweden missed the first wave of economic growth of the XIX century. We already noticed above that a simple, but powerful, explanation of such a delay can be referred to the geographical factor.

Sweden, as it is the case of Norway, and Finland, seem all have suffered their relative geographical isolation. During the XIX century, the British Industrial revolution did not reach the Scandinavian countries. And in fact, these countries maintain for the whole XIX century a very high share of countryside population, rather than urban population.[6]

Furthermore, in the absence of industrial activities, high literacy could have played in the short run against high economic performances. This is for at least two reasons.

The first has to do with population. High literacy usually raises the diffusion and the awareness of medical and sanitary knowledge. This in turn drops the mortality rates, particularly, of those categories of people more at risk: infants and elderly. Lower mortality rates, everything equal, rises population, and in this case in particular it rises the share of non-active population.

A rising population requires, on the other hand, more agricultural products. But agricultural products, when not supported by industrial inputs, suffer decreasing returns due to the fact that the new cultivated land is usually less fertile than the one already in use. Therefore, in these conditions any rise in population finishes to undermine or at least limit the performance of *per capita* GDP.

The second complementary reason deals with economic incentives. A society of culturally sophisticated farmers is, everything equal, less willing to pay the social cost of industrialization. If the population in the countryside enjoy a standard of living economically acceptable and culturally rich, they do not perceive the need of leaving their land in favor of urban cities and industrial activities. A country of this kind, as a result, will have less incentive to shift from an agricultural to an industrial economy. It remains to be seen, first, if Sweden did make at same point this shift, and second, how well it performed at that point with such a high level of educated labour. An evidence that we shall briefly tackle in the next Section.

There is, however, a final consideration that should be made. Namely, the fact that any reasoning about literacy (or, for the matter, education) as a causal factor of economic growth cannot depend solely on the quantitative study of the variable. It requires also an analysis of its contents. Being able to acquire knowledge is one thing, but another quite distinctive thing is *how* it is acquired and *what* knowledge is acquired. We have already argued elsewhere (Mariutti 2014) that the modern economic growth is based on the spread of a quite distinctive set of values and technical information. There are solid historical grounds to dispute, therefore, that any spread of knowledge has been, always and necessarily, matched by the contemporary spread of those values and information that are strictly conducive with industrialization and economic growth. Moreover, in Scandinavian countries, high literacy was referred mainly to the capacity of reading text. And far less to the capacity of writing it. This was due mainly for religious purposes: the Bible needs to be read, not to be written. Such a functional limitation had also an impact in economic terms, since it limited the publication of technical books.

6. See Flora (1987, p. 247 and following).

3.3. The XX century

Figure 2 compares the data of literacy and income in the first part of the XX century, *i.e.* in the sub-period 1897-1938.

The upper panel shows the situation at the beginning of this sub-period. The first evidence that emerges in terms of literacy (horizontal axis) is a clear split between the majority of countries that, for the end of the XIX century, displays relatively high rates, and a second smaller group which shows literacy rates still below 50 per cent. Also from the income standpoint (vertical axis) there exists a concentration of cases towards the top of the scale, with 14 countries among the DY category and only 5 cases in the LY group. However, compared with the literacy scale, the range of values is wider and the spread of points is more uniform, shifting to a continuum between 20 and 100 per cent (interestingly enough, this was the situation of literacy values in 1820).

The relative concentration of values for literacy in 1897 will adversely affect the analysis. Having variables with little variance undermines the significance of any analysis aiming to determine the potential influence of a variable over another.

Apart this sample shortcoming, the relationship between literacy and income in 1897 appears positive in sign, and rather linear in direction. The sample appears now splitted in two sub-samples. The first one is smaller and comprises countries with lower positions. More precisely, we observe a cluster of five countries near the threshold of 50% of literacy rate and another cluster much more numerous, with levels above 70% (Austria) or even 80% (all the others). Among the first cluster we observe that countries within the LL group are usually in the LY group. Just Ireland, the highest among the LL group places itself just above the borderline of 50% in terms of income. On the other hand, Finland with a literacy rate just above 50% is in 1897 still a LY country.

The other cluster of countries belongs to the higher scale of DL group. It comprises fifteen cases and they belong to the DY group, with the only exception of Norway. Considering just this latter sub-sample, one notices a low variance among literacy rates, and an absence of a clear positive correlation between the two variables. In fact, countries leaders among the DL group are not usually the country leaders among the DY group. Sweden, for instance, is still a country with a very high literacy rate (still the highest in the sample) and yet with a not-so-high level of GDP per capita.

The central panel compares the level of literacy in 1897 with that of income 40 years later, in 1938, and it helps us to assess how the relationship from literacy to relative income evolved in the first part of the XX century.

The pattern described in the upper panel is maintained and reinforced also in this dynamic setting. Countries at the bottom of literacy ranking are at the bottom also of the income scale — without exceptions in this case, all four cases of LL countries are also LY. Finland, a country just above 50% of literacy rates at the end of the XIX century, and hence a DL country, becomes by the first decades of the XX century also a DY country. The other majority of countries that were well developed in literacy in 1897, still keep 40 years later a high position in the income ranking. Now also Norway joins the group of DY countries in 1938. This establishes a much clear positive trend between initial conditions of literacy and final conditions of income, as substantiated by the empty regions of LL-DY and DL-LY. Also the goodness of fit (R^2=0.61) of the positive regression line, by and large, supports such emerging connection.

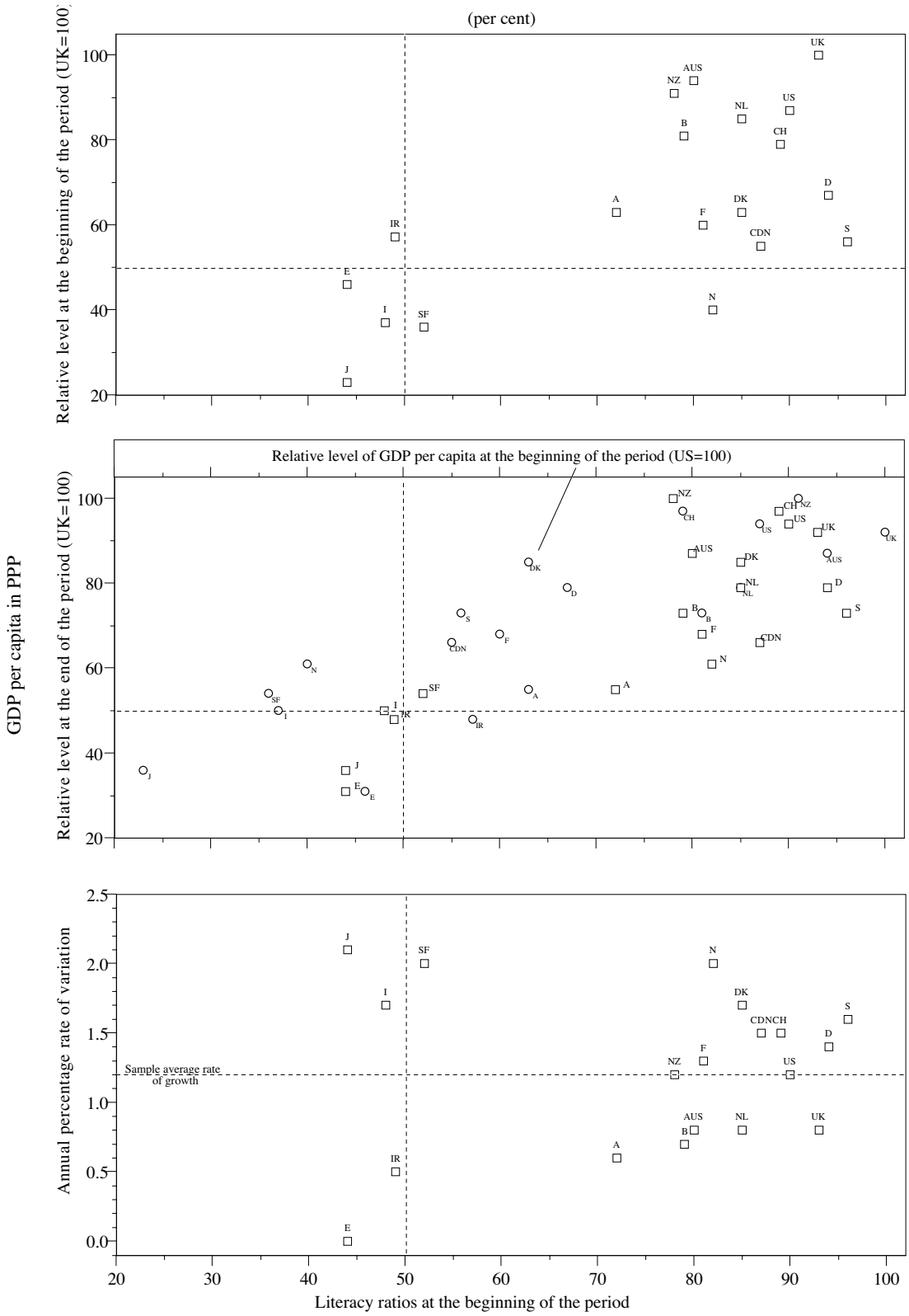
Some noticeable regularities at this stage seem to conform with those found from the extensive sample, for a short period of time, 1960-1990 (see Mariutti 2001). Namely, there are countries - here two cases - that from LY group become overtime part of the DY group. And such countries belong at the beginning of the period (1897) to the DL group. In addition, we do not have cases of initial DL countries that fell or remained into the LY category —all LY countries at the end of the forty year period were LL cases at the beginning. Obviously, the above pattern should not be overemphasized, given the small and biased sample. What can be said, however, is that the two main regularities emerged in the extended sample seem applicable to the above pattern. So the behaviour of the restricted sample for the first part of the XX century can also be summarized as follows:

- there are no LL countries at the beginning of the period that appear to be in the group of DY countries at the end of it.
- there are several LY countries at the beginning of the period that appear in the group of DY countries at the end of it.

Another meaningful comparison could be made with the analysis of the XIX century of Section 3.1. At that time two outliers did not fit easily in our statistical explanation, though the puzzle could be worked out on a broader historical perspective (see Section 3.2). It may be interesting at this point, re-examining the cases and follow up their performance. The first anomaly, we have discussed was Australia —it was an outlier due to its relatively poor literacy rate as compared to its relatively rich level of income. Now its position seems perfectly reintegrated in the cluster of points of our sample. In 1897 Australia was well developed in literacy. In the first part of the XX century, it still maintains a high position of income, though not the highest in absolute which is shifted, by this time, in favor of the neighbour country, New Zealand.

The other clear outlier was Sweden, developed in literacy, but not in income. With the new century also this anomaly disappeared. Sweden still maintains a leading position in literacy rates, but in 1938 it shows a level of GDP per capita close to the average of the DY group.

Figure 2. GDP per capita and its rate of variation in 19 countries, 1897-1938, according to the initial level of literacy



Sources: Own elaborations from Maddison (1995) and from various sources for literacy: Cipolla (1977), Flora (1983-87), Mitchell (1989, 1993a, 1993b) Unesco (1964-1998) and U.S. Bureau of Census (1960).

Finally, the lower panel compares the basic level of literacy in 1897 with the average annual rate of growth of income during the period 1897-38. As it was done in Figure 1, a dashed line denotes the sample average level of growth during the period. Using this line to compare and assess results, we may find a first confirmation of the above reasoning about outliers: Sweden grew its GDP per capita at a rate of 1.6, much faster than the 1.3 average annual rate. On the other hand, Australia showed clearly a rate of growth below the average of the sample, with its consequent drop in terms of income leadership.

Among the DL group, there are other countries with very good performance. For instance the other two Scandinavian countries, Norway and Finland, show rates even higher than Sweden and this explains why they have been able to change their income group, by moving in 1897 from LY to DY positions in 1938. At the bottom of the growth income scale with Australia, we find Austria, and all the countries of older industrialization —the United Kingdom, Belgium, Netherlands. We know that the first part of the century has been a particular difficult period for the industrialized economies: the impact of 1929 crisis is evident. We may notice in fact that the performance of these countries is particularly poor not only relatively to the others, but also relatively with their own average rates both in XIX century as well as late XX century.

Still concentrating in the lower panel, the four countries, clustered in the LL group, exihibit a very different behaviour from one to another —Ireland and Spain show the poorest economic performance, but Japan and Italy score one of the highest rate of growth of the whole sample.

In terms of variance, therefore, the lower panel of Figure 2 resembles a behaviour already emerged in the extensive sample during the recent decades. Namely, the LL group shows a higher instability of growth in terms of income—some cases are on the top of the scale of the growth table, but others are at the very bottom of it. Because there is no significant difference in the average rate of growth between LL and DL countries, the higher variance of the former is translated in a higher probability (or risk) to find cases of falling behind between the LL countries, than between the DL countries. Though the significance of this result must be cautioned by the small number of empirical cases, it should not be undermined either, since the sample by construction is biased to witness cases of convergence and not of divergence.

4. The literature on human learning and economic growth

The figures of literacy and income, and their historical connection, seem a relevant inquiry, given the interest that economists deserved to the causes of economic growth, since the Industrial revolution. One may ask therefore whether the literature offers similar studies on the subject. There are indeed few calls, asking to pursue similar lines of research (see for instance the classical book of Anderson and Bowman 1966), but a surprisingly little effort to give substance to it.

Apart the difficulties of assembling a coherent set of historical data, an explanation of a such general lack of interest by the economic literature may be the following. The great majority of economic historians, believe that literacy and education did not play any significant role in the first stages of the modern economic growth. According to them, the educational— or, as it is called, the human capital— factor started to become of some relevance, only in the XX century or, at best, at the very end of the XIX century. However, even for most part of the XX century models of economic growth continued to dismiss learning and human knowledge as a key factor of growth.

The following paragraphs present four key arguments put forward by the literature in support of the view that education - with its basic output of literacy - was almost irrilevant in the early and subsequent stages of economic growth. Obviously, the succinct account does not do justice of the vast amount of the historical contributions available in the field of the Industrial revolution and in its causes (among others, Hartwell 1970, Mokyr 1998). But it helps us to discuss its main results on the relationship investigated here—that between economic growth and human learning.

1. The first argument put forward by the literature in denying the role of education refers to the first mover of the modern economic growth —Great Britain. The prevailing view argues that it *did not have* a large stock of educated people and yet it led the process of industrialization. In bold letters "Britain became the first industrial nation, despite and not because of its levels of human capital" (Mokyr 1990). Britain shows clearly that education cannot be considered a precondition of growth. Not at least in historical terms. If this precondition would exist, Britain could not have been the first industrial nation. Other countries were far better equipped in educational achievements both in qualitative (France) and quantitative (Sweden) terms.
2. A second argument is based on the technological factor. Historians agree that in the XIX century a country could be technological innovative without being culturally sophisticated. This is because the degree of complexity of the new technologies in the XIX century was relatively simple. They were invented without the full knowledge of the formal scientific principles that governed them. Consequently, ingenuity and a practical mind were all that required to succeed technologically. The abstract and codified knowledge contained in books and allegedly taught at school was perceived as superfluous when not a waste of time altogether.

   The argument is usually supported by the comparison between France and Britain between the end of the 18^{th} century and the beginning of the XIX century. France was the most advanced country in scientific terms. All major breakthroughs in chemistry, mechanics, medicine came from French scientists. France was well known at that time for its educational excellence in teaching, training and supporting world class scientists. But the First Industrial revolution was not made by this people. It was made by the British Newcomen, Smeaton, Arkwright, people without much formal education, grew at the school of the 'rule of thumb' and actively engaged in practical professions, rather than intellectual ones. Mitch (1990) concludes that "there is little evidence to suggest that education played a central role

in England's Industrial Revolution." Therefore, the argument goes so far by saying that not only a leading economy as Britain did not have, but it *did not need* education to become the first industrial nation.

3. The third argument takes the latter observation and extends it to the labour market. It looks at the economy and its job structure. The kind of occupations available in an early stages of the Industrial revolution *did not demand* an educated labour. Again Britain is one of the most studied examples. Crafts (1985) estimates that only the 4.9 per cent of the labour force in England during the 1840s required literacy. A level too low to put the case of mass education as a precondition of growth. Other scholars even argue, not without evidence, that in its first phases, the Industrial revolution was skill-saving, rather than skill-intensive. The dull, dirty and dangerous jobs that the Industrial revolution created and the worsening conditions of the working class, as exemplified by Charlie Chaplin in the movie 'Modern times', make this point quite clear.
4. The fourth coupe de grace against the role of education as a factor of economic growth, focus on the unsuccessful stories of growth. Sweden is usually brought as an example of this kind —highly educated, but for long time relatively poor. If countries without high literacy were able to growth, and countries with mass literacy levels did not so, one must realistically conclude that literacy and education *did not work* in the promotion of economic growth. If they did work, we would have a developed Sweden already in XIX century, in place of the developed Britain.

Therefore the general conclusion is that human learning should not be considered an essential factor in explaining the modern economic growth at least in its early stages. On this position there are not only a relevant number of economic historians that look at the matter with the eyes and knowledge of today understanding. There are also the majority of contemporary XIX and XX century economists. It is difficult for instance to find any relevant passage about the role of education in the Classical Political economists. The factor was simply dismissed from the list of the causes of growth. Blaug (1986) well describes this state of affairs. Neoclassical economics, which overtook the Classical School at the end of the XIX century, rejected many points of the old economic tradition, but on this issue they followed suite their predecessors by denying that human knowledge could have a distinctive role to play in the theory of economic growth. Even when the so called 'human capital factor' was initially reintroduced in the economic research agenda in the l960s, the main concern was not economic growth, but an acceptable explanation of the wage differentials that existed in the labour market. The so-called New growth theory changed all that, but the empahsizes of this kind of models were more on analytical aspects, and on short term statistical evidence - mainly with data of the last decades of the XX century. Not surprisingly, its impact in scratching the above long run convinctions has been negligeable.

4.1. Some statistical answers to the literature

What our statistical evidence have to say to these widely accepted conclusions? Let us analyze with the help of our sample and of some additional evidence, each single point in turn.

1. The first one we discussed refers to the alleged low levels of education of those countries —Britain *in primis*— that started the process of modern economic growth. If we stick in using literacy as a proxy for education, data shows that this claim is ill founded. At the beginning of the XIX century, Britain (see Figure 1) was certainly not the most developed country in terms of literacy, but it was far from being at the bottom of the list in this respect. Its place in the DL category since the beginning of our period, made it a perfectly entitled candidate —at least according to our logic— to start and lead this process of economic growth.

   Obviously, the answer to the question 'why Britain?' cannot be exclusively resolved by appealing to a single factor explanation. But arguing that the country became the first industrial nation despite its educational levels is somewhat misleading. The point, however, is worth some further consideration.

   Britain started to take off at the end of the 18th century. Our statistical analysis starts in 1820. One would be interested to detect the situation of Britain in the decades *before* the economic transformation took place. In this respect the year 1820 as a starting point of our statistical analysis seems a bit too late. To extend back the analysis, Table 1 gives a rough representation of the levels of literacy in the 80-year period between 1750 and 1830. We may notice that there is no great difference between the outcomes achieved in the decade 1750-60 and those achieved in the decade 1820-30 —the level of literacy in 1750 was more or less the same of that achieved 50 years later. This is somewhat surprising because it means that the general level of education in the population was already relatively high back in the middle of the 18th century. A situation that few other countries could have enjoyed at that time, with the exception probably of Sweden.

Table 1. Level of literacy in England, before and during the First Industrial revolution, 1750-1830

Period	Literacy ratios
1750-60	54
1790-1800	55-60
1820-1830	65

Source: Sargant W. L. (1867), "On the Progress of Elementary Education", in *Journal of the Royal Statistical Society*, 30, pp. 127-8.
Note: Level of literacy is measured by estimating the percentage of people that were able to sign their names in country parishes.

   However, this also means that the Industrial revolution did not foster educational achievements. In other words, it seems that during its gestation, the Industrial revolution took advantage from a sufficient base of literacy and education, but that once the process started it did not call for any increase of literacy levels. Literacy may have contributed to the spark of the Industrial revolution, but certainly the Industrial revolution itself did not contribute to the rise of literacy and school enrolment. Not at least until the 1840. It is well known that the new industrial era did not generate only a new kind of wealth, but it generated also a bundle of new problems, such as social degradation, inequalities, and new forms of coercion and exploitation (Taylor 1970). One must think, for instance, of the issue of child labour, which was an obvious and direct obstacle in rising educational standards (Humphries 2010).

   This stagnation of educational achievements may also put into a different perspective the point under discussion here. After the First Industrial revolution, Britain failed to have a modern system of education. It failed to address sufficiently political interest behind the

issue of compulsory education. Compared to the continental Europe, Britain fell inescapably behind in educational standards, as it kept the firm belief that the modern economic growth could be pursued successfully without any central organization of the educational system. The claim that Britain started the First industrial revolution, despite and not because of its educational standards it is rejected by our evidence. But it is true that once the process of development started, Britain did not asked any further education, and probably even dropped on its own standards. How costly, however, this has been for future economic development in the XX century is a source of growing debate (Prais 1981, 1987; Prais and Wagner 1983).

2. There is then the second point, which refers to the unimportance of education to promote and sustain technological change. The argument is based on this simple connection. Education deals usually with the acquisition of abstract codified knowledge, like moral or scientific principles. But in the past technological change was not driven by this kind of metaknowledge. It was an empirical activity of trial and error, performed mainly on the shopfloor. Therefore the level of education did not matter (West 1975).

   Was really this kind of metaknowledge of no value for past technological change? Appearance is sometimes misleading. People create new technologies to better exploit the resources available. To start such an activity one must be confident, in first instance, that the world can be changed —and that these changes can be made for the better. How one perceives the external world, and the beliefs held about it, therefore are a crucial factor. In this respect, moral and natural sciences are of paramount importance. First, because they are a form of rational knowledge that teaches us that the world is governed by laws, and that these laws can be understood and, to a certain extent, used to one's advantage. Second, because this kind of knowledge contrasted and eventually defeated the superstition and the animism —the mortal enemies of any technological change. If every river, every piece of land, every tree is populated by spirits and gods, the environment is perceived capricious to any change —let alone the technological one. Third, because this metaknowledge told humans the boundaries of their power, by disclosing what could and what could not be realistically accomplished. But, best of all, because from this metaknowledge was developed the scientific or experimental method, that is a systematic method to rise an objective knowledge about the world. And the penetration of "scientific method" into technological research cannot be underestimated: accurate measurement, controlled experiment, insistence on reproducibility, and systematic reporting of methods and materials have been a crucial factor of technological promotion. A factor that undeniable belongs to the scientific heritage.

   England had a long tradition of this kind. One must only think to Francis Bacon, John Newton, David Hume. The way they stressed the usefulness of knowledge for practical purposes it is probably still unsurpassed. One must remember that was this tradition that brought about in the late 17^{th} century England the scientific revolution. Did the spillovers of these events did not affect the creation of new technologies? Many doubt. Pacey (1975, p. 137) has stressed that the Scientific revolution taught engineers "the method of detail" that is, to analyze problems by breaking them down into component parts. Jacob (1988, p. 208) also claims that the influence of the scientific revolution was that of forcing manufacturers and merchants to "think mechanically," that is in terms of understandable and controllable physical processes. For instance, John Smeaton, one of the most empirical and pragmatic inven-

tors, claimed that in his activity he was inspired by the experimental techniques developed by Newton, in which the partial effects of changes were measured by varying one component while keeping all others constant. Overall the idea of Baconian progress became part of the cultural heritage of the British educated élite and constituted a basic building block of the Industrial revolution.

Though important, these points are difficult to show quantitatively. Can our figures add something in this respect? The data of this Chapter does not reveal the contents of literacy and education. They are simply aggregate numbers. But in studying the potential link between metascientific principles and methods and technological effects, probably a look at the aggregate levels of secondary and tertiary education can be still revealing.

As it has been shown in another work (Mariutti 2014), the enrolment rates of the UK, the US and Germany for secondary and tertiary education during the XIX century are quite revealing in this context. The three countries started in 1820 more or less with similar values. At the end of the XIX century, however, the picture was dramatically changed. Germany (in secondary education) and the US (both in secondary and tertiary education) raised their enrolment levels constantly through time, Britain lacked increasingly behind on both fronts.

It seems as if Britain, after the initial success of the First Industrial revolution, did not think it needed much formal education. The fact that its inventors were mainly "tinkerers", reinforced this belief. The educational system therefore failed in the UK to produce that sort of technical and scientific personnel that other countries were able to produce. What impact this had in losing the world economic leadership in the XX century is an argument already put forward in economic history (Sanderson 1983, 1994).

3. There is then the claim that the range of occupations available in past economies did not require much education. The point offers some truth, but suffers of short-sight.

   It offers some truth because education has always played a role of screening device. That is, who gained education, were those people that occupy the high end of the social ladder and the occupations associated with that status. But the overall functioning, and sometimes the survival, of society does depend crucially on the nitty gritty occupations that lay at lower lever. In this context, the diffusion of mass literacy and schooling was perceived as a treat to the social order. The fear that some occupations of low profile, would be left unattended as a result of higher educational standards was until recently a constant alarm.

   If one reads the parliamentary discussions for instance of XIX century, when many countries introduced legislation for compulsory elementary school, one of the main concerns openly discussed by politicians (and not only politicians[7]) was that rising education would shrink the number of people willing to work in some key professions, such as farming. More in general those occupations associated with manual labour. The point that one shall discuss then is if the modern economic growth brought about a higher or a lower demand of this kind of occupations.

7. In 1807 the British Parliament discussed a Bill to provide elementary education. The bill passed through the House of Commons, but it was defeated in the House of Lords. Among the contrary there was the President of the Royal Society 'Giving education to the labouring classes of the poor [...] instead of teaching them subordination, it would render them factious and refractory, as was evident in the manufacturing counties.' (See Cipolla 1969).

It is at this stage that the claim suffers of short-sight. There are two factors that must be considered. The evolution of the structure of occupations, and the changes involved in terms of educational requirements of any given occupation. About the evolution of occupations, there is few doubts that the modern economic growth introduced many new occupations, and revolutionized the structure of the old ones. Mechanization eliminated many manual labour occupations for instance. On the other hand mass production was a system perfectly compatible with low-skill manpower. The new industrial sectors, more linked with science such as chemistry and electricity, may instead be conducive with qualified skilled labour. No doubt, the picture of the structure of occupations is mixed. Ultimately seems that occupations with high knowledge contents are prevailing, but admittedly the first stages of industrialization are a mixed picture of contrasting signals. In absence of a conclusive evidence, let us suppose that the modern economic growth did not show on this front any particular bias, either towards low or high skills occupations.

There is then the changes that overtime any individual occupation required. In this respect it seems that the requirements of education for each individual occupation has become increasingly higher. This has been the combined result of two factors. On the one hand the rise of the division of labour, and the expanding need to exchange information with other productive branches and economic sectors. On the other hand the internal accumulation of knowledge within each occupation.

Consider for instance the example of agriculture and how these two factors affected this key sector of the economy. Traditionally agriculture was the sector that occupied the highest share of population and this share was usually the least (formally) educated one. In the last two centuries, the share of the agriculture occupation shrunk dramatically, occupying eventually less than 5 per cent of the labour force. At the same time also the contents of the agriculture profession change dramatically. A farmer in 18^{th} century did not need much knowledge from the outside world. The agriculture practices were transmitted immutably from one generation to the other, and farmers acquired the necessary knowledge by simple emulation of their old fellows. But the agriculture of the XIX and XX century became something different. The farmer needed to know things that few decades before he could not even imagine. Machinery, synthetic fertilizers, hybrids and many other commodities started to be introduced in agriculture. The farmer was increasingly asked to acquaint himself with the necessary knowledge of these commodities. Furthermore, because these new commodities were produced in the industrial sectors, some skills of communication and commercial transactions with the outside world became necessary. Farmers started also to rely on the outside world for allocating the surplus that they were able to produced. That was where the educated farmers did better.

Similarly any standard profession, whatever poor in skills, took advantage from more education for the simple reason that the overall stock of knowledge and the division of labour were constantly rising. People increasingly needed to be acquainted with this growing knowledge as well as to communicate with other people of different professions. Those that were able to do so were ultimately better off.

4. Finally, one should deal with the apparent contradiction that those nations particularly developed in literacy (e.g. Sweden) did not lead the process of development, which was left to second-rate literate countries such as Britain.

In discussing point 1., we already noticed that Britain was not an illiterate country. Therefore the first part of the sentence is empirically unfounded. About the situation of Sweden we already presented some empirical phenomena that explain its relatively poor economic performance (see Section 3.2). But the point one should discuss on this respect is logical, more than empirical. The above sentence implies that one country just because is relatively better equipped in literacy must also be relatively better positioned in the income table. This is like saying that literacy is the sole and unique factor of economic growth, and that any rise of its level must be matched, always and necessarily, by a rise of the same sign in the per capita income.

Realistically, this is more than any advocate of the 'human learning' factor would maintain. But even in the hypothesis that such statement could be accepted, there are points that must be resolved. For instance, what is the time lag that one should concede before proclaiming the final judgment on the falsity or verity of the assertion? Or what is the most comprehensive proxy of human learning that must be used to test properly the assertion? Shall we use only literacy, or enrolment rates, or either a mix of the two?

Consider for instance the case of Sweden and the UK and their trends respectively of income and literacy and secondary enrolment of the two centuries. They reveal that Sweden was always ahead in terms of education, but it was lagging behind in the XIX century in terms of income. However, eventually in the XX century, Sweden forged ahead compare to the UK also from an economic point of view.

Therefore, logic and empirics are not necessarily in contradiction. The claim that in the Modern economic growth (in the sense of Kuznets 1966) the 'human learning' factor did not work can be challenged. Sweden was in the XX century one of the fastest growing economy in Europe. Only Norway, Finland and Italy grew faster. The UK, on the other hand, during the same time period was one of the slowest economy among all. This empirical result can be turned and summarized in at least three simple propositions:

1. An economic latecomer country, that holds a stock of educated labour higher than the country leader, ultimately will reach the latter in terms of income.
2. Conversely the leader that falls in its stock of educated labour, would eventually lose its leading economic position.

   If the two above propositions would be made operational, it would draw an additional conclusion:
3. A country which persistently holds a higher level of educated labour can emerge as the economic leader and preserve this position as far as it is able to keep the advantage in terms of educational levels.

   This latter consideration, in fact, fits quite well with the position gained by the U.S. during the XX century.

5. Conclusion

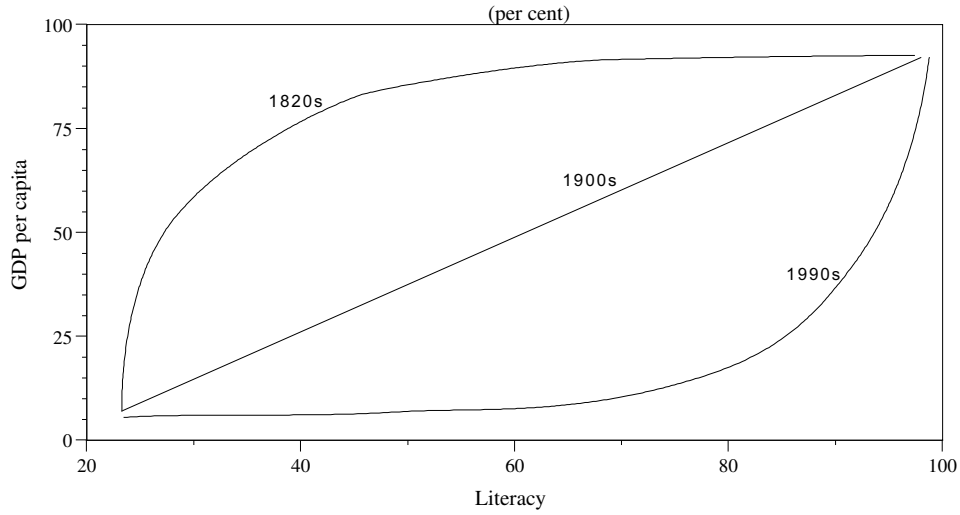
At the end of this inventory review, in connecting quantitatively human learning and economic growth, one may wonder whether there exists any significance in the results. The first impres-

sion is that everything is growing in our proxies — GDP per capita and literacy. This general upward trend is an undeniable key feature of the industrial world. A crucial question to ask at this point, however, is *how* each variable grew overtime.

Figure 3 shall assist us in tackling a possible synthetic answer. It summarizes the two-centuries relative movements of literacy and income in a stylized form. Specifically, it shows how the relative level of income of the sample has shifted, on average, compared to the literacy rates present some decades before. The three displayed curves have been constructed by simply replotting, in stylized form, the trends of the central panel of Figures 1 and 2 and by tacking advantage to complete the XX century connection of some results from Mariutti (2001 and 2014).

This is what the Figure tells us. In all three broad time-periods, there is always a positive relationship between literacy and income. However, the pattern followed over time by the two variables is different and exhibits a perceivable and significant evolution in its *dynamics*. At the beginning of the Industrial revolution the connection starts with a relationship of logarithmic shape —that is, with a curve concave down. This is the result of the fact that in the first part of the XIX century only those countries with very negligible levels of literacy showed relatively low levels of GDP per capita. That is, the LL countries, to begin with, resulted to be LY countries one decade or more later. But countries with a level of literacy of 40 per cent were already belonging in the DY group. At that point any rise of literacy, across countries, was attended by systematically smaller gains of income. Furthermore, above a certain level of literacy, the relationship with income reaches a sort of ceiling, without any positive correlation —more literacy is not followed decades later by an higher position in the income table.

Figure 3. Stylized relationship between literacy and income, 1820s, 1900s, 1990s



Sources: Stylized lines constructed with the patterns emerged from Figure 1, 2 and from Mariutti (2001, 2014).

In the 1900s, at the turn of the two centuries, however, the curve shifts downwards. Now the trend with income is almost linear for the whole range of values, letting emerge an almost perfectly proportional, positive, relationship between literacy levels and achievements of relative GDP per capita.

After another one hundred years or so, at the end of the XX century, there is a further downward shift, making the underying trend of exponential shape. This result has been discussed at lenght in other studies (Mariutti 2001) with the support of an extensive sample, which included an additional 100 countries above the 19 of this long run analysis. As we may recall in 1960, those countries at the beginning of the literacy scale have a rather flat relationship with their income positions. In fact, there are no cases of LL countries in the DY category. Also those countries that have passed the threshold of the DL group, did not still experience, as a general pattern, great improvements in the income table. Only cases of almost full literacy are attended by a direct strong positive relationship with their relative levels of income.

What does this mean? At the beginning of the XIX century literacy appears a sufficient factor for being a developed economy, since all countries developed in literacy were also developed in income.

From the shape of the curve in the 1820s, however, one notices also that being in the DL group was not necessary, since there were some countries developed in income, that there were not so in literacy in the previous decades. Therefore, at this initial stage of development, literacy appears, on average, a sufficient factor of economic growth, but not a necessary one.

Things changed progressively, decade after decade, in the following two hundred years, though. Looking at the situation of literacy at the end of XX century, we notice the opposite pattern. To be a country developed in literacy is no longer a sufficient condition to be at the top of the income table. There are too many examples of DL countries still in the LY group. At the same time, we do not have any country that is poor in literacy and developed in income. Hence, literacy, and more in general the knowledge factor has become a necessary factor of economic growth, *i.e.* the developed income economies comes only from those countries previously developed in literacy.

Apart from policy considerations, does this result imply something for the theoretical studies of economic growth. It is quite well known, that theory - as oppose to empirical and historical analysis - needs to be asbstract. And abstraction requires to be essential. Since at least Bain (1890), the Occam's razor with its law of parsimony is still a required, and appreciated, heuristic feature in model building. In explaining a phenomon, theory should use those factors, and only those factors, that are essential in generating the investigated outcome. The human knowldge seems after the Industrial revolution one of these factors. Theories of economic development, and above all of economic growth, for long time considered physical capital as the central factor in

explaining the "wealth of Nations". In recent decades something has changed, with the new growth theories (see for instance Aghion Howitt and Bursztyn 2008). What our work seems to suggest is that the impact of human learning on the economy is even more profound than it is supposed and theorized nowadays. Since the Industrial revolution, not only it appeared an additional input, alongside the more traditional ones, like labour and capital, in the promotion of economic growth. It has also become an essential factor of such a growth. In importance, it may precede, and not only integrate, the capital factor, on which both neoclassical Solowian and classical Harrodian growth models (Solow 1956, Harrod 1939) have been traditionally based.

6. References

Aghion, P., Howitt, P. and Bursztyn, L. (2008) *The Economics of Growth*. Cambridge, Mass: The MIT Press.

Anderson A.C. and Bowman M. (eds.) (1966), *Education and Economic Development*, New York, Frank Cass & Co.

Bain, F. W. (1890). *Occam's Razor: the Application of a Principle to Political Economy, to the conditions of Progress, to Socialism, to Politics*, Oxford, Parker & Co.

Blaug M. (1986), "The Economics of Education in English Classical Political Economy: A Re-Examination", in Blaug M. (ed.)*Economic History and the History of Economics*, Brighton, Wheatsheaf, pp. 150-177.

Blaug M. (ed.) (1992), *The Economic Value of Education: Studies in the Economics of Education*, Aldershot, Elgar.

Boserup E. (1981), *Population and Technological Change*, Chicago, Chicago University Press.

Cipolla C. (1969), *Literacy and Development in the West*, London, Penguin Books.

Cipolla C. (ed.) (1977), *The Fontana Economic History of Europe*, vol. 6, Statistical Appendix, Cambridge, Cambridge University Press.

Crafts N.F.R. (1985), *British Economic Growth During the Industrial Revolution*, Oxford, Oxford University Press.

Flora P., (ed.) (1983-87), *State, Economy, and Society in Western Europe, 1815-1975*. Frankfurt, Campus Verlag, 2 voll..

Gospel H. (ed.) (1991), *Industrial Training and Technological Innovation. A Comparative and Historical Study*, London, Routledge.

Gowing M. (1978), "Science, Technology and Education: England in 1870", *Oxford Review of Education*, n. 1.

Harrod R.F. (1939), "An Essay in Dynamic Theory", *Economic Journal*, vol. 49, pp. 14-33.

Hartwell, R. M. (1970). *The causes of the Industrial Revolution in England*, London, Methuen.

Humphries, J. (2010). *Childhood and child labour and the British industrial revolution*, Cambridge, Cambridge University Press.

International Encyclopedia of the Social Sciences (1951), vol. 12, London & NewYork, Macmillan & The Free Press.

Jacob M. (1988), *The Cultural Meaning of the Industrial Revolution*, New York, Alfred A. Knopf.

Kuznets S. (1966), *Modern Economic Growth: Rate, Structure and Spread*, New Haven and London, Yale University Press.

Landes D. (1969), *The Unbound Prometheus. Technological Change and Industrial Development in Western Europe,* Cambridge, Cambridge University Press.

Maddison A. (1991), *Dynamic Forces in Capitalist Development. A Long-Run Comparative View,* Oxford, Oxford University Press.

Maddison A. (1995), *Monitoring the World Economy 1820-1992*, Paris, OECD publication.

Maddison A. (1996), *Explaining the Economic Performance of Nations: Essays in Time and Space*, London, Elgar.

Maddison, A. (2007), *The World Economy*: vol. 1: *A Millennial Perspective*, vol. 2: *Historical Statistics.* Paris, OECD.

Mariutti GP. (2001), "Human Learning as the Essential Factor of Economic Growth: A Suggested Interpretation of the Evidence", Università della Svizzera Italiana, Working Paper, May.

Mariutti GP. (2014), "Economic Growth and Formal Learning in the Long Run", Working Paper Series Department of Economics University of Verona - ISSN:2036-2919.

Mitchell B.R. (1989), *International Historical Statistics. Europe 175O-1980*, New York, Stockton Press and MacMillan.

Mitchell B.R. (1993a), *International Historical Statistics*, *The Americas 1750-1988*, London, Stockon Press, second edition.

Mitchell B.R. (1993b), *International Historical Statistics. Asia 1750-1985*, New York, Stockton Press and MacMillan.

Mokyr J. (1990), *The Lever of Riches. Technological Creativity and Economic Progress,* Oxford, Oxford University Press.

Mokyr, J. (ed.) (1998) *The British Industrial Revolution: An Economic Perspective*. 2nd edition. Boulder, Westview Press.

Mowery D. and Rosenberg N. (1989), *Technology and the Pursuit of Economic Growth*, Cambridge, Cambridge University Press.

Pacey, A. (1975), *The Maze of Ingenuity: Ideas and Idealism in the Development of Technology*, New York, Holmes and Meier.

Prais S. J. (1981), Vocational Qualifications of the Labour Force in Britain and Germany", *National Institute Economic Review*, vol. 98, pp. 47-59.

Prais S. J. (1987), "Education for Productivity: Comparisons of Japanese and English Schooling for Vocational Preparation", *National Institute Economic Review*, vol. 119, pp. 40-56.

Prais S.J. (1993), "Economic Performance and Education: The Nature of Britain's Deficiencies", *National Institute of Economic and Social Research*, Discussion Paper, London.

Prais S.J. (1981), *Productivity and Industrial Structure: A Statistical Study of Manufacturing Industry in Britain, Germany and the United States,* Cambridge, Cambridge University Press.

Prais S.J. (1993), "Economic Performance and Education: The Nature of Britain's Deficiencies", *National Institute of Economic and Social Research*, Discussion Paper n. 52.

Prais S.J. and Wagner K. (1983), "Some Practical Aspects of Human Capital Investment: Training Standards in Five Occupations in Britain and Germany", *National Institute Economic Review*, vol. 105, pp. 46-65.

Sanderson M. (1983), *Education, Economic Change and Society in England, 1780-1870*, London, Macmillan.

Sanderson M. (1994), *The Missing Stratum*, London, The Athlone Press.

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

Solow R. (1985), "Economic History and Economics", *American Economic Review (Papers and Proceedings)*, vol. 75, n. 2, pp. 328-31.

Taylor, P. A. M. (1970), *The Industrial Revolution in Britain: Triumph or Disaster?* Lexington, Mass., Heath.

Unesco, (1964-98), *Statistical Yearbook*, United Nations Educational, Scientific and Cultural Organization, New York, Unesco publications.

Unesco, (1986-), *Science and Technology Indicators*, United Nations Educational, Scientific and Cultural Organization, Paris and New York, Unesco publications.

U.S. Bureau of Census (1960)*, Historical Statistics of the United States*, *Colonial Times to 1957*, Washington D.C.

U.S. Department of Commerce (1973), *Historical Statistics of the United States. Colonial Times to 1970*. Washington, Department of Commerce.

West, E. G. (1975), Education and the Industrial Revolution. London, Batsford.

World Bank (2015), *World Economic Indicators,* Washington, Oxford University Press for World Bank.