Human Capital Accumulation and Growth in Spain, 1850-2000

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Abstract

Between 1850 and 2000, Spain's real output and labor productivity grew at average rates of 2.5 and 2.1 percent. We investigate the effect of human capital accumulation on Spanish growth rates using two alternative approaches based on the concept of 'labor quality' and on the idea of education. We, then, discuss the implications of the different measures for Total Factor Productivity growth. Physical and human capital accumulation and efficiency gains appear as complementary in Spain's long-term growth. Factor accumulation dominated long-run growth up to 1950, while total factor productivity led thereafter and, especially, during periods of growth acceleration.

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The role of human capital in the growth process has been extensively analyzed since Adam Smith and Alfred Marshall, although it was not until the mid-20th century that Gary Becker, Theodore W. Schultz and Jacob Mincer developed a complex theory of human capital, according to which the individual level of education and experience determines future labor income. Schultz argued that a large share of economic growth comes from further additions to the initial stock of human capital and that human capital accumulation was largely responsible for the "residual" of the early growth accounting exercises. Denison, Jorgenson and Griliches examined empirically this hypothesis 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' and, in particular, the important contribution by Lucas (1988), the relationship between human capital and growth became central for those interested in the causes of growth.

Over the last century and a half aggregate economic activity in Spain experienced a sustained expansion at an average rate of 2.5 percent per year, while per capita GDP did it at an annual rate of 1.9 percent. GDP per hour worked expanded at a faster rate (2.1 percent) as hours of work per person declined. Did factor accumulation or productivity improvement account for it? In particular, did human capital contribute to accelerating growth and facilitating TFP growth?

FIGURE 1]

[TABLE 1]

The main goal of the paper is to provide new empirical evidence on human capital accumulation and to explore its connections with economic growth for the case of Spain. Human capital is a complex theoretical concept. Generally speaking, it refers to the resources in people. The OECD defines it as "the knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity". This broad definition is not restricted to education but encompasses all investments in humans which are made to improve their skills, including schooling and parental education, on-the-job training and learning-by-doing (i.e., acquiring skills through work experience) or any other activities that improves the productive use of a person's skills. Two

alternative measures of human capital are presented: the first is based on the concept of 'labor quality' and the second on the idea of education. We, then, use a growth accounting approach to decompose this long-run growth into the contribution of production factors in terms of quantity and efficiency.[1] The sources of Spain's growth have changed dramatically since 1850. Physical and human capital accumulation and TFP growth appear complementary in Spain's long-term growth and our results for Spain confirm Collins and Bosworth's finding of low TFP growth for countries in their early stages of development.[2] Factor accumulation dominated long-run growth up to 1950, while efficiency gains led thereafter and, especially, during periods of growth acceleration.

The rest of the paper is divided into three parts. Section 2 presents the alternative measures of human capital. Section 3 discusses the implications of the different measures for Total Factor Productivity using a reduced form of Jorgenson's growth accounting. Then, in Section 4, we discuss the role of TFP and factor accumulation in GDP and labor productivity growth on the basis of alternative growth-accounting measures.

ALTERNATIVE MEASURES OF HUMAN CAPITAL

In this section we will compute two alternative measures of human capital. We will begin, first, with the labor quality approach and, then, we will turn to the education approach to human capital. In order to evaluate the contribution of human capital during the past one-and-a-half century, a measure for the effects of both schooling and training is necessary. An alternative approach suggested

[1] 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, "Growth Accounting"; Collins and Bosworth, "Economic Growth", p. 139). In this paper, we make a historical adaptation of Domar's, "Measurement of Technological Change", and Griliches and Jorgenson's, "Explanation of Productivity Change", approach to measure factor inputs in terms of quality.

[2] As Collins and Bosworth, "Economic Growth", p. 164, point out, technical advances might be embodied in new capital while increasing TFP might induce greater capital accumulation by raising the returns to capital.

by recent growth accounting exercises gives a simple solution to this problem through computing the quality of the labour force; that is, the set of skills employed during production.[3] There are two basic ideas behind this: (1) the quality of the labour force is enhanced by past investments in human capital, (2) differentials in individuals' earnings are the consequence of these same investments. These two ideas are derived directly from the seminal arguments of human capital theory. Put simply, the argument is that the income employed in enhancing human capacities raises the worker's earnings because it increases productivity per worker. This argument is widely debated. Some authors have maintained that earnings differentials are due to institutional constraints. As a result, human capital accumulation cannot be measured by computing individual earnings since they do not imply a direct relationship between age, experience, skill and productivity.

d) Labor input

The appropriate measure of labor input is the flow of services for production emanating from this factor.[4] Hence, our task is to estimate the labor force cross-classified by as many attributes as possible to capture its heterogeneity.[5] 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, Spanish working population has been cross-classified by gender, two different age attributes (adult, child), branch of activity, income, and hours of work but we have been unable to match the income received by each

[3] See, for example, Jorgenson (1990), "Productivity", and Young, "Tyranny of Numbers".

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

(12) $$Li_t = \lambda_{Li} Hi_t,$$

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

[5] 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).

worker with her/his age and level of education. However, as a sensitivity test, we provide below alternative estimates for the labor input on the basis of educational attainment data.

The first step in the construction of 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 [EAP, thereafter], with 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 female population,[6] while assumed that female labor represented a stable proportion of male labor force in agriculture and, thus, we have increased the number of days assigned to each male worker (see below).[7] 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 moved along the proportion of rural population (living in villages with less than 5,000 inhabitants) in total population.[8] 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

[6] 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 20th century. The exclusion of females working in agriculture from the total working population is usual in Spanish historical literature. Cf. Nicolau, "Población"; Erdozáin and Mikelarena, "Cifras de activos agrarios"; and Pérez Moreda "Población y economía", p. 55.

[7] A similar strategy was followed by Carré et al., *French Economic Growth*, p. 89.

[8] We follow here Prados de la Escosura, *Progreso*, pp. 207-8, and adjusted downwards the percentage of EAP employed in agriculture between 1887 and 1920 redistributing the 'excess' agricultural workers proportionally between industry and services.

cycle (obtained as deviations from the Hodrick-Prescott trend in output). Later, employment figures by sector were corrected to preserve additive congruence 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 working population into 19 industries up to 1900, 21 industries for 1900-10, 22 for 1911-50, and 24, thereafter.[9] Alas, lack of data for 1850-1900 forced us to breakdown manufacturing employment into its branches by assuming that its distribution in 1900 was representative for the entire period.[10]

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 270 days per annum in industry and services. Such figure results from deducting Sundays and religious holidays plus an allowance for illness.[11] This assumption is consistent with contemporary testimonies and supported by the available evidence.[12] In agriculture, however,

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

[10] Unfortunately we cannot 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 (above 80 percent) the bias introduced by our assumption should not be very large. The fact that the number of hours worked across manufacturing industries did not change significantly during the late 19th century also works to reduce the size of the bias. Employment data on mining and construction is drawn from Chastagnaret *L'Espagne* and Prados de la Escosura *Progreso*, respectively.

[11] 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 2,005 hours worked per person in Spain, while ILO reckoned that, on average, Spanish workers spent 44.2 hours per week at their place of work. This means that, on average, Spaniards worked 272 days per year.

[12] Soto Carmona (*Trabajo industrial*, p. 608) pointed out that, on average, the number of days worked per occupied up to 1919 ranged between 240 and 270.

contemporary and historians' estimates point to a lower figure for the working days per occupied.[13] Throughout most of the nineteenth and 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.[14] 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 producing their own implements, clothing and, especially, providing services such as transportation and storing.[15] However, Spanish population censuses tend to include only information about people's main occupation, and given 'pluriactivity' in agricultural EAP, non-agricultural occupations performed by peasants tend to be underestimated. At the same time, the inconsistency of population census numbers for 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

[13] Day laborers, according to García Sanz, "Jornales agrícolas", p. 63, worked an average of 242 days per year in mid-nineteenth century Spain. Gómez Mendoza, *Ferrocarriles*, p. 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, "Richesse et Revenue", reckoned that, in 1914, the average number of days worked per year in agriculture was 250. Simpson, "Technical change", estimated labor requirements in Andalusia's agriculture between 1886 and 1930 and obtained even lower figures, ranging from 108 to 130 days.

[14] Using Simpson's, "Technical change", labor requirements per hectare for each type of crop, we have computed, under the astringent 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 percent, the number of days worked would range from 172 (1891/95) to 238 days (1929/33).

[15] Pérez Moreda, "Población y economía", p. 57, mentions a contemporary estimate for 1960 that puts disguised unemployment at 1.8 million in a potential agricultural workforce of over 5 million.

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 in the countryside, distributed between agriculture (240 days) and services (30 days).

As regards the numbers of yearly hours worked per occupied 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, Fermín Caballero pointed to 10 hours per day while a similar average figure, 9.7 hours, was found for the mid 1950s.[16] We decided to accept 10 hours per day for 1850-1911 and to interpolate these two figures exponentially over 1912-35, while we maintained 9.7 hours for the period 1936-54. For industry and services, Michael Huberman's figures for 1870-1899 were accepted and exponentially interpolated to derive annual hours worked, while the number of hours worked in 1870 was accepted for 1850-69.[17] Jordi Domenech's estimates for different industries and services in 1910 were adopted for 1900-1910, while Javier Silvestre's annual computations for industry were used over 1911-1919.[18] Álvaro Soto Carmona provides some construction and services figures for the Interwar years.[19] 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 General 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.

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[16] Caballero, *Memoria*. The figure for the 1950s was obtained dividing yearly hours, which was provided by Teresa Sanchis (private communication), by the amount of yearly working days.

[17] Huberman, "Working Hours".

[18] Doménech, "Working Hours"; Silvestre, *Migraciones interiors*, p. 190.

[19] Soto Carmona, *Trabajo industrial*, pp. 596-613.

For the post-1954 period, labor force data comes from the MOISSES base for the period 1954-1963,[20] from *Encuesta de Población Activa* (thereafter EPA) for 1964-1980,[21] and from the official national accounts for 1980-2000.[22] The distribution of overall labor force across the different industries was based on *Banco de Bilbao*'s studies.[23] 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 amount 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 amount of hours per year.[24]

The amount of labor, measured by total hours worked, presents a moderate increase over the long run. Labor force grew moderately up to World War I while accelerated during the 1920s and early 1930s partly as a result of population growth and rural-urban migration. Labor quantity rose again during the Golden Age (1951-74). The 'transition to democracy' decade (1975-86) witnessed a dramatic employment destruction driven by the oil shocks and the exposition 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 beneath the rise in employment since 1987.

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

[21] Reconstructed in Baiges *et al., Economía española*.

[22] 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, *Progreso*. Official national accounts, CNE80, CNE85, CNE95, and CNE2000 have been used for 1980-85, 1985-95 and 1995-2000, respectively.

[23] These are collected in Fundación BBV, *Renta nacional*.

[24] Sanchis (private communication), furnished us with data on hours per economically active population for the 1950s. We used Maluquer de Motes and Llonch, "Trabajo y relaciones laborales", who rely on ILO data, for 1958-63; Ministerio de Trabajo's *Salarios* for 1964-78; and OECD, *Labor Force Statistics* from 1979 onwards.

[TABLE 2]

A closer look at the evolution of the labor quantity can be obtained by breaking down the amount of hours worked into its components using the identity 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 population in working age, 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):

(1) $$H = (H/E) * (E/L)* (L/WAN) * (WAN/N)* N$$

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

(2) $$h = (h/e) + (e/l) + (l/wan) + (wan/n) + n$$

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 shrank from 2,800 at mid-nineteenth century to 1,800 by the end of the twentieth century (Figure 2).[25]

[FIGURE 2]

Throughout the hundred and fifty years of modern economic growth considered here, the rise of the quantity of labor measure in the total amount of hours worked was mainly determined by population growth. However, a closer look reveals how other factors at work conditioned 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 eight hours per day standard associated to increasing urbanization and structural change. In the 1920s, falling hours per worker went hand-in-

[25] The decline in the number of daily hours worked per occupied led Denison, *Sources*, to introduce the caveat that the effort per hour was inversely related to the number of hours worked. This reasoning leads to make employment rather than hours worked the relevant indicator of the quantity of labor in growth accounting (Gordon, "U.S. Economic Growth", p. 124). However, here we follow the conventional approach and use total hours worked as a measure of the labor quantity.

hand with a significant increase in the employment rate, also linked to structural transformation. Between the early 1930s and 1950s, the rising share of the working age population, a gift from 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, with the consequence of 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, 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 help explain the increase in the total hours worked.

The third phase in the construction of the labor input is to weight each category of workers by its average nominal earnings.[26] 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.[27] From 1908 to 1920, we employed in our calculations

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

[27] Agricultural wages were taken from Bringas, *Productividad de los factores*. Wages in construction (Madrid unskilled wages) and services were obtained from Reher and Ballesteros, "Precios y salarios", although they have been re-scaled to the national levels provided by Rosés and Sánchez-Alonso, "Regional Wage Convergence". Chastagneret, *L'Espagne*, and Escudero, *Minería*, 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, *Teoría General*, U.S. Department of Labor, *Fifteenth Annual Report*, and *Anuario Estadístico de Barcelona*. Annual variations between benchmarks were derived by means of Fisher

the detailed wage enquires conducted by the *Instituto de Reformas Sociales*.[28] Their reports (*Memorias Generales de la Inspección de Trabajo*) contained information by gender on minimum, maximum and average wages for twenty branches of industry.[29] The quality of wage data decreases dramatically over the years 1920-1954.[30] In 1920, *Instituto de Reformas Sociales* disappeared, being replaced by the *Ministerio de Trabajo*, and such a change implied that wage data collection was interrupted. Subsequently, wages for only nine occupations and fifty Spanish provinces were published in the *Anuario Estadístico de España* (hereafter *AEE*) that was extended up to fifteen occupations by 1925. Nonetheless, a detailed survey on industry wages for 1914, 1920, 1925 and 1930 was published in 1931.[31] 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 to obtain wage data increased since the Civil War. During the early years of General Franco's Dictatorship –the so called Autarchy period-, wages and earnings were severely regulated and included in-kind and extra-payments not comprised in the wage data from earlier publications. Moreover, the only published information was collected at *AEE*.[32] We, then, spliced wage levels for 1930 and 1955 with a Fisher index of wage yearly variations constructed from the *AEE* data to obtain yearly wage series. From 1954 onwards, we

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indices with data drawn from Camps, *Formación del Mercado de trabajo*; Llonch, "Jornada, salarios"; and Soler, "Evolución del salario", in the case of consumer industries, and Escudero, *Minería*; and Pérez Castroviejo, *Clase obrera*, in the remaining industries.

[28] Javier Silvestre has kindly given us access to his wages database.

[29] Unfortunately, the source does not provide information on wages in agriculture and services so we had to rely on data from Bringas, *Productividad de los factores*; and Reher and Ballesteros, "Precios y salarios", respectively.

[30] Vilar, "Ruptura posbélica" for a review on the wage sources for this period.

[31] Ministerio de Trabajo, *Estadística de salarios*.

[32] Recently, Vilar "Ruptura posbélica" collected new data from unpublished local sources that we have employed in our calculations.

employed labor costs by sectors of economic activity from *Banco de Bilbao*.[33] These do not provide, however, a breakdown by occupational categories that had to be obtained, then, from the official enquiries on wage, labor costs, and wage structure,[34] and which were later re-scaled to match aggregate figures in *Banco de Bilbao*'s statistics.

[FIGURE 3]

Figure 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 the labor input and the labor quantity- that, in so far 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 3, Col. III). Labor quality improvements contributed significantly to labor input growth in the Interwar and the Golden Age, while represented an offsetting force when labor destruction took place during the 'transition to democracy' years (1975-86) (Table 3, Col. II). Interestingly, labor quality hardly seems to have made a contribution to the growth of labor input following Spain's accession to the European Union in 1986 (Figure 4).

[TABLE 3]

Since human capital is usually approximated through education measures,[35] we have made alternative estimates of the quality of labor on the basis of educational attainment. Thus, we computed a human capital measure using data on age structure (as a measure of experience) and years of education attained, calibrated with the parameters from a Mincer equation for Spain in the early 1990s (Table 3, Col. IV).[36]. The average age of Spanish population ages 15 to 64 comes from

[33] Collected in Fundación BBV, *Renta nacional*; and Alcaide and Alcaide, *Renta nacional*.

[34] *Salarios*, *Encuesta de Salarios y de Coste Laboral* and *Encuesta de Estructura Salarial*.

[35] For Spain, see Mas et al., *Capital Humano*; and Doménech and de la Fuente, "Human Capital".

[36] Arrazola et al., "Returns to Education", p. 297. The estimate was carried out with data for 1993/4.

data supplied by David Reher and are assumed representative for the labor force.[37] Education attainment is based on Núñez estimates of the years of schooling received for population ages 15 to 50 for the period 1897-1974, projected backwards to 1877 with Núñez's own estimates for years of education of population ages 15-40 (1887-97) and 15-30 (1877-87), and, again, to 1850 with years of primary education acquired at the age of 15.[38] For the post-1974 period, we have relied on Daniel Cohen and Marcelo Soto's benchmark estimates of years of education interpolated log-linearly to obtain a yearly series and spliced with Nuñez's figures.[39] We carried out additional estimates and, following Bosworth and Collins, we obtained alternative human capital measures by relating educational attainment (*EDU*) to average years of schooling (*s*). Thus, $EDU = (1+r)^s$, with *r* being the rate of return.[40] We assumed alternatively 9 and 7.2 percent rates of return to each year.[41] The results of these alternative estimates, presented in Table A-1 of the Appendix, are highly coincidental.

If we now compare our labor quality estimates obtained through the Jorgenson and the Mincer approaches (Table 3, Cols. II and IV, respectively) their results largely concur, except for the 1920s, when educational attainment figures show no improvement, and the 1987-2000 period, when the labor quality obtained through the Mincer approach shows a gain of 0.9 percent growth,

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[37] We gratefully acknowledge David Reher who provided us with his unpublished yearly estimates of age composition of Spanish population between 1858 and 1970. We used INI official figures from 1970 onwards, and assumed that 1858 age composition was representative of that of 1850-57.

[38] Núñez, "Educación", pp. 167, 239-40 (Tables 3.1 and 3.13).

[39] Cohen and Soto, "Growth and Human Capital". The data used refer to "years of schooling of population 15-64 who is not studying". It is worth noting the high coincidence between figures by Núñez and Cohen and Soto during the years in which their estimates overlap (1960-74).

[40] Bosworth and Collins, "Empirics of Growth", pp. 119-20.

[41] The 9 percent return has been obtained by Alba and San Segundo, "Returns to Education", p. 162, after controlling for self-selection. The 7.2 percent return is quoted in Psacharopoulos and Patrinos, "Returns to Investment in Education": 127, and derives from Mora, Socioeconomic Background.

against the 0.2 percent obtained with the Jorgenson approach. In the case of the 1920s, our view is that the Jorgenson labor quality estimates seem to be more consistent with the evidence on growth and structural change than those suggesting negligible growth derived from the educational attainment approach.

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 Jorgenson index were replaced by educational categories and workers and, then, weighted by the average remuneration of their education level in their respective industries. Thus, we, firstly, we substituted five educational categories (illiterate, primary schooling, secondary schooling, previous to tertiary, tertiary) from Mas et al. study on human capital for our occupational categories.[42] Then, we employed the parameters from Alfonso Alba and María-Jesús San Segundo's Mincerian regression[43] for 1990 to weight each category by its relative value (wage) while maintaining the congruence with the total remuneration of the industry. 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 cast annual growth rates of 1.0 and 0.8 percent for 1975-86 and 1987-2000, respectively. These results match quite well those previously derived with the educational attainment approach to human capital confirming the discrepancy regarding labor quality growth over 1987-2000 between our direct Jorgenson-type estimate and that derived from the Mincerian approach. It could be that such a discrepancy resulted from internal changes in the composition of labor categories, as the amount of education per type of worker increased dramatically from 1986 to 2000 with the diffusion of compulsory schooling, secondary and tertiary education. We can, then, conclude that our Jorgenson labor input measure is biased against human capital since 1986 but

[42] Mas et al. *Capital Humano*

[43] Alba and San Segundo, "Returns to Education", p. 159. These parameters represent the average educational premium for each educational category.

captures reasonably well the impact of human capital on labor quality over the long-run. Actually, over the period 1964-2000, the Jorgenson and the new Mincer estimates cast similar growth rates (0.8 and 0.9 percent, respectively). Therefore, we will take both estimates into account in our analysis of the sources of growth in Spain.

THE 'PROXIMATE' SOURCES OF GROWTH

Growth accounting is "a means of allocating observed output growth between the contributions of changes in factor inputs and a residual, total factor productivity, which measures a combination of changes in efficiency in the use of those inputs and changes in technology."[44] In the growth accounting approach favored by Jorgenson, superlative indices are used, as well as heterogeneous measures of factor inputs that make it possible to separate their contribution to growth into quantity and composition changes.[45]

a) The Translog Index of Total Factor Productivity

The point of departure for our estimate of the sources of long-run growth in Spain is the production function given by:

$$Q = F(X, K, L) \tag{3}$$

In which output (Q) is as function of land (X), capital (K), and labor (L) inputs.

Specifically:

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[44] Bosworth and Collins, "Empirics of Growth", p. 114.

[45] As a consequence, a reduction in the 'unexplained residual' or total factor productivity can occur as the 'residual' no longer includes composition ("quality") changes in inputs. See Jorgenson, "Productivity". It is worth noting that Jorgenson's approach resembles but has striking differences with that of Denison, *Sources*. More specifically, Denison also cross-classified hours worked by workers' attributes and weighted them by wage rates. However, ignoring the heterogeneity among components of capital input, he did not cross-classified capital by type of asset and weighted it by rental rates like Jorgenson did. As Jorgenson, "Productivity", points out, this violated the equilibrium conditions for growth accounting analysis.

$$\ln Q = a_0 + a_x \ln X + a_k \ln K + a_l \ln L + \frac{1}{2} b_{xx} (\ln X)^2 + \frac{1}{2} b_{kk} (\ln K)^2 + \frac{1}{2} b_{ll} (\ln L)^2 b_{xk} \ln X \ln K + b_{xl} \ln X \ln L + b_{kl} \ln K \ln L \quad (4)$$

In two discrete periods of time, and after differentiating and taking logarithms:

$$\ln Q(t) - \ln Q(t-1) = \Theta_X [\ln X(t) - \ln X(t-1)] + \Theta_K [\ln K(t) - \ln K(t-1)] + \Theta_L [\ln L(t) - \ln L(t-1)] + TFP_{t-1,t,} \quad (5)$$

Θ_i denotes the elasticity of output with respect to each input.[46] Under the assumptions of perfect competition and constant returns to scale these elasticities are equivalent to the share of inputs in total factor payments. Weights are, then, given by the average share of each component in the total outlay for the two periods.[47] Under constant returns to scale, the values of factor shares sum to unity. [48] The Translog index of TFP ($TFP_{t-1,t}$) is the difference between the growth rate of output and a weighted average of the growth rates of factor inputs.

The rate of growth of output and of each input *i* between two periods is a weighted average of the growth rates of its *n* components.[49] The respective equations for output, land, capital, and labor are:

$$\ln Q_t - \ln Q_{t-1} = \sum_i [\overline{\Theta}_{Q_i} (\ln Qi_t - \ln Qi_{t-1})] \quad (6)$$

$$\ln X_t - \ln X_{t-1} = \sum_i [\overline{\Theta}_{L_i} (\ln Xi_t - \ln X i_{t-1})] \quad (7)$$

$$\ln K_t - \ln K_{t-1} = \sum_i [\overline{\Theta}_{K_i} (\ln Ci_t - \ln Ci_{t-1})] \quad (8)$$

$$\ln L_t - \ln L_{t-1} = \sum_i [\overline{\Theta}_{L_i} (\ln Li_t - \ln Li_{t-1})] \quad (9)$$

Where share values are computed as:

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[46] See Christensen *et al.* "Transcendental Logarithmic".

[47] Total outlay is practically equivalent to the total payments received for outputs. However, in some cases, these payments can be adjusted for direct taxation and monopoly gains to obtain the total outlay (that would reduce the share of capital in total payments and, hence, increase the rate of TFP growth). We make no adjustments here and assume that total outlay is equivalent to total payments.

[48] The Translog Index offers a justification for using variable shares and for adjusting production factors according their social product. See Jorgenson, "Productivity".

[49] Weights are given by the share of each component in the corresponding payments for each input.

(10) $$\overline{\Theta}_{n_i} = 1/2[\,\theta_{ni}(t) + \theta_{ni}(t-1)], \qquad (i = 1,..i,..n).$$

MAIN TRENDS IN TOTAL FACTOR PRODUCTIVITY

The sources of long-run growth in Spain are offered in Table 4, with labor quality estimates using the Jorgenson approach and the resulting TFP estimates in Cols. (VI) and (VII), and alternative estimates using the Mincer approach and the subsequent TFP estimates in Cols. (VIII) and (IX). Estimates derived with variable factor shares are presented in the upper panel and those with fixed factor shares (namely, their average for 1850-2000) in the lower panel. Over the one-and-a-half century considered, TFP and broad capital (physical and, to less extent, human capital) appear to be equally responsible for GDP growth. A glance at long periods shows that the early 1950s represent a divide between hundred years of moderate growth dominated by factor accumulation, and half a century of fast growth led by total factor productivity. Actually, 70 percent of the acceleration in GDP growth over 1951-2000 compared with 1850-1950, is due to efficiency gains.

[TABLE 4]

A closer look at long swing intervals reveals that prior to 1950 total factor productivity played a far from negligible role in phases of faster GDP growth: 1850-83 and the 1920s. Thus, TFP contributed between one-third and one-half (depending on whether Jorgenson or Mincer labor quality estimates are chosen) to acceleration of GDP growth in the 1920s over 1884-1920. Furthermore, the importance of TFP as a source of growth tends to be underestimated as it does not include the additional capital accumulation that results from a productivity increase.[50] Thus, in the absence of the innovation represented by the introduction of the railroads and the modern exploitation of Spanish mining ore deposits during 1850-83 and by electrification in the 1920s, we

[50] Cf. Hulten and Srinivasan, "Indian Manufacturing".

could speculate that the Spanish economy would have experienced not only lower efficiency gains but also lower capital intensity resulting from the lack of new capital goods.[51]

Total factor productivity led GDP growth during 1953-1986, a period that included both the Golden Age and, unexpectedly, the decade of sluggish growth when the transition from dictatorship to democracy was undertaken. TFP contributed with more than half of GDP growth during the Golden Age, and two-thirds to its acceleration over the previous hundred years. In fact, about two-thirds and four-fifths of the acceleration in GDP growth in 1953-58 and 1959-74 over the previous long swings (1930-52 and 1953-58, respectively) were due to TFP. Then, in the 'transition to democracy' years (1975-86) efficiency gains prevented a GDP contraction, as the increase in broad capital fell short to compensate the dramatic decline in employment. Conversely, since Spain's entry into the European Union (1986) employment creation and the recovery of physical capital accumulation offset the slowdown in total factor productivity.[52] The alternative use of variable and fixed factor shares across long swings does not cast conflicting results.[53]

If, alternatively, labor quality is measured through a Mincer approach (Table 4, Cols. (VIII) and (IX)), noticeable differentials in the labor quality contribution only appear and have, therefore,

[51] Cf. Crafts, "Productivity Growth", pp. 522-4. As regards the impact of railroads on Spain's growth, see Herranz-Loncán, "Railroad Impact". This author (p. 873) estimates the railroad TFP contribution to GDP growth (through a social saving approach) in 0.045 percent. This would represent between 7 and 12 percent of Spain's TFP growth over 1850-1883 (using variable and fixed factor shares, respectively) that would rise to 9-20 percent with Mincer labor quality estimates. This back-of-the-envelope exercise suggests a far from negligible contribution of the railroad to aggregate TFP growth. On electrification in 1920s Spain Cf. Betrán, Natural Resources, and Sanchis, "Economic 'Miracle'".

[52] Spain is not the only case in Europe. For example, van Ark "European Union" claims that a slow adjustment towards a new industrial structure is behind the productivity slowdown. In particular, he blames the slow ICT diffusion in market services.

[53] Only a minor discrepancy comes out for 1987-2000 due to the lower weight capital receives in this period with fixed factor shares that results in higher TFP growth (0.6 versus 0.2 percent).

an impact on TFP growth in the 1920s and since 1987. During the 1920s, a lower improvement in Mincer labor quality estimates increases TFP growth from the 1.1 percent obtained with the Jorgenson approach (1.0 with fixed factor shares) to 1.6 percent, rising its contribution to GDP growth from one-fourth to two-fifths, while, conversely, between 1987 and 2000, the more intense labor quality gains in the Mincer estimates suppresses the TFP contribution to GDP growth (from 0.2 to -0.3 percent using variable factor shares, and from 0.6 to 0.1 percent with fixed factor shares).[54]

[TABLE 5]

Modern economic growth is associated with improvements in GDP per head but, so far, the discussion has been focused on absolute GDP trends. We need, therefore, to establish the connection between increases in per capita GDP and efficiency gains. Table 5 provides an intermediate stage, namely, the decomposition of output per head into hours per person and output per hour. Although hours worked per person declined in the long run trend, the 1920s and the post-1986 years show a marked increase in the labor quantity per head. Labor productivity, in turn, grew at a modest pace before 1920 and, again, since Spain's entry into the EU, while stagnated in the thirties and forties, and experienced impressive gains between 1953 and 1986. Sluggish labor productivity lies beneath weak improvements in GDP per head, with the exception of the last quarter of the twentieth century when labor quantity and productivity evolve inversely. Employment disappeared during the 'transition to democracy' years but was more than offset by the

[54] An alternative set of estimates in which land is not taken as a separate factor of production but included as a part of capital, is provided in Table A-3 of the Appendix. The main difference with our previous estimates that incorporate land as an independent factor is to cut down the rate of TFP growth, as land grows less than capital. The exclusion of land as an independent factor of production provides, thus, a lower bound for TFP growth. This is noticeable for 1850-83, the 1920s, and, especially, for 1953-58, with variable factor shares (and for the second half of the twentieth century, with fixed factor shares). Thus, TFP growth is suppressed for 1850-1950, as a whole using the Jorgenson approach to labor quality, while becomes negative for 1987-2000 with the Mincer approach.

productivity surge associated to industrial re-structuring and shifts of resources away from agriculture and traditional industrial sectors. Since 1987 the productivity slowdown has been compensated by a strong increase in hours worked. As Riccardo Faini put it for the Euro zone, Spain seems to have been unable to combine employment and productivity growth since the mid-1970s.[55]

[TABLE 6]

Labor productivity trends are determined, in turn, by human and physical capital/labor ratios and efficiency gains. Table 6 provides the decomposition of labor productivity growth using alternative sets of estimates (with variable and fixed factor shares in the upper and lower panels, respectively) using Jorgenson (Cols. (IV)-(V)) and Mincer (Cols. (VI)-(VII)) labor quality measures. A main finding is that TFP accounts for half the increase in labor productivity over the one and a half centuries considered. Nonetheless, the divide between factor input accumulation as the dominant force (contributing from two-thirds –Jorgenson- to three-fourths –Mincer- of labor productivity growth) prior to 1950 and TFP as the hegemonic role of thereafter (with a contribution of two-third of labor productivity growth in the Golden Age and around one-half thereafter), already observed for the sources of GDP growth, remains. If we look now at long swing intervals we find that TFP largely contributed to the rise in output per hour in each of them but for the *Restauración* (1884-1920), the 1930s and 1940s, and the post-1987 years. Furthermore, changes in the pace at which labor productivity advanced are closely associated to those in TFP. For example, TFP accounted for most, if not all, of labor productivity acceleration over the previous long swing in the 1920s and, in the Golden Age, TFP made the largest contribution to the increase in output per hour worked (about three-quarters). Even more important was its role in phases of labor productivity decline when TFP accounts for nearly all of it.

CONCLUDING REMARKS

[55] Faini, "Europe", p. 80.

The main arguments of the paper can now be re-stated. First, physical and human capital accumulation and TFP growth seem to have been complementary for GDP and labor productivity growth over the long-run [56] Spanish experience suggests a two-stage process in which improving efficiency appears as a complex learning process that takes place once growth has been initiated on the basis of allocating additional capital and labor to production. Abstention, rather than ingenuity dominated long-run growth in Spain up to 1950. Thereafter, TFP growth, a 'free lunch' to use Joel Mokyr's words, drove economic progress and our results do not confirm Krugman's intuition that growth on the basis of capital accumulation leads to a growth slowdown in the future.[57]

Second, we accept that our growth accounting yields only a range of best guesstimates and that our coverage of factor accumulation is far from perfect. However, it is important not to exaggerate the skepticism. After computing the sources of growth with alternative measures of factor accumulation and factor shares the resulting rates of TFP growth generally exhibit fairly small differences.

Third, our results do not appear unusual in international perspective where there is growing evidence suggesting that factor accumulation prevailed over efficiency gains in the early stages of development. Factor accumulation seems to play a role during the transitional phase to long-run growth.[58] Once modern economic growth is under way, TFP tends to perform a more significant part. Indeed, TFP provided at least one-quarter of British GDP growth between 1780 and 1860, a proportion

[56] New investment opportunities that increase capital accumulation as a result of technological change and exogenous increases in investment that rise TFP growth as new capital vintages appear offer ways for their interaction (Crafts, "Productivity Growth", pp. 522-3). As Collins and Bosworth, "Economic Growth", p. 164, point out, technical advances might be embodied in new capital while increasing TFP might induce greater capital accumulation by raising the returns to capital.

[57] Mokyr, *Level of Riches*, p. 3. According to Krugman, "Myth", pp. 77-8, this happens as a result of the law of diminishing returns The fact that TFP has slowed down since 1986 opens, nonetheless, this possibility in the early twentieth-first century.

[58] Grossman and Helpman, *Innovation and Growth*, p. 26.

that increases to three-eights when embodied technological change is taken into account.[59] Slow TFP growth has also been confirmed for the nineteenth century in the United States.[60] Long run assessments for countries in the European Periphery such as Portugal and Turkey show similar results.[61] During the last four decades of the twentieth century developing countries exhibited growth rates dominated by factor accumulation.[62] In modern Spain, as in Britain during the Industrial Revolution, TFP accounted for most of labor productivity acceleration.[63] Does the ability to absorb and to adapt productively foreign ideas and technology depend on a country's development level?[64] Comparative historical research will be needed to widen our analysis of the sources of long-run growth to countries at different levels of development before this hypothesis can be put to the test.

[59] Crafts, "Productivity Growth", p. 533.

[60] Kendrick, *Productivity Trends*; Abramovitz and David, "Two centuries", p. 35.

[61] Lains, "Catching Up"; Altug et al., "Sources".

[62] Collins and Bosworth, "Economic Growth", p. 159. Young, "Tyranny of Numbers", pp. 657-61; and Young, "Razor's Edge".

[63] Crafts, "Productivity Growth".

[64] Abramovitz, "Catching Up"; Collins and Bosworth, "Economic Growth"

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TABLE 1
GDP AND PER CAPITA GDP GROWTH, 1850-2000
(Annual average logarithmic rates %)

	(I) GDP	(II) Per Capita GDP
1850-2000	2.5	1.9
Panel A.		
1850-1950	1.4	0.8
1951-1974	6.5	5.5
1975-2000	3.0	2.6
Panel B.		
1850-1883	1.8	1.4
1884-1920	1.3	0.7
1921-1929	3.8	2.8
1930-1952	0.8	0.0
1953-1958	4.7	3.9
1959-1974	6.9	5.8
1975-1986	2.5	1.8
1987-2000	3.5	3.3

Sources: Prados de la Escosura, *Progreso*, and see text, fn. 1

TABLE 2
LABOR QUANTITY GROWTH DECOMPOSITION, 1850-2000
(Annual average logarithmic rates %)

	(I) Hours worked (H)	(II) Hours per occupied (H/E)	(III) Occupied per EAP (E/L)	(IV) EAP per Pop 15-64 (L/WAN)	(V) Pop 15-64 /Population (WAN/N)	(VI) 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

Sources: See text

TABLE 3
LABOR QUANTITY, QUALITY, AND INPUT GROWTH, 1850-2000: ALTERNATIVE ESTIMATES
(Annual average logarithmic rates %)

		Jorgenson Approach		Mincer Approach	
	(I) Labor Quantity	**(II) Labor Quality**	**(III) Labor Input [(I)+(II)]**	**(IV) Labor Quality**	**(V) Labor Input [(I)+(IV)]**
1850-2000	0.4	0.4	0.8	0.4	0.9
Panel A.					
1850-1950	0.5	0.2	0.7	0.2	0.7
1951-1974	1.0	1.0	2.0	0.9	1.9
1975-2000	-0.4	0.7	0.3	0.9	0.5
Panel B.					
1850-1883	0.6	0.1	0.7	0.3	0.9
1884-1920	0.2	0.1	0.4	0.3	0.5
1921-1929	1.8	0.8	2.6	-0.1	1.7
1930-1952	0.8	0.0	0.8	0.2	1.0
1953-1958	0.4	1.2	1.6	0.9	1.2
1959-1974	0.6	1.1	1.7	0.9	1.5
1975-1986	-3.6	1.2	-2.4	0.8	-2.8
1987-2000	2.4	0.2	2.6	0.9	3.3

Sources: See text

TABLE 4
SOURCES OF GROWTH (1850-2000): VARIABLE AND FIXED FACTOR SHARES AND ALTERNATIVE LABOR QUALITY ESTIMATES
(Annual average logarithmic rates %)

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
	I. Variable Factor Shares					**Jorgenson Approach**		**Mincer Approach**	
	GDP	**Land**	**Capital Stock**	**Capital Quality**	**Labor Quantity**	**Labor Quality**	**TFP**	**Labor Quality**	**TFP**
1850-2000	2.5	0.0	0.8	0.1	0.3	0.3	1.1	0.3	1.0
Panel A.									
1850-1950	1.4	0.0	0.6	0.0	0.3	0.1	0.3	0.1	0.2
1951-1974	6.5	0.1	1.2	0.1	0.7	0.8	3.7	0.7	3.8
1975-2000	3.0	0.0	1.2	0.0	-0.4	0.5	1.7	0.8	1.4
Panel B.									
1850-1883	1.8	0.0	0.6	0.1	0.5	0.0	0.6	0.2	0.5
1884-1920	1.3	0.1	0.6	0.0	0.1	0.1	0.2	0.1	0.2
1921-1929	3.8	0.1	1.0	0.1	1.1	0.5	1.1	-0.1	1.6
1930-1952	0.8	0.1	0.5	0.0	0.4	0.0	-0.1	0.3	-0.4
1953-1958	4.7	-0.2	1.3	0.1	0.2	0.8	2.4	0.5	2.7
1959-1974	6.9	0.1	1.2	0.1	0.5	0.9	4.2	0.6	4.4
1975-1986	2.5	0.0	1.0	0.0	-2.8	0.9	3.4	0.7	3.7
1987-2000	3.5	0.0	1.5	0.1	1.6	0.2	0.2	0.6	-0.3
	II. Fixed Factor Shares								
						Jorgenson Approach		**Mincer Approach**	
	GDP	**Land**	**Capital Stock**	**Capital Quality**	**Labor Quantity**	**Labor Quality**	**TFP**	**Labor Quality**	**TFP**
1850-2000	2.5	0.0	0.8	0.0	0.3	0.3	1.0	0.3	1.0
Panel A.									
1850-1950	1.4	0.0	0.6	0.0	0.4	0.1	0.3	0.1	0.2
1951-1974	6.5	0.1	1.4	0.1	0.7	0.7	3.5	0.6	3.6
1975-2000	3.0	0.0	1.1	0.0	-0.3	0.5	1.7	0.6	1.6
Panel B.									
1850-1883	1.8	0.0	0.9	0.1	0.4	0.0	0.4	0.2	0.2
1884-1920	1.3	0.1	0.6	0.0	0.2	0.1	0.4	0.2	0.3
1921-1929	3.8	0.1	0.8	0.1	1.3	0.5	1.0	-0.1	1.6
1930-1952	0.8	0.0	0.4	0.0	0.6	0.0	-0.1	0.1	-0.2
1953-1958	4.7	-0.2	1.1	0.1	0.2	0.9	2.6	0.6	2.8
1959-1974	6.9	0.1	1.7	0.1	0.4	0.7	3.9	0.6	4.0
1975-1986	2.5	-0.1	1.1	0.0	-2.5	0.8	3.1	0.6	3.4
1987-2000	3.5	0.0	1.1	0.0	1.6	0.2	0.6	0.6	0.1

Sources: Tables 1-3 and see text

TABLE 5
PER CAPITA GDP GROWTH AND ITS COMPONENTS, 1850-2000
(Annual average logarithmic rates %)

	(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

Sources: Col. (I), Table 1; rest, see text

TABLE 6
SOURCES OF LABOR PRODUCTIVITY GROWTH (1850-2000): WITH VARIABLE AND FIXED FACTOR SHARES AND ALTERNATIVE LABOR QUALITY ESTIMATES
(Annual average logarithmic rates %)

Variable Factor Shares

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
				Jorgenson Approach		Mincer 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	0.2
1951-1974	5.5	0.0	1.2	0.6	3.7	0.6	3.8
1975-2000	3.4	0.0	1.4	0.4	1.7	0.6	1.4
Panel B.							
1850-1883	1.2	-0.1	0.6	0.0	0.6	0.2	0.5
1884-1920	1.0	0.1	0.6	0.1	0.2	0.2	0.2
1921-1929	2.0	-0.1	0.6	0.5	1.1	-0.1	1.6
1930-1952	0.0	0.0	0.2	0.0	-0.1	0.2	-0.4
1953-1958	4.3	-0.2	1.3	0.8	2.4	0.6	2.7
1959-1974	6.3	0.0	1.2	0.9	4.2	0.7	4.4
1975-1986	6.1	0.0	1.9	0.9	3.4	0.6	3.7
1987-2000	1.1	0.0	0.8	0.1	0.2	0.6	-0.3

Fixed Factor Shares

				Jorgenson Approach		Mincer Approach	
	GDP per hour worked	Land	Capital Input	Labor Quality	TFP	Labor Quality	TFP
1850-2000	2.1	0.0	0.8	0.3	1.0	0.3	1.0
Panel A.							
1850-1950	0.9	0.0	0.5	0.1	0.3	0.1	0.2
1951-1974	5.5	0.0	1.3	0.7	3.5	0.6	3.6
1975-2000	3.4	0.0	1.2	0.5	1.7	0.6	1.6
Panel B.							
1850-1883	1.2	0.0	0.8	0.0	0.4	0.2	0.2
1884-1920	1.0	0.0	0.5	0.1	0.4	0.2	0.3
1921-1929	2.0	-0.1	0.5	0.5	1.0	-0.1	1.6
1930-1952	0.0	0.0	0.2	0.0	-0.1	0.1	-0.2
1953-1958	4.3	-0.2	1.1	0.9	2.6	0.6	2.8
1959-1974	6.3	0.0	1.6	0.8	3.9	0.6	4.0
1975-1986	6.1	0.2	2.0	0.8	3.1	0.6	3.4
1987-2000	1.1	-0.2	0.6	0.2	0.6	0.6	0.1

Sources: Col. (I), Table 5; rest, Table 4 and see text

TABLE A-1
LABOR QUALITY GROWTH, 1850-2000: ALTERNATIVE ESTIMATES
(Annual average logarithmic rates %)

	(I)	(II)	(III)	(IV)
	Mincer Equation		Rate of Return	
			9 percent	7.2 percent
	(Arrazola et al)	(Alba and San Segundo)	(Alba and San Segundo)	(Mora)
1850-2000	0.4		0.4	0.3
Panel A.				
1850-1950	0.2		0.2	0.2
1951-1974	0.9		0.8	0.6
1975-2000	0.9	0.9	0.9	0.7
Panel B.				
1850-1883	0.3		0.2	0.2
1884-1920	0.3		0.3	0.2
1921-1929	-0.1		-0.1	-0.1
1930-1952	0.2		0.2	0.1
1953-1958	0.9		0.7	0.6
1959-1974	0.9		0.8	0.6
1975-1986	0.8	1.0	0.9	0.7
1987-2000	0.9	0.8	1.0	0.8

Sources: Arrazola et al., "Returns to Education"; Alba and San Segundo, "Returns to Education"; Mora, "Socioeconomic Background". See text

TABLE A-2
SOURCES OF GROWTH (WITH LAND INCLUDED AS PART OF CAPITAL) (1850-2000):
VARIABLE AND FIXED FACTOR SHARES AND ALTERNATIVE LABOR QUALITY ESTIMATES
(Annual average logarithmic rates %)

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
	I. Variable Factor Shares				**Jorgenson Approach**		**Mincer Approach**	
	GDP	**Capital Stock**	**Capital Quality**	**Labor Quantity**	**Labor Quality**	**TFP**	**Labor Quality**	**TFP**
1850-2000	2.5	1.0	0.1	0.3	0.3	0.9	0.3	0.8
Panel A.								
1850-1950	1.4	0.9	0.1	0.3	0.1	0.0	0.1	0.0
1951-1974	6.5	1.5	0.1	0.7	0.8	3.5	0.7	3.6
1975-2000	3.0	1.3	0.0	-0.4	0.5	1.6	0.8	1.4
Panel B.								
1850-1883	1.8	1.0	0.1	0.5	0.0	0.2	0.2	0.1
1884-1920	1.3	0.9	0.1	0.1	0.1	0.1	0.1	0.0
1921-1929	3.8	1.4	0.1	1.1	0.5	0.7	-0.1	1.3
1930-1952	0.8	0.6	0.0	0.4	0.0	-0.2	0.3	-0.5
1953-1958	4.7	1.7	0.2	0.2	0.8	1.7	0.5	2.0
1959-1974	6.9	1.4	0.1	0.5	0.9	4.0	0.6	4.2
1975-1986	2.5	1.0	0.0	-2.8	0.9	3.3	0.7	3.6
1987-2000	3.5	1.5	0.1	1.6	0.2	0.2	0.6	-0.3
	I. Fixed Factor Shares				**Jorgenson Approach**		**Mincer Approach**	
	GDP	**Capital Stock**	**Capital Quality**	**Labor Quantity**	**Labor Quality**	**TFP**	**Labor Quality**	**TFP**
1850-2000	2.5	1.1	0.1	0.3	0.3	0.8	0.3	0.8
Panel A.								
1850-1950	1.4	0.9	0.0	0.4	0.1	0.1	0.1	0.0
1951-1974	6.5	1.9	0.1	0.7	0.7	3.1	0.6	3.2
1975-2000	3.0	1.4	0.1	-0.3	0.5	1.4	0.6	1.2
Panel B.								
1850-1883	1.8	1.1	0.1	0.4	0.0	0.1	0.2	-0.1
1884-1920	1.3	0.7	0.0	0.2	0.1	0.3	0.2	0.2
1921-1929	3.8	1.1	0.1	1.3	0.5	0.8	-0.1	1.4
1930-1952	0.8	0.5	0.0	0.6	0.0	-0.2	0.1	-0.3
1953-1958	4.7	1.4	0.1	0.2	0.9	2.1	0.6	2.3
1959-1974	6.9	2.2	0.1	0.4	0.7	3.4	0.6	3.5
1975-1986	2.5	1.4	0.0	-2.5	0.8	2.7	0.6	3.0
1987-2000	3.5	1.5	0.1	1.6	0.2	0.2	0.6	-0.3

Sources: See text

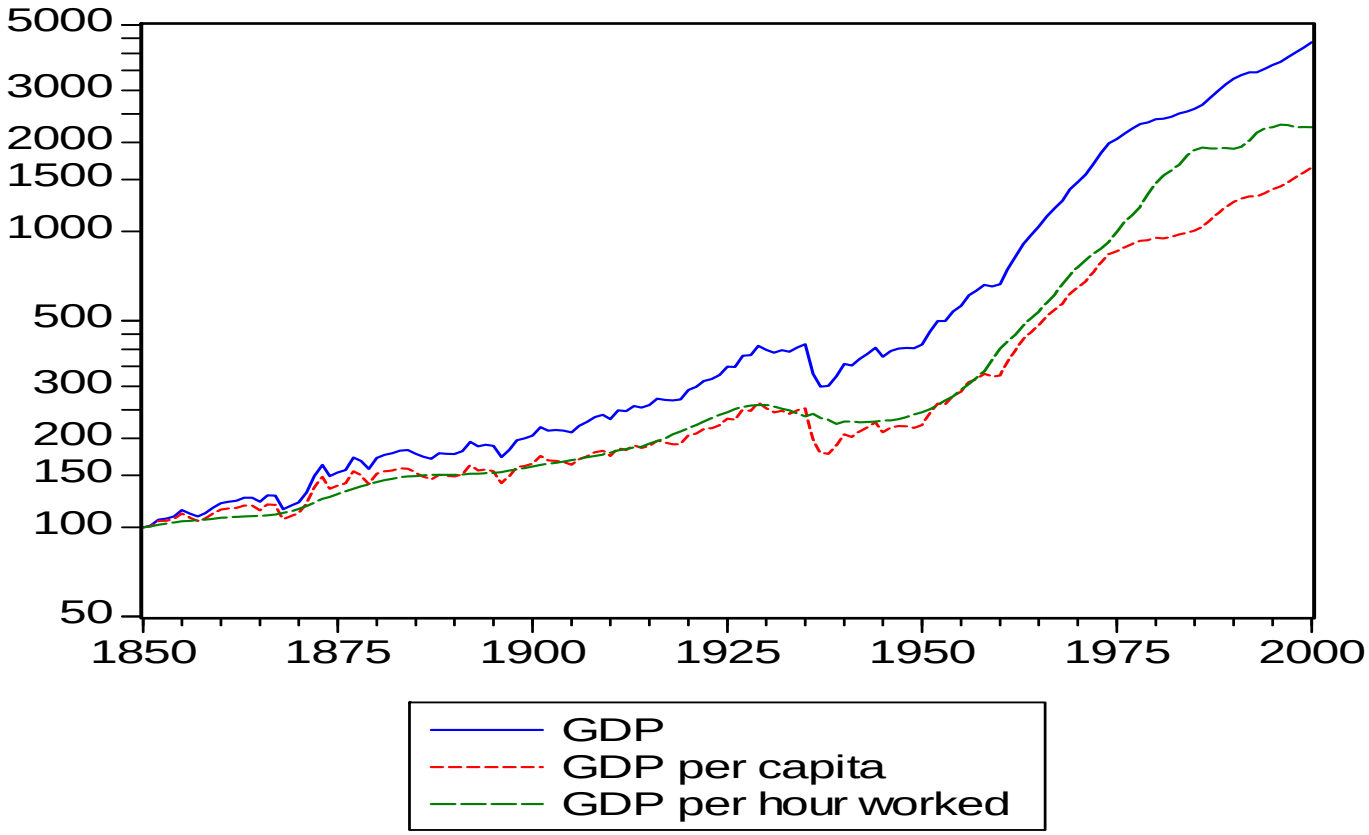

FIGURE 1

GDP, GDP PER CAPITA AND PER HOUR WORKED, 1850-2000 (1850 = 100) (semilog scale)

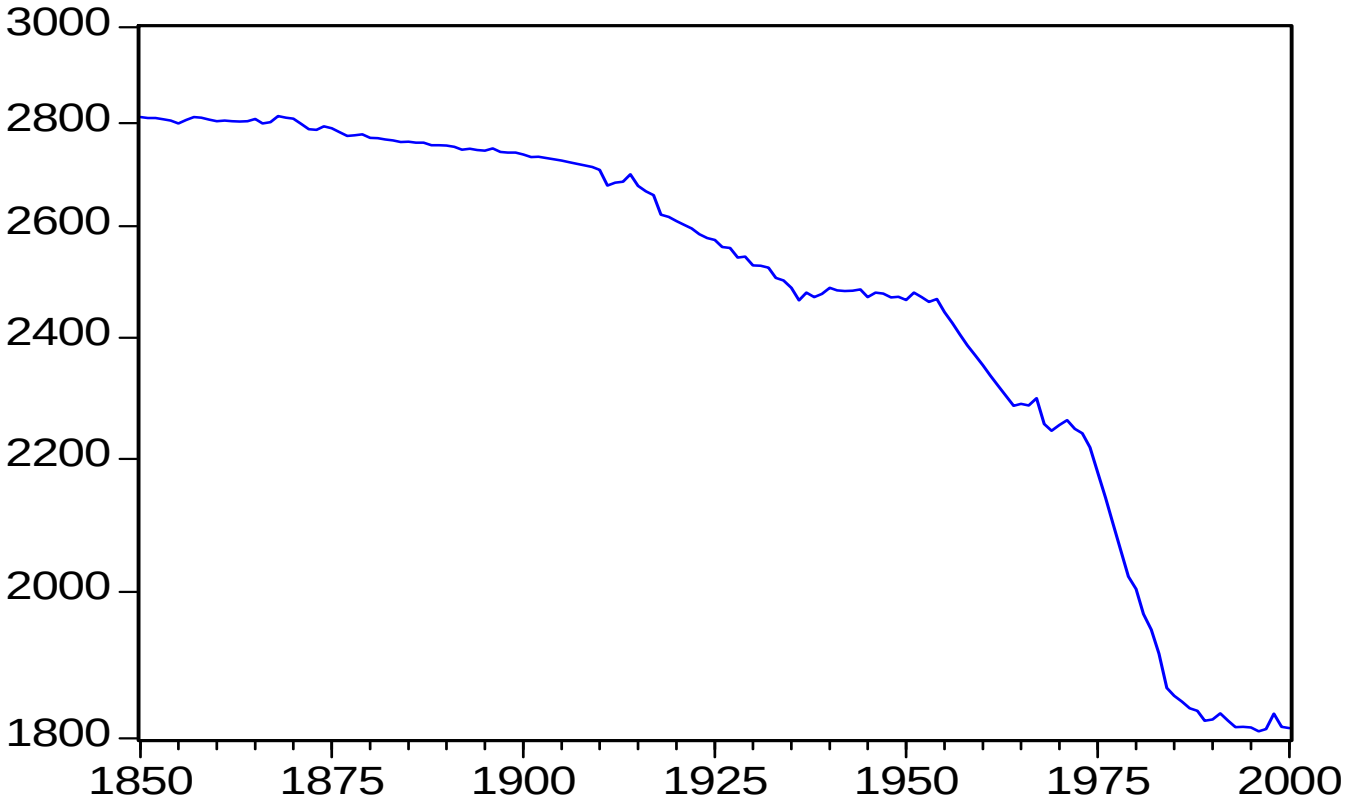

FIGURE 2

HOURS PER WORKER-YEAR, 1850-2000 (semilog scale)

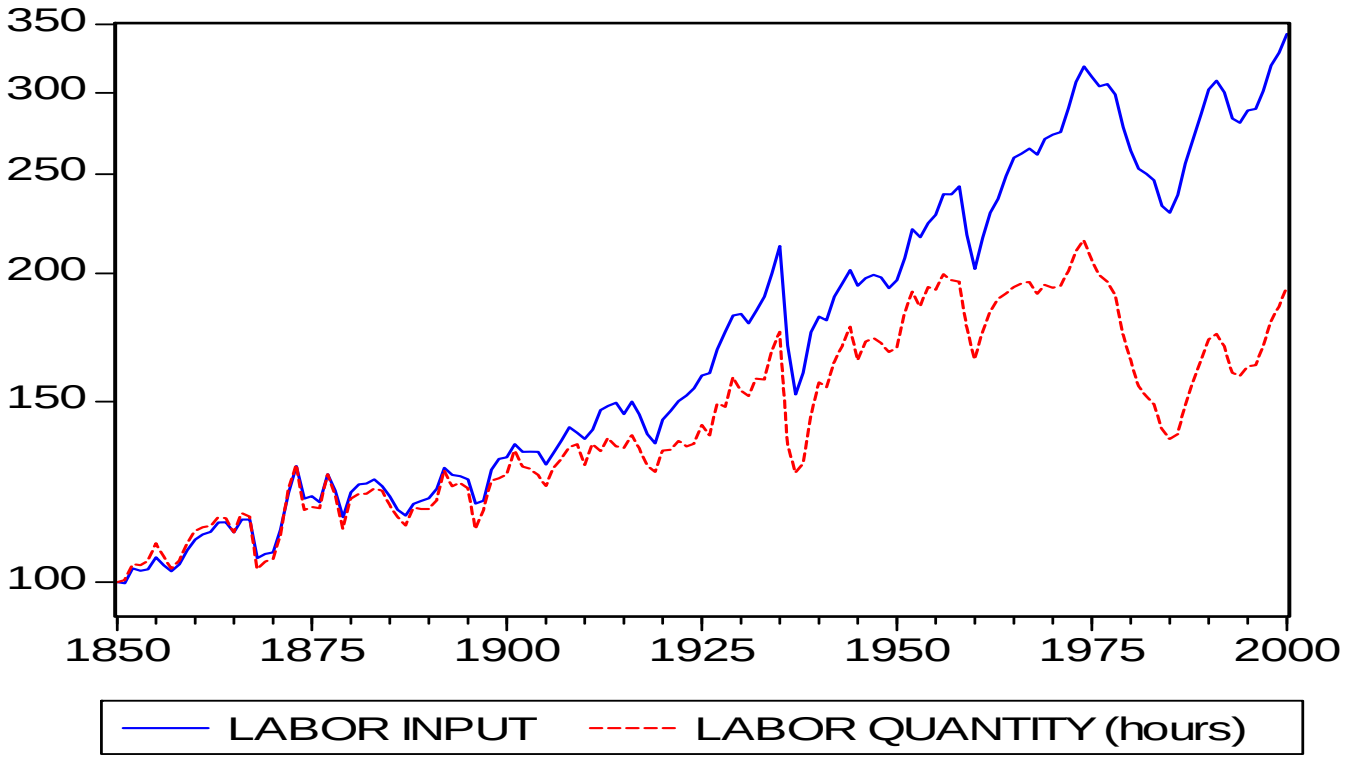

FIGURE 3
LABOR INPUT AND QUANTITY, 1850-2000 (1850=100) (semilog scale)

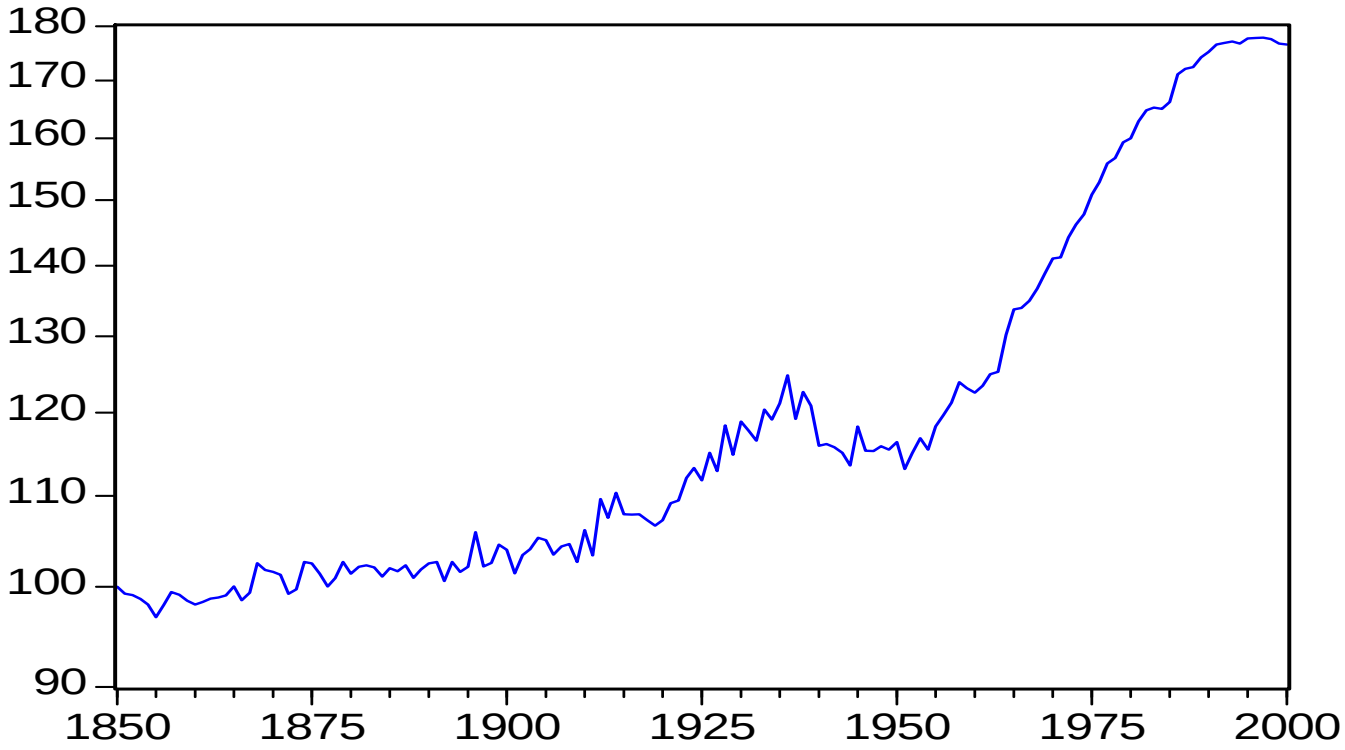

FIGURE 4
LABOR QUALITY, 1850-2000 (1850=100) (semilog scale)