Human capital and economic growth in Spain, 1850–2000☆

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A B S T R A C T

We investigate human capital accumulation in Spain using income and education based alternative approaches. We, then, assess human capital impact on labor productivity growth and discuss the implications of its alternative measures for TFP growth. Trends in human capital are similar with either measure but the skill premium approach fits better Spanish historical experience. As education is a high income elastic good, human capital growth computed with the education based approach seems upward biased for the recent past. Human capital provided a positive albeit small contribution to labor productivity growth facilitating technological innovation.

1. Introduction

The role of human capital in the growth process has been extensively analyzed since Adam Smith and Alfred Marshall, and has interested both theoretical economists and economic historians. However, it was not until the mid twentieth century that Becker (1964), Schultz (1961), and Mincer (1958) developed a complete theory of human capital, according to which the individual level of education and experience determines future labor income. The United Nations (1997) defines human capital as “productive wealth embodied in labor, skills and knowledge” while the OECD describes it as “the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well being” (OECD, 2001). This broad definition does not restrict human capital to education but encompasses all investments in humans which are made to improve their skills, including schooling and informal education provided by parents or other family members, on the job training and learning by doing (i.e., acquiring skills through work experience) or any other activities that improve the productive use of a person's skills.

The measurement of human capital is even more elusive than its definition. Many authors have employed formal education measures, such as enrolment rates or the level of educational attainment, while others resorted to indirect proxies including literacy and numeracy as a way to identifying human capital. However, none of these measures adequately defines human capital since they ignore informal education, vocational training, workers' experience, and on the job training. Further, these partial measures do not consider the economic value (benefit) of human capital, the potential differences in rates of return between different types of education, and the acquisition of human capital for individual consumption and not for production. The point is that a “sound” measure of human capital should be not only comprehensive but also consistent with theoretical underpinnings. How to measure human capital will be the first question to be addressed in this paper.

The second question we will consider, the contribution of human capital to economic growth, has attracted considerable attention from the literature. There is a degree of consensus among economists and economic historians about the important role of human capital in long run growth and its contribution to convergence and catching up (Abramovitz, 1986). Schultz (1963) argued that a large share of economic growth comes from further additions to the initial stock of human capital and that human

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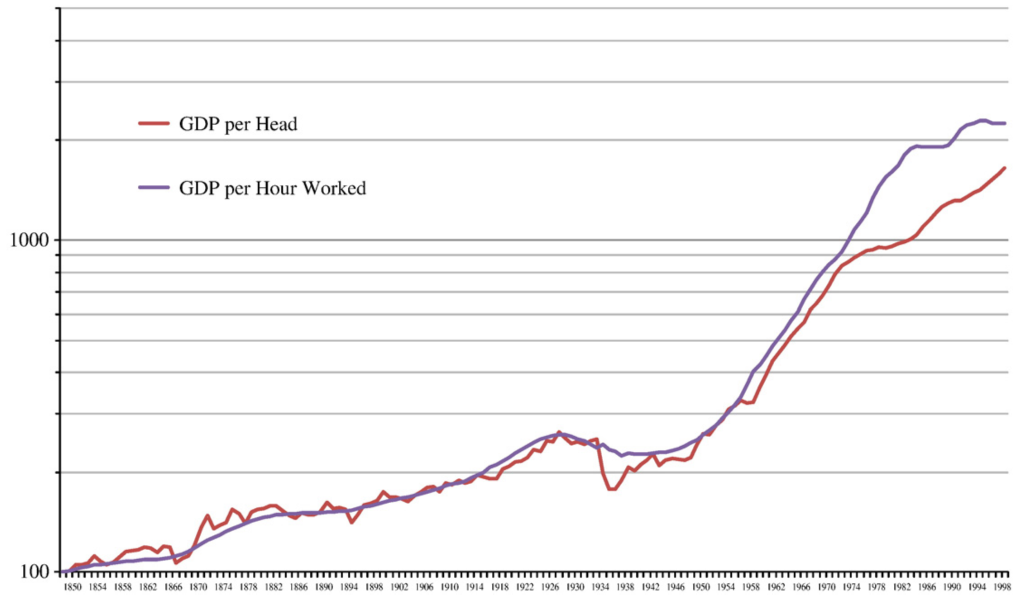

Fig. 1. Real GDP per head and per hour worked.
Source: Prados de la Escosura (2003, updated).

capital accumulation was largely responsible for the “residual” in early growth accounting exercises. Denison (1962) and Griliches and Jorgenson (1967) examined this hypothesis empirically and concluded that changes in the quality of the workforce did not account for all total factor productivity (TFP) increases. With the emergence of ‘new growth theory’ in the 1980s and 1990s and, in particular, with the important contribution by Lucas (1988), the relationship between human capital and growth became even more central for those interested in the causes of growth. Again, new empirical studies, in this case based on cross country regressions, have served to qualify initial theoretical arguments. Benhabib and Spiegel (1994) and Krueger and Lindahl (2001) pointed out that it is the level of educational attainment rather than its increase that matters for growth. More recently, Cohen and Soto (2007) have argued, instead, that growth in schooling rates has a statistically significant influence (albeit a relatively modest one) on GDP growth rates. Among economic historians, Sandberg (1979) attributed the successful development of the Swedish economy during the nineteenth century to its comparatively higher literacy levels.[1] In a similar vein, several studies related successful and unsuccessful development stories during the nineteenth century to the presence or absence of certain education levels.[2]

The contribution of this article is twofold. On the one hand, we provide two alternative measures of human capital for Spain from 1850 to 2000: the first is based on the concept of education, and the second on Jorgenson's income based concept of ‘labor quality’. Then, we review the advantages and shortcomings of each measure and discuss whether they are compatible. As a contrast, we present new empirical evidence on human capital accumulation, and we use a growth accounting framework to explore its contribution to economic growth.[3] As a country whose people were poor and ignorant during the nineteenth century, but which had joined the club of rich countries by the late twentieth century, Spain's experience is particularly relevant for the debate. Over the past century and a half, Spain has experienced a sustained expansion of GDP per head at an average rate of 1.9% per year, and GDP per hour worked has increased by an annual average of 2.1% (Fig. 1). Although long run trends in human capital are similar whichever of the two measures is used, we conclude that the direct, skill premium approach favored by Jorgenson fits better the historical experience of Spain as observed over shorter periods. Human capital provided a positive, albeit small, contribution to labor productivity growth and it could be suggested that human capital accumulation probably had a positive effect on GDP level facilitating technological innovation (Table 1).

[1] A more recent assessment of the Swedish case is provided by Ljungberg and Nilsson (2009).

[2] In sharp contrast, another stream of literature stresses the limited contribution of human capital to growth during the Industrial Revolution (see the review by Mitch (2004)). A revisionist view that emerged late in the 1990s claimed, on the basis of microeconomic evidence, that the industrial workforce was skilled despite its low levels of formal education (Rosés, 1998; Bessen, 2003; Boot, 1995). Industrial labor acquired skills in different ways (for example, children and young people got practical know how and experience working in the factories). However, these studies also showed that the level of human capital facilitated the adoption of new technologies, but its accumulation did not contribute significantly to increasing GDP growth rates.

[3] Thus, we will decompose growth rates into the contribution of production factors in terms of quantity and efficiency. This framework does not include a particular growth theory since it only provides a descriptive procedure and it is, therefore, compatible with the alternative specifications of different growth models (Barro, 1999; Collins and Bosworth, 1996). In this paper, we make a historical adaptation the approach of Domar (1961) and Griliches and Jorgenson (1967) to measure factor inputs in terms of quality.

Table 1
Per capita GDP growth and its components, 1850–2000. (Annual average logarithmic rates %).
Source: Prados de la Escosura and Rosés (2009).

	(I) Per capita GDP	(II) Hours worked/population	(III) GDP per hour worked
1850–2000	1.9	0.2	2.1
Panel A			
1850–1950	0.8	0.1	0.9
1951–1974	5.5	0.0	5.5
1975–2000	2.6	0.8	3.4
Panel B			
1850–1883	1.4	0.2	1.2
1884–1920	0.7	0.3	1.0
1921–1929	2.8	0.8	2.0
1930–1952	0.0	0.0	0.0
1953–1958	3.9	0.5	4.3
1959–1974	5.8	0.5	6.3
1975–1986	1.8	4.4	6.1
1987–2000	3.3	2.2	1.1

2. The education-based approach to human capital

Human capital is usually approximated through education measures.[4] For this reason, we have made estimates of human capital on the basis of educational attainment. More specifically, we have computed different measures of human capital using data on age structure (as a measure of experience), and years of education attained, weighted by their rate of return per year of schooling. These procedures supersede more simple calculations of educational attainment such as literacy, enrolment rates, or average years of education which fail to incorporate any adjustment for quality changes.[5] In particular, all years of education are given equal weight, regardless of whether the year in question is spent at primary school in 1850 or at university in 2000 (Hanushek and Kimko, 2000: 1185).[6]

In order to estimate average years of schooling for a population aged 15 to 64, several steps were followed. We started from the annual average gross stock of schooling at ages 15, 20, and 25 for population born since 1858 (Núñez, 2005: 234 6), completed with schooling years in primary education for population born since 1835 (Núñez, 2005: 167), and distributed it over five year cohorts (aged 15 19, 20 24, …60 64) over time. Specifically, years of schooling at 14, 19, and 24 for those born in 1858 represented years of education at 15, 20, and 25 in 1873, and if we reasonably assume that formal education is already completed at age 25, we can, then, infer that the average years of schooling of population aged 30 in 1878, 35 in 1883, …50 in 1898, …, and 64 in 1912 are all identical to that of population aged 25 in 1873. In this way we were able to reconstruct the corresponding years of schooling for each five year cohort (aged 15 19, 20 24 … 60 64) annually throughout the twentieth century. Then, years of schooling for each cohort were weighted by its share of population aged 15 to 64 (which implies taking mortality rates and migration into account) and the result was the average years of education per person aged 15 to 64 from 1909 onwards.[7] We, then, projected the resulting figures backwards to 1850 using the weighted average of schooling years for a declining population group derived through the same procedure as for 1910 2000, that is, population aged: 15 to 59 over 1904 1909; 15 to 54 over 1900 1904; etc.

Then, we calibrated human capital, firstly, with the parameters from a Mincer equation for Spain in the early 1990s, HC_{Mincer} (Table 2, col. 1).[8] Specifically, the equation considered is the following:

$$ln(HC)_{Mincer} = 5.2982 + 0.0823{*}schooling + 0.0390{*}experience - 0.0005{*}experience^2 \quad (1)$$

in which schooling is the average years of formal education received by the Spanish population aged 15 to 50; and experience is the average age of the Spanish population aged 15 to 64. The estimated coefficient on years of schooling represents the average

4 For Spain, see Núñez (2005), Mas et al. (2005), and Doménech and de la Fuente (2006).

5 It is worth recalling Collins and Bosworth (1996: 151) who wrote: "years of schooling alone is a poor index of labor quality because it assigns workers with zero education a weight of zero and it implies disproportionate changes in labor quality for countries with low initial levels of schooling". Unfortunately, lack of data prevents us from measuring educational quality change over time as proposed by Hanushek and Kimko (2000).

6 See the critical assessment of education-based measures of human capital in Le et al. (2003).

7 It is worth mentioning that although our estimates are adjusted for the mortality rate in each age cohort (which is part of the depreciation of human capital), due to lack of data we ignore another important component of depreciation, the obsolescence of knowledge. Our guess is, however, that given slow technological change its impact would have been negligible before the late twentieth century. In fact, the most appropriate procedure for assessing the depreciation of human capital is to exclude from the labor force those workers who have quit the labor market and to weight workers by their marginal productivity as Jorgenson does. See de Grip (2006).

8 Arrazola et al. (2003: 297). The estimate was carried out with data for 1993–94.

Table 2
Human capital growth, 1850–2000: education approach. (Annual average logarithmic rates %).
Sources: Arrazola et al. (2003) for Mincer equation; Collins and Bosworth (1996), Psacharopoulos and Patrinos (2004), and Alba and San Segundo (1995) for rates of return. See the text.

	Mincer eq.	Rate of return			
	(I)	(II)	(III)	(IV)	(V)
	8.2%	12.0%	10.9%	9.0%	7.0%
1850–2000	0.5	0.7	0.6	0.5	0.4
Panel A					
1850–1950	0.2	0.3	0.3	0.2	0.2
1951–1974	1.0	1.1	1.0	0.9	0.7
1975–2000	1.3	1.8	1.6	1.3	1.0
Panel B					
1850–1883	0.3	0.4	0.3	0.3	0.2
1884–1920	0.1	0.1	0.1	0.1	0.1
1921–1929	0.2	0.3	0.3	0.2	0.2
1930–1952	0.4	0.5	0.4	0.4	0.3
1953–1958	1.1	1.0	0.9	0.8	0.6
1959–1974	0.9	1.1	1.0	0.9	0.7
1975–1986	1.3	1.9	1.8	1.5	1.2
1987–2000	1.3	1.6	1.5	1.2	1.0

marginal return to an additional year of schooling, 8.2% (Collins and Bosworth, 1996: 151).[9] The exponential of this number generates an index number.

Unfortunately, there is no rigorous way to estimate experience from a long run perspective and we have been forced to use this conventional and crude short cut. Therefore we carried out alternative estimates of human capital using the straightforward approach of Bosworth and Collins (2003). Specifically, we obtained alternative human capital measures by relating educational attainment (HC_{BC}) to average years of schooling (schooling). Thus,

$$(HC)_{BC} = (1 + r)^{schooling}, \tag{2}$$

with r being the rate of return (Bosworth and Collins, 2003: 119 120). We used alternative rates of return that correspond to different levels of development. Thus, we employed 10.9 and 12% the average for low income countries and for Latin America and Sub Saharan Africa, respectively (Psacharopoulos and Patrinos, 2004: 115) and, in addition, 9 and 7.2%, estimated for Spain in the 1990s.[10] The results derived from using alternative rates of return do not differ significantly from each other until the late twentieth century, even though human capital growth rates tend to be higher when higher rates of return are assumed. This is an important finding because it is in early phases of development that rates of return are usually higher, while they tend to be much lower for developed countries. Thus, the high degree of coincidence of alternative estimates obtained with a wide range of rates of return prior to the 1950s confirms the robustness of our results (Table 2 and Fig. 2). Nonetheless, since private rates of return overestimate social rates of return (Psacharopoulos and Patrinos, 2004: 114), it appears sensible to adopt low values for the rate of return in our type of calibration exercises, and we have employed a 7% rate of return per year of education in our estimates of the sources of growth.[11]

Growth rates of the education based measure of human capital are low during the first one hundred years of our period, particularly in the late nineteenth and early twentieth century. From these results, it is easy to infer that the 'high school movement' arrived relatively late in Spain and investment in education was extremely limited over this period (Viñao Frago, 1990; Núñez, 2005).[12] Human capital as measured by education experienced a sustained increase during the 1920s and up to the Civil War but fell in 1936 45, and the 1936 level was not attained again until 1950. The Civil War and the initial phases of Franco's Dictatorship had a negative impact on the levels of primary education (Núñez, 2003).[13] Since the 1950s, however, the provision of education accelerated significantly and, on average, growth rates were 4.5 times higher than in the preceding century.

[9] We gratefully acknowledge David Reher who provided us with his unpublished yearly estimates of the age composition of the Spanish population between 1858 and 1970. We used INI official figures from 1970 onwards, and assumed that 1858 age composition was representative for that of 1850–57.
[10] The upper bound used by Collins and Bosworth (1996: 153) is also 12%. The 9% return has been obtained by Alba and San Segundo (1995: 162), after controlling for self-selection. The 7.2% return is quoted in Psacharopoulos and Patrinos (2004: 127), and derives from Mora (1999).
[11] See Collins and Bosworth (1996: 153) and Bosworth and Collins (2003: 138). Psacharopoulos and Patrinos (2004: 115) provide rates of return of 7.1 and 7.4% for Europe and for high income countries, respectively. Collins and Bosworth (1996: 153) favor the general use of a 7% rate of return for each year of education because the "likely biases due to omitted variables imply overestimates of returns to schooling among developing countries".
[12] See Goldin (1998) on the importance for the United States of this transformation.
[13] Human capital declined at a yearly rate which ranges from 0.3 (7% rate of return) to 0.5% (12% rate of return) over 1936–1945.

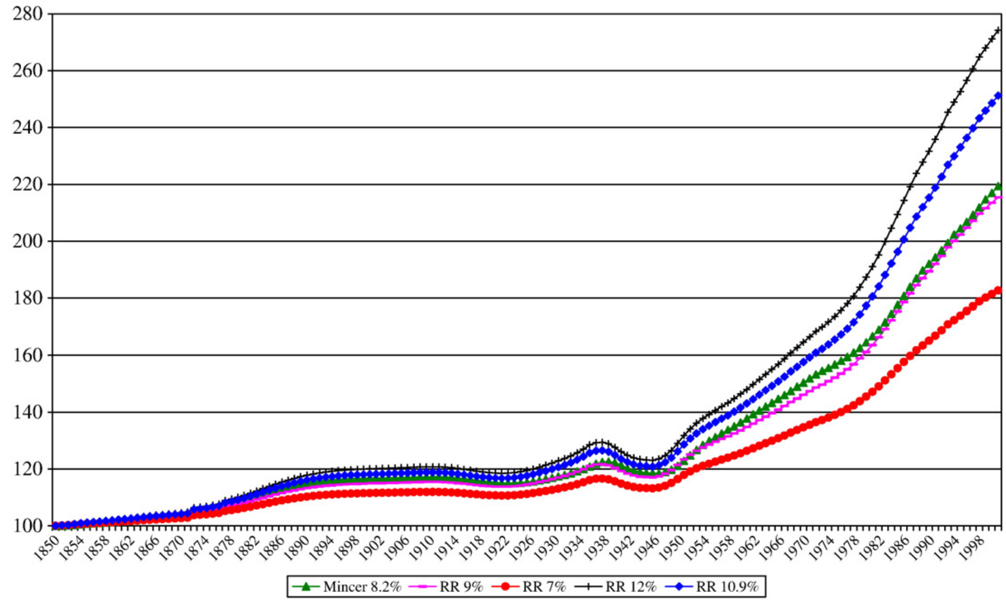

Fig. 2. Human capital through the Education-based approach: alternative estimates.
Source: See text.

How was education distributed among population groups? Was education concentrated among the young and inexperienced, or were those more experienced the ones who had higher levels of formal education? In order to provide an answer we classified average years of schooling by five year age cohorts and found two clear patterns that correspond to the periods before and after 1950. Prior to 1950, and particularly before 1930, the dispersion of years of schooling between age cohorts is low, and the maximum level of education does not correspond to the same cohort over time. Conversely, in the second half of the twentieth century, the highest level of education corresponds to population aged 25 29 and the dispersion is high (about a 0.2 coefficient of variation), increasing in the years from 1950 to the early 1980s and declining thereafter. In other words, it seems that during the late twentieth century the younger and relatively less experienced people were relatively more educated than the rest.

3. The income-based approach to human capital

Measures of human capital obtained on the basis of education data have important shortcomings as they do not consider the different ways in which people enhance their capabilities. Therefore, to evaluate the contribution of human capital during the past 150 years, a measure that captures the effects of both schooling and training is necessary.

An alternative approach suggested by the growth accounting literature provides a solution by computing the quality of the labor force; that is, the set of skills employed during production (hereafter, we will call this method the 'income based approach').[14] There are two basic ideas behind this: (1) the quality of the labor force is enhanced by past investments in human capital, and (2) differentials in individuals' earnings are the consequence of these same investments. The rationale is that the income employed in enhancing human capacities raises the worker's earnings because it increases productivity per worker.[15]

In the income based approach the appropriate measure of labor input is the flow of services for production emanating from this factor.[16] Algebraically, the equation is:

$$lnL_t - lnL_{t-1} = \Sigma_i[\overline{\Theta}_{Li}(lnLi_t - lnLi_{t-1})] \qquad (4)$$

[14] See, for example, Jorgenson (1990), and Young (1995).

[15] This argument is widely debated. Some authors maintain that earnings differentials are due to institutional constraints. As a result, human capital accumulation could not be measured by computing individual earnings as there would be no persuasive evidence of a direct relationship between age, experience, skill and productivity.

[16] It is usually assumed that such a flow is proportional to the hours of work involved. That is,

$$Li_t = \lambda_{Li} Hi_t,$$

where L is labor input, λ_{Li} is a constant, and H is the measured work hours.

where share values are computed as:

$$\overline{\Theta}_{Li} = 1/2[\theta_{Li}(t) + \theta_{Li}(t{-}1)],\ (i = 1, \ldots i, \ldots n). \tag{5}$$

L is labor; i is an index of different labor attributes and Θ the average share of each component in the total outlay for the two periods. Hence, our task is to estimate the labor force cross classified by as many attributes as possible to capture its heterogeneity.[17] Unfortunately, in the case of Spain, census and survey data for distant periods contain limited information and we can only offer a simplified version of labor input accounts. Thus, we have employed two different procedures. For 1850 1954, the Spanish working population has been cross classified by gender, two different age attributes (adult and child), branch of activity, income, and hours of work but we have been unable to match the income received by each worker with her/his age and level of education.

The first step in the construction of the labor input series was to elaborate yearly employment figures for the four main sectors (agriculture, forestry, and fishing, industry, construction, and services) on the basis of population censuses. Major shortcomings are posed by Spanish census data: working population is only available at benchmark years and refers to the economically active population (hereafter EAP), taking no regard of involuntary unemployment, while female EAP in agriculture is inconsistent over time. Therefore, we had been forced to make some tough choices. For example, in order to derive consistent figures over time for EAP in agriculture, we excluded the census figures for the female population,[18] assuming instead that female labor represented a stable proportion of male labor force in agriculture and, thus, we increased the number of days assigned to each male worker (see below).[19] Moreover, as the share of EAP in agriculture is suspiciously stable over 1797 1910, in spite of increasing industrialization and urbanization, we adjusted it by assuming that the share of EAP in agriculture changed in parallel with the proportion of rural population (living in villages with fewer than 5000 inhabitants) in the total population.[20] The next step was to obtain yearly EAP figures through log linear interpolation of benchmark observations. Employment figures for each major sector of economic activity were, then, derived by adjusting yearly EAP series for the economic cycle (obtained as deviations from the Hodrick Prescott trend in output). Later, employment figures by sector were corrected to maintain consistency with the cycle adjusted figures for total employment.

Employment in these four large sectors was, then, distributed into their branches. Up to 1955 population censuses allowed us to cross classify the working population into 19 industries up to 1900, 21 industries for 1900 10, 22 for 1911 50, and 24 thereafter.[21] Unfortunately, lack of data for 1850 1900 forced us to break down manufacturing employment into its branches by assuming that its distribution in 1900 was representative for the entire period.[22]

Second, the data on employment (number of workers) was converted into days and, then, hours worked per year, for the period 1850 1954. We assumed that each full time worker was employed for 270 days per annum in industry and services. This figure results from deducting Sundays and religious holidays plus an allowance for illness.[23] This assumption is consistent with contemporary testimonies and supported by the available evidence.[24] In agriculture, however, contemporary and historians' estimates point to a lower figure for the working days per occupied person.[25] Throughout most of the nineteenth century and in the early twentieth century, full employment among peasants only occurred during the summer period and, consequently, workers were idle for up to four months every year.[26] Moreover, as the opportunity cost of allocating agricultural labor to alternative occupations during the slack season was minimal, peasants carried out additional non agricultural activities, such as

[17] Ideally, one should estimate the working population classified by gender, age, education, sector of economic activity, income (wages), hours of work, and type of worker (i.e., employee, self-employed, and so on).

[18] Female labor was not included in agricultural EAP in the 1797 and 1860 population censuses and represented a small and declining proportion of male labor thereafter. Thus, female/male ratios in agricultural EAP were, according to population censuses, around 0.2 over 1877–1900 and ranged between 0.05 and 0.1 during the early twentieth century. The exclusion of females working in agriculture from the total working population is usual in Spanish historical literature. See Nicolau (2005); Erdozáin and Mikelarena (1999); and Pérez Moreda (1999: 55).

[19] A similar strategy was followed by Carré et al. (1975: 89).

[20] We follow here Prados de la Escosura (2003: 207–8), and have adjusted downwards the percentage of EAP employed in agriculture between 1887 and 1920, redistributing the 'excess' agricultural workers proportionally between industry and services.

[21] Population censuses are available in Spain for 1860, 1877, 1887, 1900, 1910, 1920, 1930, 1940, and 1950.

[22] We have been unable to carry out a sensitivity test for the consequences of such an arbitrary assumption. However, since agriculture and services provided most of the employment prior to 1900 (more than 80%) the bias introduced by our assumption is unlikely to be very large. The fact that the number of hours worked across manufacturing industries did not change significantly during the late nineteenth century also helps to reduce the size of the bias. Employment data on mining and on construction is drawn from Chastagnaret (2000) and Prados de la Escosura (2003), respectively.

[23] Interestingly enough, a similar number of days is obtained for the 1960s and early 1970s. For example, for 1973, the Conference Board, on the basis of OECD data, estimated 2005 h worked per person in Spain, while ILO reckoned that, on average, Spanish workers spent 44.2 h per week at their place of work. This means that, on average, Spaniards worked 272 days per year.

[24] Soto Carmona (1989: 608) pointed out that, on average, the number of days worked per occupied individual up to 1919 ranged between 240 and 270.

[25] Day laborers, according to García Sanz (1979–80: 63), worked an average of 242 days per year in mid-nineteenth century Spain. Gómez Mendoza (1982: 101) emphasized the seasonal nature of late nineteenth century employment and estimated that, on average, a farm laborer worked 210 days out of 275–300 working days per year. Vandellós (1925) reckoned that, in 1914, the average number of days worked per year in agriculture was 250. Simpson (1992) estimated labor requirements in Andalusia's agriculture between 1886 and 1930 and obtained even lower figures, ranging from 108 to 130 days.

[26] Using Simpson's (1992) labor requirements per hectare for each type of crop, we have computed, under the assumption of constant technology, the number of full days of work required by Spanish agriculture at different agricultural benchmarks (1891/95, 1897/1901, 1909/13, 1920, 1929/33, 1950, and 1958) and divided the resulting figures by the male EAP in agriculture. They range from 129 (1891/95) to 178 days (1929/33) per male worker. Simpson considers his estimates to be on the low side. In fact, even if we arbitrarily raise them by 25%, the number of days worked would range from 172 (1891/95) to 238 days (1929/33).

making their own implements and clothing and providing services such as transportation and storage.[27] However, Spanish population censuses tend to include only information about people's main occupation, and given 'pluriactivity' among agricultural EAP, non agricultural occupations performed by peasants tend to be underestimated. At the same time, the inconsistency of population census numbers for the female labor in agriculture led us to exclude these figures (see above) but, at the same time, required an allowance for female EAP in agricultural activities. Thus, we assumed that female labor represented a stable proportion of male labor force in this sector and, hence, the number of days assigned to each male worker was raised to 270 days per year per occupied person in the countryside, distributed between agriculture (240 days) and services (30 days).[28]

As regards the numbers of yearly hours worked per occupied person we observed that there was not only a long run decline over 1850 1954, but also a large variance across sectors. For mid nineteenth century agriculture, Caballero (1864) suggested 10 h per day, and a similar average figure, 9.7 h, was found for the mid 1950s.[29] We decided to accept 10 h per day for 1850 1911 and to interpolate these two figures exponentially over 1912 35, and we retained 9.7 h for the period 1936 54. For industry and services, Huberman's (2005) figures for 1870 1899 were accepted and exponentially interpolated to derive annual hours worked, and the number of hours worked in 1870 was accepted for 1850 69. Doménech's (2007) estimates for different industries and services in 1910 were adopted for 1900 1910, while Silvestre's (2003) annual computations for industry were used for 1911 1919. Soto Carmona (1989: 596 613) provides some construction and services figures for the interwar years. The next period for which we had quantitative evidence on hours worked was the early 1950s. We found that the number of hours per worker was often close to that of 1919, a far from surprising fact as qualitative evidence suggests that the number of hours per worker probably declined during the 1920s and early 1930s in a context of trade unions' rising bargaining power, but remained unchanged or even grew during the early years of Franco's dictatorship. So we chose to accept the number of working hours per occupied in 1954 for the years 1936 53, and to interpolate exponentially the figures for 1919 and 1936.

For the post 1954 period, labor force data comes from the MOISSES base for the period 1954 1963,[30] from *Encuesta de Población Activa* (hereafter EPA) for 1964 1980,[31] and from the official national accounts for 1980 2000.[32] The overall distribution of the labor force across the different industries was based on *Banco de Bilbao*'s studies.[33] We, then, distributed workers for each industry into four occupational categories (unskilled and skilled operatives, technicians, and managers) with information provided by *Instituto Nacional de Estadística* (INE). Finally, we converted the number of workers into hours worked for each occupation and branch of economic activity by assuming that, in a given sector, all employees worked the same number of hours per year.[34]

The amount of labor, measured by total hours worked, represents a moderate increase over the long run. The labor force grew moderately up to World War I and accelerated during the 1920s and early 1930s partly as a result of population growth and rural urban migration. The work force increased again during the Golden Age (1951 74). The 'transition to democracy' decade (1975 86) witnessed a dramatic fall in employment driven by the oil shocks and the exposure of traditionally sheltered industrial sectors to international competition. Labor market deregulation, a marked increase in female participation rate, and the arrival of immigrants only in the last decade of the twentieth century, are behind the rise in employment since 1987.

A clearer picture of the evolution of the labor quantity can be obtained by breaking down the number of hours worked into its components using the formula in which total hours worked, (H), equals hours per employee, (H/E), times the rate of employment, that is, the employee, E, to EAP, L, ratio (E/L), times the participation rate (that is, the ratio of EAP, L, to the working age population, that is, 15 to 64 years old, WAN), (L/WAN), times the share of working age population in total population, (WAN/N), times total population (N):

$$H = (H / E)*(E / L)*(L / WAN)*(WAN / N)*N \tag{6}$$

that in rates of change (lower case letters), can be expressed as:

$$h = (h / e) + (e / l) + (l / wan) + (wan / n) + n. \tag{7}$$

[27] Pérez Moreda (1999: 57) mentions a contemporary estimate for 1960 that puts disguised unemployment at 1.8 million in a potential agricultural workforce of over 5 million.

[28] Our decision to assign peasants' extra-agricultural activities to services is due to the destruction of traditional crafts (particularly textiles) by modern industry, cotton goods in particular (Carmona Badía, 1990; Rosés, 2004), while work in services, such as transportation, persisted throughout the second half of the nineteenth century (Gómez Mendoza, 1982).

[29] The figure for the 1950s was obtained by dividing the figure for yearly hours, which was provided by Teresa Sanchis (private communication), by the number of working days per year.

[30] Antonio Díaz Ballesteros kindly provided us with this data.

[31] Reconstructed in Baiges et al. (1987).

[32] The different time segments were spliced using the gap distribution procedure for those years in which the different estimates overlap, as employed in Prados de la Escosura (2003). Official national accounts, CNE80, CNE85, CNE95, and CNE2000 have been used for 1980–85, 1985–95 and 1995–2000, respectively.

[33] These are collected in Fundación BBV (1999).

[34] Sanchis (private communication) furnished us with data on hours per economically active population for the 1950s. We used Maluquer de Motes and Llonch (2005), who rely on ILO data, for 1958–63; Ministerio de Trabajo (1964–78) for the period 1964–1978; and OECD (2006) from 1979 onwards.

Table 3
Labor quantity growth decomposition, 1850–2000. (Annual average logarithmic rates %).
Source: See the text.

	(I)	(II)	(III)	(IV)	(V)	(VI)
	Hours worked (*H*)	Hours per occupied (*H*/*E*)	Occupied per EAP (*E*/*L*)	EAP per Pop 15–64 (*L*/*WAN*)	Pop 15–64/population (*WAN*/*N*)	Population (*N*)
1850–2000	0.4	0.3	0.1	0.1	0.1	0.6
Panel A						
1850–1950	0.5	0.1	0.0	0.0	0.1	0.6
1951–1974	1.0	0.4	0.3	0.4	0.3	1.0
1975–2000	0.4	0.8	0.6	0.2	0.4	0.4
Panel B						
1850–1883	0.6	0.1	0.1	0.1	0.0	0.4
1884–1920	0.2	0.2	0.1	0.0	0.0	0.6
1921–1929	1.8	0.3	1.0	0.0	0.1	1.0
1930–1952	0.8	0.1	0.1	0.1	0.3	0.9
1953–1958	0.4	0.6	0.4	0.8	0.3	0.8
1959–1974	0.6	0.5	0.0	0.2	0.2	1.1
1975–1986	3.6	1.5	2.4	0.8	0.4	0.7
1987–2000	2.4	0.1	1.0	1.0	0.3	0.2

Population growth and the decline in working hours per employee explain, in a proportion of two to one, most of the moderate increase in the labor quantity over the long run (Table 2). Hours per worker and per year fell from 2800 at mid nineteenth century to 1800 by the end of the twentieth century (Table 3).[35]

Throughout the hundred and fifty years of modern economic growth considered here, the rise in the total number of hours worked was mainly determined by population growth. However, a closer look reveals how other factors influenced its evolution across different long swings. For example, the declining hours per worker/year over 1914 36, a result of the gradual adoption of the 8 h per day standard associated with increasing urbanization and structural change. In the 1920s, falling hours per worker went in parallel with a significant increase in the employment rate, also linked to structural transformation. Between the early 1930s and the 1950s, the rising share of the working age population, a legacy of the demographic transition, made up for the contraction in participation (*L*/*WAN*) and employment (E/L) rates. In the Golden Age, the participation rate fell short of offsetting the rise in the dependency rate and the significant fall in annual hours worked per employed person, resulting in a deceleration in the growth of the total hours worked. Later, during the 'transition to democracy' years (1975 86), the fall in the participation rate, the dramatic surge in unemployment, and the intensified decline in yearly hours per occupied person, that resulted from employment restructuring and the trade unions' increased bargaining power provoked a dramatic contraction in the quantity of labor. Since Spain's entry into the European Union (1986), the brisk recovery in the participation and employment rates helps explain the increase in the total hours worked.

The third phase in the construction of the labor input was to weight each category of workers by its average nominal earnings.[36] The quality and availability of wage data necessary to construct these estimates vary enormously through time and, due to data availability, four periods have been considered: 1850 1908, 1908 1920, 1920 1954, and 1954 2000. We have drawn on a wide variety of sources to obtain wage data for 1850 1908.[37] From 1908 to 1920, we have used the detailed wage inquiries conducted by the *Instituto de Reformas Sociales*.[38] Their reports (*Memorias Generales de la Inspección de Trabajo*) contain information by gender on minimum, maximum and average wages for twenty branches of industry.[39] The quality of wage data decreases dramatically over the years 1920 1954.[40] In 1920, *Instituto de Reformas Sociales* ceased operations and was replaced by the *Ministerio de Trabajo*, and such a change implied that wage data collection was interrupted. Subsequently, wages for only nine occupations in each of the fifty Spanish provinces were published in the *Anuario Estadístico de España* (ad annum, hereafter *AEE*)

[35] The decline in the number of daily hours worked per occupied individual led Denison (1962), to introduce the caveat that the effort per hour was inversely related to the number of hours worked. This reasoning leads us to the use of employment rather than hours worked as the relevant indicator of the quantity of labor in growth accounting (Gordon, 1999: 124). However, here we follow the conventional approach and use total hours worked as a measure of the labor quantity.

[36] In the case of self-employed workers, we have assumed, following the principle of opportunity cost, that their labor cost was equal to that of the average worker in their industry (Prados de la Escosura and Rosés, 2003).

[37] Agricultural wages were taken from Bringas Gutiérrez (2000). Wages in construction (Madrid unskilled wages) and services were obtained from Reher and Ballesteros (1993), although they have been re-scaled to the national levels provided by Rosés and Sánchez-Alonso (2004). Chastagnaret (2000) and Escudero (1998) provided wages for mining. Levels of manufacturing wages in all industry and services sectors at different dates (1850, 1880, 1905) were obtained, respectively, from Cerdá (1867), U.S. Department of Labor (1990), and *Anuario Estadístico de Barcelona* (1905). Annual variations between benchmarks were derived by means of Fisher indices with data drawn from Camps (1995), Llonch (2004), and Soler (1997), in the case of consumer industries, and Escudero (1998); and Pérez Castroviejo (1992) in the remaining industries.

[38] Javier Silvestre has kindly given us access to his wage database.

[39] Unfortunately, the source does not provide information on wages in agriculture and services, so we had to rely on data from Bringas Gutiérrez (2000), and Reher and Ballesteros (1993), respectively.

[40] See Vilar (2004), for a review on the wage sources for this period.

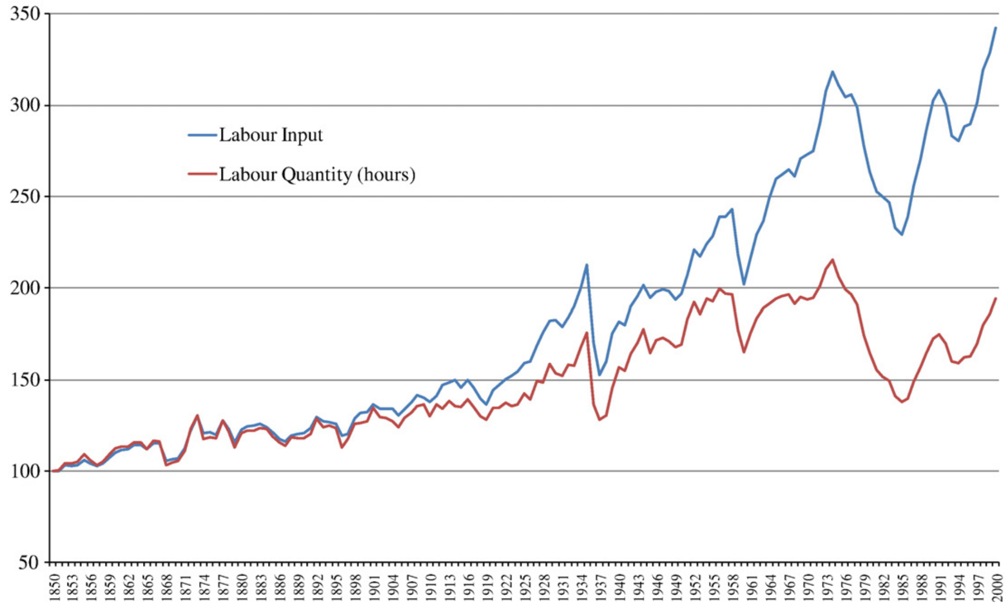

Fig. 3. Labor input and quantity: income-based approach.
Source: See text.

that was extended to cover fifteen occupations by 1925. However, a detailed survey of industry wages for 1914, 1920, 1925 and 1930 was published in 1931 (Ministerio de Trabajo, 1931). By combining the wage levels from the *Ministerio de Trabajo*'s survey for 1930 and wage variation rates from *AEE*, we constructed our nominal wage series, classified by industry, for the period 1920 1936. Difficulties in obtaining wage data increased after the Civil War. During the early years of General Franco's Dictatorship the so called Autarchy period, wages and earnings were severely regulated and encompassed in kind and extra payments not included in the wage data from earlier publications. Moreover, the only published information was collected at *AEE*.[41] We, then, spliced wage levels for 1930 and 1955 with a Fisher index of yearly wage variations constructed from the *AEE* data to obtain yearly wage series. From 1954 onwards, we employed labor costs by sectors of economic activity from *Banco de Bilbao*.[42] Because these do not provide a breakdown by occupational categories, the breakdown had to be obtained from the official inquiries on wage, labor costs, and wage structure[43] and which were later re scaled to match aggregate figures in *Banco de Bilbao*'s statistics.

Fig. 3 reports the evolution of labor input and labor quantity (unweighted hours worked) from 1850 to 2000. Although the evolution of labor input parallels that of labor quantity, a faster growth is observed in the labor input resulting from shifts in labor composition (“quality”) derived as the ratio between input and quantity that, in so far as it captures improvements in workers' skills, provides a measure of human capital. Three acceleration phases stand out in the evolution of the labor input: the 1920s, the Golden Age, and 1986 2000 (Table 4, col. III). Labor quality improvements contributed significantly to labor input growth in the interwar period and the Golden Age, and offset its decline when the total hours worked fell during the ‘transition to democracy’ years (1975 86) (Table 4, col. II). Interestingly, labor quality seems to have made only a very slight contribution to the growth of labor input following pain's accession to the European Union in 1986 (Fig)

4. Comparing alternative approaches

If we now compare our labor quality estimates obtained through income based and education based approaches (Table 4, Cols. II and IV, respectively) their trends largely concur: slow growth prior to 1950 and acceleration thereafter. The main exceptions are the 1920s, when education based figures represent only one fourth of the significant improvement shown using the income based approach, and the 1987 2000 period, when the labor quality obtained through the education based approach shows a gain of 1.0% per year, against the 0.2% obtained with the income based approach.[44] In the case of the 1920s, the income based estimates

[41] Recently, Vilar (2004) collected new data from unpublished local sources that we have employed in our calculations.
[42] Collected in Fundación BBV (1999) and Alcaide and Alcaide (2001).
[43] Ministerio de Trabajo (ad annum; 1964–78), *Salarios*, *Encuesta de Salarios y de Coste Laboral (ad annum)*, and *Encuesta de Estructura Salarial (ad annum)*.
[44] Less striking discrepancies are found for the 1930–50 period, in which a deeper decline during the Civil War and its autarchic aftermath suppress any growth in Jorgenson-income based results, and for the Golden Age (1950s–early 1970s), when the education-based approach exhibits slower growth.

Table 4
Labor quantity, quality, and input growth: alternative estimates. (Annual average logarithmic rates %).
Sources: col. (I), Table 3, col. (I); Col. (IV), Table 2, col. (VI). Otherwise, see the text.

		Income-based approach		Education-based approach	
	(I)	(II)	(III)	(IV)	(V)
	Labor quantity	Labor quality	Labor input	Labor quality	Labor input
			[(I) + (II)]		[(I) + (IV)]
1850–2000	0.4	0.4	0.8	0.4	0.8
Panel A					
1850–1950	0.5	0.2	0.7	0.2	0.7
1951–1974	1.0	1.0	2.0	0.7	1.7
1975–2000	0.4	0.7	0.3	1.0	0.6
Panel B					
1850–1883	0.6	0.1	0.7	0.2	0.9
1884–1920	0.2	0.1	0.4	0.1	0.3
1921–1929	1.8	0.8	2.6	0.2	2.0
1930–1952	0.8	0.0	0.8	0.3	1.1
1953–1958	0.4	1.2	1.6	0.6	1.0
1959–1974	0.6	1.1	1.7	0.7	1.3
1975–1986	3.6	1.2	2.4	1.2	2.5
1987–2000	2.4	0.2	2.6	1.0	3.3

seem to be more consistent with the evidence on growth and structural change than those suggesting negligible growth derived from the educational attainment approach (Fig. 4).

We have made an attempt to solve the conundrum for the post 1986 period by carrying out a sensitivity test for the period 1964 2000, when better data are available. Thus, we have computed a new labor quality index in which the occupational categories of our income based index were replaced by educational categories and workers and, then, weighted by the average remuneration of their education level in their respective industries. Firstly, we substituted five educational categories (illiterate, primary schooling, secondary schooling, pre tertiary, and tertiary) from the study by Mas et al. (2005) on human capital for our occupational categories. Then, we employed the parameters from Alba and San Segundo's (1995: 159) Mincerian regression for 1990 to weight each category by its relative value (wage) while maintaining the congruence with the total remuneration of the industry.[45] Hence, the relative remuneration of different educational categories is identical within all industries but average wages differed across industries. The new Mincerian labor quality estimates give annual growth rates of 1.0 and 0.8% for 1975 86 and 1987 2000, respectively. These results match quite well those previously derived using the education based approach to human capital (Table 2) and confirm the discrepancy between the income based and the education based human capital estimates over 1987 2000. All in all, over the period 1964 2000, the income based and the new Mincer estimates give similar growth rates (0.8 and 0.9%, respectively). The discrepancy for 1987 2000 may stem from internal changes in the composition of labor categories, as the amount of education per type of worker increased dramatically with the diffusion of compulsory schooling, secondary and tertiary education. However, it could also be the case that increases in education resulted from a growing consumption demand of a highly income elastic good, schooling, with no corresponding impact on the quality of the labor force. Thus, growth rates of human capital computed with the education based approach would tend to be upward biased. As a partial test we have carried out a comparison between human capital estimates derived through the Jorgenson and the education based approaches for a sample of East Asian countries and the US. We find that, over 1966 90, human capital in Hong Kong, Korea, Singapore, and Taiwan grew at 0.6, 1.0, 1.2, and 0.3% per year, respectively, using the income based approach (Young, 1995), and at 0.9, 1.2, 0.4, and 0.9% with the education based approach (computed with years of schooling from Barro and Lee (2000) for 1965 1990, and a 7% rate of return), so in all cases but Singapore's, the education based procedure gives a higher growth rate. The same finding is obtained for the US over 1960 73, as human capital grew at 0.5% with the income based approach (Gollop and Jorgenson, 1980) and 0.8% with the education based approach (Christensen et al., 1980). Hence, the exercise confirms our finding for Spain and provides a hypothesis that deserves further research.

5. Implications for long-run productivity growth

A final step in our investigation is to assess the impact of human capital on labor productivity growth and in order to do this we use a growth accounting framework.[46] This exercise provides another opportunity to judge which of the two approaches to measuring human capital trends offers a more reasonable picture. The sources of labor productivity growth over the long run are

[45] These parameters represent the average educational premium for each educational category.
[46] The growth accounting framework and its sources are fully described in Prados de la Escosura and Rosés (2009).

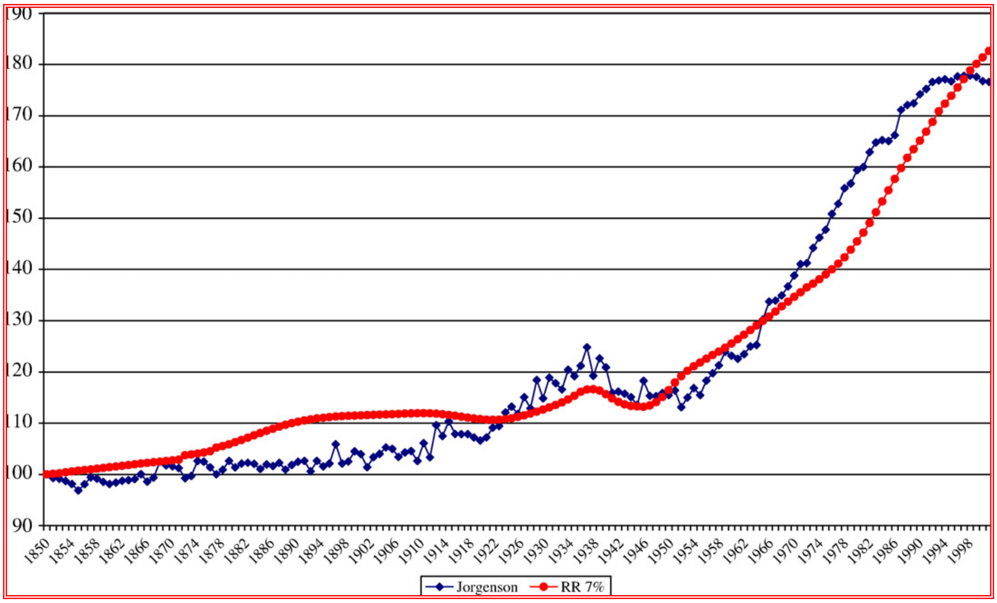

Fig. 4. Human capital estimates: education- (7% rate of return) and income-based approaches.
Source: See text.

presented in Table 5, with labor quality estimates using the income based approach and the resulting TFP estimates in Cols. (IV) and (V), and alternative estimates using the education based approach and the subsequent TFP estimates in Cols. (VI) and (VII). Hence labor productivity trends are determined by human and physical capital/labor ratios and efficiency gains.

A main finding is that TFP accounts for half the increase in labor productivity over 150 years considered, with broad capital (mostly physical capital) for the other half. Nonetheless, there is a clear divide between factor input accumulation as the dominant force (contributing two thirds of labor productivity growth) pre 1950 with the exception of the 1920s, and TFP then taking over, with a contribution of two thirds of labor productivity growth in the Golden Age (1951 74) and about one half during the democratic transition (1975 86), but losing its importance again in 1987 2000.

As regards the contribution of human capital to labor productivity growth, we can observe that, with any measure, human capital contributed less than physical capital and TFP. Moreover, there are only slight differences between the contributions of

Table 5
Sources of labor productivity growth (1850–2000): Alternative labor quality estimates. (Annual average logarithmic rates %).
Sources: col. (I), Table 5, col. (III); col. (IV), Table 4, col. (IV); Prados de la Escosura and Rosés (2009). See the text.

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
				Income-based approach		Education-based approach	
	GDP per hour worked	Land	Capital input	Labor quality	TFP	Labor quality	TFP
1850–2000	2.1	0.0	0.8	0.2	1.1	0.3	1.0
Panel A							
1850–1950	0.9	0.0	0.5	0.1	0.3	0.1	0.3
1951–1974	5.5	0.0	1.2	0.6	3.7	0.4	3.9
1975–2000	3.4	0.0	1.4	0.4	1.7	0.7	1.3
Panel B							
1850–1883	1.2	0.1	0.6	0.0	0.6	0.1	0.5
1884–1920	1.0	0.1	0.6	0.1	0.2	0.1	0.3
1921–1929	2.0	0.1	0.6	0.5	1.1	0.1	1.4
1930–1952	0.0	0.0	0.2	0.0	0.1	0.3	0.5
1953–1958	4.3	0.2	1.3	0.8	2.4	0.4	2.9
1959–1974	6.3	0.0	1.2	0.9	4.2	0.5	4.6
1975–1986	6.1	0.0	1.9	0.9	3.4	0.8	3.4
1987–2000	1.1	0.0	0.8	0.1	0.2	0.6	0.3

alternative measures of human capital to labor productivity growth over the long run. Hence, using alternative measures does not change the broad interpretation of the role of capital accumulation in productivity advance.

In fact, differences between alternative measures of human capital are concentrated in short run periods. A closer look shows that the contribution of human capital to labor productivity growth varies according to whether it is measured through the income based or the education based approach. For example, it is only in the 1920s and, particularly, in the last period considered l987 2000 that noticeable differentials in labor quality appear and have, therefore, an impact on TFP growth. In the 1920s, human capital would have contributed one fourth of labor productivity growth according to the income based approach estimate, but its contribution would have been negligible under the education based approach. In 1987 2000, the latter's figure contribution to labor productivity growth was 57%, and the former only about 13%. However, over the period of fast productivity advance, 1953 86, the estimated contribution of human capital was twice as much in the income based approach.

As regards the implications of human capital alternative measures for TFP growth, it is worth noting that during the 1920s, a lower improvement in education based estimates increases TFP growth to 1.4%, compared to the 1.1% obtained under the income based approach, which would indicate that TFP contributed more than two thirds and one half of labor productivity growth, respectively. Conversely, between 1987 and 2000, the more intense labor quality gains in the education based estimates suppress the TFP contribution to labor productivity growth (−0.3% compared to 0.2 using the income based approach).

The results for 1987 2000 cast doubt on the use of the education based approach as a measure of human capital. With per capita income growth, the population invested more in education, but not all education was employed in the production side of the economy. Thus, any measure of human capital based on education would tend to overestimate the contribution of human capital to economic growth and, in consequence, to underestimate TFP growth.

In Spain, although human capital contributed little to the increase in labor productivity growth, it could be the case that human capital accumulation had a “level” effect of facilitating technological innovation. In particular, the increase in human capital during the Golden Age correlates well with the spectacular rise in TFP growth rates, which was facilitated by the massive adoption of foreign technologies. However, further research will be required to test this proposition.

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