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JEL Classification: O47; N13; N14

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The Sources of Long-run Growth in Spain 1850-2000[*]

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Between 1850 and 2000, Spain's real income increased by about 40-fold, at an average rate of 2.5 percent. The sources of this long-run growth are investigated using Jorgenson-type growth accounting analysis. We find that growth upsurges are closely related to increases in TFP. Spanish economic growth went through three successive phases. The century before 1950 was characterized by slow growth driven by factor accumulation. TFP improvements pushed up explosive growth during the Golden Age and mitigated the deceleration during the transition to democracy years (1975-86). Since the accession to the European Union Spain has experienced a dramatic productivity slowdown.

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This article examines the sources of Spain's transformation from a largely rural, traditional society into present day's developed economy. By 1850, much of the country was backward, ignorant, and poor, and few would have believed that a hundred and fifty years later Spain joined the world wealthiest economies. This process of growth and structural change has generated a large and evolving literature, alive with controversies and compelling insights. Aggregate economic activity in Spain multiplied by 40 over one hundred and fifty years at trend growth rate of 2.5 percent per year. At the end of the twentieth century, per capita GDP was 15 times larger than at mid-nineteenth century, which implies a trend annual rate of 1.9 percent.[1]

[FIGURE 1]

What does account for sustained long-run growth in Spain? Is factor accumulation or productivity improvement the main immediate source of long-run growth?[2] It has been also stressed the role played by machinery investment in economic growth. In this scenario technology is mainly embodied in capital goods and follower countries can benefit from technological diffusion without incurring in the costs of technological innovation.[3] Non capital-embodied innovations that affect the organization of labor, firms and markets and, hence, productivity improvement, as partly independent of factor accumulation, have been underlined too. Are any of these interpretations applicable to Spain's historical experience? The literature on Spanish sources of growth, scarce and focused on the post-1964 era, emphasizes the role of TFP growth and

[1] A new Translog index has been constructed for real GDP in order to make the comparison between GDP and factor inputs consistent (see expression (4) below). The Translog index has been constructed on the basis of current values and quantity indices for the four main sectors of economic activity (agriculture, industry, construction, and service) provided in Leandro Prados de la Escosura (*Progreso económico*). The new Translog index exhibits a slightly faster growth than the chain Laspeyres index used in Prados de la Escosura (*Progreso económico*).

[2] See, among others, S. N. Broadberry, *Productivity Race*; N.F.R. Crafts, "Exogenous or Endogenous", "Economic Growth"; Sergio Rebelo, "Long-run Policy"; and Alwyn Young, "Tyranny of Numbers".

[3] The diffusion and adoption of new machinery has been emphasized by David Landes *Unbound Prometheus* and more recently, by Bradford De Long and Larry Summers "Equipment Investment". This view has been severely criticized by Alex Field, "Equipment Investment".

physical capital accumulation during the Golden Age and the absence of TFP improvements during the last years of the twentieth century.[4] But do their conclusions apply to earlier periods?

A way of testing these interpretations is to use the growth accounting method to decompose the contribution of factors of production (capital and labor accumulation, and total factor productivity) to economic growth in the long run.[5] More specifically, we employ Evsey Domar's and Zvi Griliches and Dale Jorgenson's approach that allows us to measure capital and labor inputs in terms of quality.[6] This framework has a major advantage: it 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.[7]

The sources of Spain's growth have changed dramatically over these one and a half centuries of sustained growth. In the first hundred years, with the notable exception of the 1920s, the growth of tangible capital was the most important proximate source of economic growth while TFP growth was negligible. Over the period that encompasses the Golden Age (1951-74) and the so-called 'transition to democracy' years (1975-86), TFP was largely responsible for the great speed-up of growth. Since 1987 a TFP growth slowdown has taken place. By the end of the twentieth century, the coming-of-age of the 'baby boom' cohorts, combined with the accelerated incorporation of women into paid work, and, very recently, with an episode of mass immigration, have made labor input again an important source of output growth. Moreover, since 1975, the contribution to GDP growth of capital accumulation, eased by the inflows of foreign public (European subsidies and transfers) and private capital, was significant. Interestingly, labor quality, largely a result from the rising educational level of the workforce, seems to have had a significant contribution in the 'transition to democracy' years (1975-86) but hardly any thereafter.

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[4] See Appendix B for a comparison between our results and other authors' estimates.

[5] Unfortunately, detailed growth-accounting exercises with long-run evidence are rare. Angus Maddison's "Growth and Slowdown" work represents an exception to the rule. Other examples are R.C.O. Matthews, C.H. Feinstein, and J.C. Odling-Smee, *British Economic Growth*, for Britain; J.-J. Carré, P. Dubois, and E. Malinvaud, *French Economic Growth*, for France; and Moses Abramovitz and Paul David, *Two Centuries*, for the United States.

[6] Domar, "Measurement of Technological Change"; Griliches and Jorgenson, "Explanation of Productivity Change".

[7] Robert Barro, "Growth Accounting".

[FIGURE 2]

What accounts for TFP growth? Our measures of this variable include gains derived from both technological and organizational innovations proper, improvements in allocative efficiency of business, enterprises, and markets, and economies of scale. In the first century of modern economic growth (1850-1950), TFP growth was practically non-existent, with the exception of the 1920s when the adoption of 'general purpose technologies' such as electrification, gave way to more rapid technological progress. Extensive growth, involving population growth and capital investment, that facilitated the creation of an infrastructure network (railroads, roads, harbors), was the basis for gains from economies of scale, together with institutional reforms. The 1920s may be seen as a precedent of what happened in the 1950s and the 1960s. In fact it could be argued that the Civil War (1936-39) and the autarchic years that followed (enhancing the impact of the Depression and World War II uncertainty) interrupted a process of electrification that was only resumed in the 1950s. In the Golden Age (1951-74), the adoption of foreign technologies and mass production, led to fast TFP growth rates. Productivity improvements remained the leading force beneath economic performance during the following period (1975-1986), as a consequence of institutional change and the productive modernization (industrial restructuring, sharp decline in agricultural employment) that accompanied the transition to democracy and accession to the European Union.

The rest of the paper is divided into four parts. In section II, we examine main trends and episodes of Spanish long-run growth. Section III describes the Jorgenson-type growth accounting with 'quality' measures that we adopt in the paper and presents our new database, which comprises new estimates of GDP, and the stock and input of capital and labor, over one-and-a-half centuries. Then, we discuss with alternative growth-accounting measures, the role of TFP and factor accumulation. Lastly, we conclude and propose a research agenda.

MAIN TRENDS IN ECONOMIC GROWTH

Table 1 provides long-run trends and phases of Spanish growth. Over the long run, GDP grew at 2.5 percent per year that with a population growth of 0.6 percent represents a per capita income growth of 1.9 percent. Meanwhile GDP per hour worked expanded at a faster rate (2.1 percent) than per employee (1.8 percent) as a result of the declined in the amount of hours worked per occupied over these 150 years.

[TABLE 1]

Economic growth in Spain did not take place at a steady rate and growth rates are also presented for significant periods. GDP series are trend stationary with structural breaks in level by 1936 and in trend by 1951 and 1975.[8] Three main phases can be established in long-run economic development: 1850-1950, 1951-1974 and 1975-2000, with a shift to a lower level during the first period as a consequence of the Civil War (1936-1939).[9] As it is shown in panel A, during the Golden Age (1951-1974) per capita GDP rose seven times faster than in the previous hundred years (1850-1950), and twice as fast as during the last quarter of the twentieth century. Thus the rate of growth experienced between 1850 and 1950 meant that product per person doubled every 88 years while the same increase was achieved every 13 years in 1951-1974 and every 27 years over 1975-2000.

Spanish growth also exhibited long swings in which growth rates differ from its long-run trend (See panel B). These long swings can be caused by a variety of disparate forces, which can act alone or interact, like institutional breakouts, shifts in domestic economic policies, changes in the relation with the international markets, and technological revolutions.[10]

During the first phase, 1850-1883, the rate of growth of product per person was well above the 1850-1950 average. This phenomenon can be partly attributed to a 'reconstruction effect' after the political instability and social unrest characteristic of the early nineteenth century when demographic expansion

[8] Prados de la Escosura, "Growth and Structural Change". A change of trend indicates a break in the long-term rate of growth while a change in level represents an increase or, as in the case of the Civil War years, a drop in economic activity that does not alter the established growth rate. It should be distinguished between the trend growth rate and the GDP level, the former being the relevant one to establish a periodization. Thus, the relevant fact for accepting 1951 as structural break is that the trend growth rate change after this year and not that the GDP level was lower in 1951 than in 1929.

[9] If the slump caused by the Civil War were not taken into account the trend growth rate would reach 2.7 percent. The difference between these two figures, 0.2 percent, could be interpreted as the reduction in the long run annual growth rate caused by the civil conflict.

[10] The phases defined in Table 1 correspond with the time division arising from econometrically estimated deviations from the established trend (Prados de la Escosura, "Growth and Structural Change"). Growth rates are measured as average annual logarithmic rates of change over periods delimited by peak years. These rates have a clearer meaning than trend growth rates based on statistical adjustment. In addition, they have additive properties.

cancelled out most of the moderate GDP gains.[11] Also, institutional reforms, which included the liberalization of domestic markets for factors and goods, and opening up to foreign capital and international trade lie beneath such a significant growth.

In spite of a remarkable institutional stability, a slowdown in growth took place between mid-1880s and the early 1920s. It is likely that restrictions on both internal and external competition help explain sluggish growth.[12] Furthermore, Spanish received with a notable delay the technological innovation of the Second Industrial Revolution while productivity gains associated with the use of steam had already been exhausted.[13]

In a sharp contrast with the previous period, the most intense growth of the first hundred years considered was achieved during the 1920s. Conventional wisdom attributes the success to governmental intervention through protectionist and regulatory policies and direct investment on infrastructure.[14] Spain, however, opened up to international factor flows during the 1920s benefiting largely from the favorable international conjuncture. A significant inflow of foreign capital allowed the purchase of capital goods and raw materials that contributed to growth acceleration.[15]

A fourth long swing took place between 1929 and 1952. The overall consequences of the Great Depression on the Spanish economy were comparatively milder but more persistent than in other Western

[11] The fact that per capita income improved little over the early nineteenth century should not obscure the achievement of maintaining the standard of living despite the acceleration in population growth (Prados de la Escosura, *Imperio a Nación*; Joan Rosés, "Industrialización regional"; Carlos Álvarez-Nogal and Prados de la Escosura, "Searching for the Roots"). Vicente Pérez Moreda ("Población y economía": 44) calculates a demographic growth of 0.76 percent between 1821 and 1860 compared with 0.42 percent for the eighteenth century.

[12] Pedro Fraile, *Industrialización y grupos de presión*; and Fraile and Álvaro Escribano, "Spanish 1898 Disaster".

[13] See, for example, Rosés ("Primera Etapa").

[14] Juan Velarde, *Política Económica*, but see also objections to this interpretation in Francisco Comín, "Período de Entreguerras" and Fraile, *Industrialización y grupos de presión.*

[15] Prados de la Escosura, "Posición internacional". It has also been noted that the positive situation of the current account balance of payments during the First World War contributed to the boom of the 1920s (Carles Sudrià, "Beneficios de España").

countries.[16] Moreover, Civil War (1936-39) prevented Spain from participating in the world recovery of the late 1930s. The weak post-World War II performance stands out in the international context.[17]

The change in trend, which began in the early 1950s, ushered in an exceptional phase of rapid growth that lasted until 1974. Like in the rest of Europe, this was an exceptional episode in which not only were growth rates exceptionally high but cyclical fluctuations mild and inflation socially acceptable. Spain grew faster than the rest of European countries and benefited largely from the influx of capital, technology, and ideas from abroad.[18]

The move towards a pro-market attitude with de-regulation and the gradual opening up of Spain to the international economy resulted in sustained growth and catching up with Western Europe during the second half of the twentieth century. A dramatic growth slowdown followed by a sustained catching up, separated by 1986, the year of Spain's accession to the European Union, characterized the last quarter of the twentieth century.

THE 'PROXIMATE' SOURCES OF GROWTH: METHODS AND SOURCES

Growth accounting is a framework that purports to distinguish the individual contributions of total factor productivity, capital accumulation and labor in raising output.[19] Three main ideas are encapsulated in the growth accounting method: output is a function of its inputs; inputs' contribution to growth can be computed as their individual growth rate weighted by their share in total payments; and the part unexplained by inputs ('residual')

[16] In comparison with the nations that succeeded in abandoning the Gold Standard early (Barry Eichengreen, *Golden Fetters*), Spain did not experience a quick recovery. A restrictive public spending policy and the interruption of public projects in progress, together with political uncertainty has been pointed as the main causes of the 1930s crisis (Jordi Palafox, *Atraso económico*). Another view sustains, however, that expansionary monetary and anti-cyclical fiscal policies were tried to compensate for the fall in private investment and exports (Comín and Pablo Martín Aceña, "Política monetaria y fiscal", Nieves García Santos and Martín Aceña, "Comportamiento de gasto público").

[17] Prados de la Escosura, "Growth and Structural Change".

[18] Prados de la Escosura, *Progreso económico*, "Growth and Structural Change".

[19] Jorgenson, "Productivity".

constitutes the improvement in total factor productivity (efficiency gains).[20] New developments in growth accounting have allowed to reduce the size of the unexplained 'residual' mainly through the use of superlative indices and their derived production functions, as well as to the introduction of heterogeneous measures for factor inputs that made possible to separate their contribution to growth due to quantity and quality changes. Hours worked were classified by age, sex, and employment status, and weighted by the relevant labor payments. Capital, in turn, was divided into homogeneous components and each one weighted by its rental value. Thus, while composition or quality changes in labor input are associated to increases in human capital, composition or quality changes in capital input can be associated to embodied technical change.[21] In consequence, a considerable reduction in the 'unexplained residual' or total factor productivity took place as the 'residual' no longer included embodied innovation in capital goods (capital quality) and human capital (labor quality).[22]

a) The Translog Index of Total Factor Productivity

The point of departure in our estimate of the sources of growth in Spain between 1850 and 2000 is the production function given by:

(1) $$Q = F(K, L)$$

in which output (Q) is as function of capital input (K) and labor input (L).

We can approach this function by means of the Translogarithmic production function, which gives the theoretical justification for the use of factor shares to weight growth rates. Specifically:

(2) $$\ln Q = a_0 + a_k \ln K + a_l \ln L + \frac{1}{2} b_{kk} (\ln K)^2 + \frac{1}{2} b_{ll} (\ln L)^2 + b_{kl} \ln K \ln L$$

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

[20] It implies strong assumptions such as the technology in each industry replicates the aggregate production function, that all sectors are perfectly competitive, and that the economy allocates resources without any market failures (Jorgenson, "Productivity": 66).

[21] Charles Hulten, "Measurement of capital": 134; and "Growth accounting"; F. Sakellaris and P. Vijselaar, "Capital Quality". For a contrary view, see Young, "Tyranny of Numbers": 649.

[22] For example, Jorgenson has shown that changes in factor quality account for two-fifths of the growth of capital input and for more than one-third of the growth of labor input for the United States between 1947 and 1985 (Jorgenson, "Productivity": 24-25).

(3) $$\ln Q(T) - \ln Q(T-1) = \Theta_K [\ln K(T) - \ln K(T-1)] + \Theta_L [\ln L(T) - \ln L(T-1)] + TFP_{T-1,T,}$$

The Θ_i denotes the elasticity of output with respect to each input.[23] 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.[24] Note that the relative prices decide the share of each factor of production in total inputs and that, under constant returns to scale, the value shares sum to unity. 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 land, capital, and labor inputs. It is, thus, a measure of the increase in output attributable to a time-related shift in the production function.

Following Jorgenson, in our production account output and inputs are not treated as homogeneous.[25] Thus, the rate of growth of output and each input *i* between two periods is a weighted average of the growth rates of its *n* components. Weights are given by the share of each component in the corresponding payments for each input. In the case of output, capital and labor, their respective equations are:

(4) $$lnQ_t - lnQ_{t-1} = \sum_i [\overline{\Theta}_{Q_i} (\ln Qi_t - \ln Qi_{t-1})]$$

(5) $$lnK_t - lnK_{t-1} = \sum_i [\overline{\Theta}_{K_i} (\ln Ci_t - \ln Ci_{t-1})]$$

(6) $$lnL_t - lnL_{t-1} = \sum_i [\overline{\Theta}_{L_i} (\ln Li_t - \ln Li_{t-1})]$$

where value shares are computed as:

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

[23] For the mathematical development of the Translog index, see Christensen *et al.* "Transcendental Logarithmic".

[24] 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. In this case, we make no adjustments and assume that total outlay is equivalent to total payments (it should be noted that adjustments would reduce the share of capital in total payments and, hence increase the TFP growth rate).

[25] Jorgenson, "Productivity".

b) Capital input

We develop our measure of capital input,[26] which is an index number elaborated with information on the services of the stock of capital and its prices, in three successive phases: first, we construct the stock of capital;[27] we, then, estimate the relative prices of the different types of assets and, finally, we combine prices and quantities of capital into a single index.

Let us move, then, to the estimation of the stock. Commonly, the amount of new additions to the stock of capital (investment, I_t) is directly observable but not the stock itself, C_t. Thus, the challenge is to infer the stock of capital from successive yearly investments but taking into account that a part of the stock is retired when obsolete and that older vintages of capital are less productive than newer ones. In other words, we need a procedure to estimate the stock of capital (C) for the year t from the accumulation of past years investment (I). Using the perpetual inventory method (PIM),[28] the stock of capital in the year t (C_t) is equal to the weighted sum of the investment realized during this same year and the previous ones where each generation of capital is weighted by its depreciation rate in the period t.[29] Specifically,

$$C_t = (1 - \delta t)\, C_{t-1} + GFCF_t \tag{8}$$

The capital stock C in year t is equal to the amount of capital of the year $t-1$ multiplied by 1 minus the depreciation rate (δ) of the year t, plus the gross fixed capital formation, *GFCF*, during the year t. The

[26] As it is usually assumed (Jorgenson, "Productivity"), capital *input* (K) in year t is proportional to the *stock* of capital at the beginning of the period t. Thus, $K_t = \lambda \cdot C_{t-1}$ where the constant (λ) transforms the capital *stock* into its services, and where the capital *stock* C_t moves according to the new investments, at constant prices, during the year and to the depreciation and replacement rates.

[27] We define the *stock* of capital as all tangible goods that can be used during more than one period to produce other goods and services. More specifically, the capital *stock* comprises residential and non-residential structures, transport equipment, and producer durable equipment (machinery and industrial equipment).

[28] It should be noted, however, that the use of PIM requires: (1) an initial benchmark for the stock of capital; (2) historical series of Gross Fixed Capital Formation by types of assets at constant prices; and (3) the efficiency of each vintage of capital.

[29] This is the case under the following assumptions: (1) all durable goods bought in a certain period of time t form a vintage of capital; (2) the services produced for different vintages of capital in a period t are perfect substitutes; and (3) their services are proportional to the initial investment. See, on this model, Hulten (1990).

depreciation rate is $\delta=X/T$, where X is a parameter[30] (*declining balance*) and T is the life of each type of asset.[31] This method allow us to generate a measure of capital that takes into account the productive capacity of each component and, hence, measures capital stock in *efficiency units*.[32]

The second step in developing measures of capital *input* is to construct rental prices for each category. In competitive equilibrium, the cost of producing a unit of capital is equal to its price and its expected rent during its life. Assuming, along Jorgenson[33], that old and new vintages of capital are perfect substitutes, the services of capital (rents) can be estimated with the Hall-Jorgenson[34] equation:

(9) $$p_k(T) = p_i(T-1)r(T) + \delta\, p_i(T) - [\, p_i(T) - p_i(T-1)]$$

where $p_k\,(T)$ is the rental price, $p_i\,(T)$ is the investment price of the capital good i, $r\,(T)$ is the nominal rate of return between (T) and $(T\text{-}1)$ years, and δ_i is the depreciation rate for the capital good i. The rental price of the capital input is, thus, the sum of the nominal price and depreciation less revaluation.[35] Implicitly, this equation assumes that the composition change implied by the transition from long duration to short duration capital goods represents an increase in the quality of the capital input. Thus, capital goods with a higher amortization rate have a larger weight in the capital input index and, hence, machinery is, for example,

[30] The parameter X is, according to Hulten and F. Wykoff "Economic Depreciation", 1.65 for machinery and equipment and 0.91 for buildings and structures.

[31] This modified geometric depreciation pattern is somewhere in between the arithmetic and geometric depreciation patterns (that is, it moves between one and two times the inverse of asset lives). Moreover, it is easy to compute and widely employed in TFP studies (Jorgenson, "Productivity").

[32] Hulten, "Measurement of Capital".

[33] Jorgenson, "Productivity".

[34] R.J. Hall and Jorgenson, "Tax Policy".

[35] It should be noted that we already know the depreciation rates and the prices of acquisition of capital for Spain but we do not for the rates of return. There are two methods for estimating rates of return (r). The first uses the long-run interest rate as equivalent to the competitive benefit rate. The second derives the rate of return from the share of national income received by the owners of capital assets as a compensation for their properties, that can be obtained by solving equation (10). The difference between the two estimations is the amount of monopolistic competition rents.

allocated a higher weight than buildings in the index. The final step is to combine price and quantity data into an index of capital input employing previous equation (5).

Data on yearly investment (quantities and prices) by type of asset are taken from Prados de la Escosura *Progreso económico*. For each type of capital assets their lives were established from available information for Spain, the United States and Britain.[36] Three different epochs (1850-1913, 1914-1958, and 1959-2000), with their particular asset lives, were considered for productive capital (all capital assets but residential dwellings). This is due to the fact that assets lives tend to shorter as one gets closer to the present.

An additional difficulty was to establish the initial level of capital stock (C_0) for each type of asset *j* in our PIM estimate. We derived this initial stock by assuming that the growth rate of investment during the first decade of the time span considered, that is, the 1850s, was representative of the growth rate of investment prior to 1850.[37] Algebraically:

$$C_{0j} = I_{0j} / (\delta + g), \tag{10}$$

where C is the capital stock, I the investment rate, δ the depreciation rate, and g the rate of variation between 1850/54 and 1855/59 for each type of asset *j*.

Finally, we chose to approximate the competitive benefit rate with the long-run interest rate. The internal return of private liabilities, used as a proxy for the long-term interest rate since 1964, comes from the MOISSES and BDMORES databases[38], while the corporate rates of return[39] were employed for 1880-1954,

[36] We provide further details on the construction of capital measures in Prados de la Escosura and Rosés, "Alternative Measures".

[37] J. Baigés *et al. Economía española* and Young, "Tyranny of Numbers". Following Young "Tyranny of Numbers", we tested the sensitivity of our results to the initial value of capital and alternatively assumed that initial values of capital were zero and double the figure obtained with expression (10). In the latter case, as capital would have slowed down its pace during the early years, TFP growth (quality adjusted) would have grown at a yearly rate of 0.3 percent, rather than -0.2 percent, over 1850-83, and its contribution to GDP growth would have correspondingly increased from -11 to 14 percent (see Table 3 for the basic estimates).

[38] Dabán Sánchez, T., A. Díaz Ballesteros, F.J. Escribá Pérez, and M.J. Murgui García, "base de datos".

[39] Tafunell, "Rentabilidad financiera".

and the net rate of return on public debt for 1857-1880[40], was projected backwards to 1850 with the interest rate of Banco de Barcelona.[41] Figure 3 and table 2 present the evolution of capital stock and input from 1850 to 2000.

[FIGURE 3]

As figure 3, capital input and stock have not followed a stable development path. Quite the contrary, their long-run development was characterized by periods of acceleration and stagnation. Broadly speaking, four waves can be distinguished. An initial period with explosive capital growth rates, which finishes in the early 1880s, followed by a period of stability which ended abruptly with the Civil War and stabilized during the autarchic 1940s and early 1950s. Then, a new phase of rapid capital accumulation occurred during the Golden Age (1953-74) that slowed down in the last quarter of the twentieth century.

Changes in the composition of capital by type of assets: from residential construction toward productive capital (machinery and equipment) increased the services provided by the capital stock to production and reflected in the growing gap between the growth rates of capital input and stock, the so-called quality of capital or embodied technological change, that rose in phases of fast capital growth. Four periods stand out in capital quality growth: from the mid-1850s to the early 1880s, a period of opening up in which foreign capital was invested in the railways construction and in mining; the 1920s, that witnessed another episode of foreign capital inflow and the electrification of Spanish industry; the Golden Age (1953-74), in which Spain replaced old vintage for new vintage capital after two decades of international isolation due to the Great Depression, the Civil War (1936-39) and the inward looking policies of Franco's regime; and, finally, since the late 1980s, when Spain received a large influx of foreign capital, accompanied at the turn of the century by arrival of the ICT technologies. Figure 4 presents the evolution of capital quality.

[FIGURE 4]

c) Labor input

The appropriate measure of labor input is the flow of services for production emanating from this factor.[42] Thus, our task is to estimate the working force cross-classified in as many attributes as possible to

[40] Tafunell, "Asociación mercantil".

[41] Gabriel Tortella, *Orígenes del capitalismo*.

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

capture its heterogeneity. 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). Unfortunately, census and survey data for distant and recent periods do not contain such information and we can only offer a simplified version of labor input accounts. Due to data constraints, we have employed two different methodologies for the period before and after 1954.

We begin by describing the method employed for the earlier period, 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. Consequently, no use is made of information on education, age structure, and type of worker. Low education levels suggest, however, that the contribution of education to workforce heterogeneity was relatively minor.[43]

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. Some major shortcomings are posed by population censuses data: agrarian labor tends to be inconsistent over time, working population refer to the economically active population [EAP, thereafter], with no regard of involuntary unemployment, and is only available at census benchmark years. We had to make some dramatic choices. Thus, in order to derive consistent figures over time for EAP in agriculture, we had to exclude the female population.[44] Moreover, as the share of EAP in agriculture is suspiciously stable between 1850 and 1913, in spite of the increase in industrialization and urbanization, we corrected it by assuming that the share of EAP employed in agriculture (from which the female population has been excluded) moved along with the proportion of population living in rural areas (in villages with fewer than

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

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

[43] C.E. Núñez "Educación".

[44] The exclusion of females working in agriculture from the total working population was forced by their lack of consistency between censuses. Our temporary solution is imperfect but unfortunately quite frequent. See, for example, R. Nicolau, "Población"; P. Erdozáin and F. Mikelarena, "Cifras de activos agrarios"; and Pérez Moreda "Población y economía": 55.

5,000 inhabitants).[45] This implies to adjust downwards the percentage of EAP employed in agriculture between 1887 and 1920 redistributing the 'excess' agricultural workers proportionally between industry and services.[46] 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, which was done by superimposing on them the 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.

The second step is to distribute employment of these four large sectors into their branches. The sources for this cross-classification up to 1955 are the available population censuses (1860, 1877, 1887, 1900, 1910, 1920, 1930, 1940, 1950). These sources allowed us to cross classify working population into 19 industries up to 1900, 21 industries for 1900-1910 and 22 for 1911-1950. Thereafter we had information on employment for 24 industries. Unfortunately, lack of data forced us to breakdown manufacturing

[45] It is commonly accepted that agriculture does not employ the whole of the rural population, as a certain share of it, however small, is employed in the provision of services and processed goods. It is often argued that population centers did not become truly urban in nature, at least in the south of Spain, until the mid twentieth century as a non-negligible proportion of inhabitants remained occupied in agriculture. We have assumed that the population employed in agriculture and resident in urban centers would tend to offset those living in the countryside but employed in non-agrarian activities. It is possible to verify that, in modern Europe, as income rises, both the share of rural population and the EAP in agriculture fall, although the latter does so more rapidly, as there will always be a part of the population which prefers to live in the countryside but is no longer employed in agriculture (Prados de la Escosura, "Gerschenkron Revisited"). Estimates of urbanization prior to 1930 are those of David Reher, "Ciudades".

[46] Thus the proportion of agriculture in the economically active population for 1887, 1900, 1910, and 1920, 65.3, 66.3, 66.0, and 57.2 percent, respectively (Nicolau, "Población") was reduced to 62.7, 60.7, 58.0, and 54.5 percent, respectively. Pérez Moreda (1999) gives 64.7 and 64.8 as the shares of EAP in agriculture for 1887 and 1900.

employment into its branches by assuming that the distribution of employment in 1900 was representative for the period 1850-1900.[47]

The next step was converting data on employment (number of workers) into days and, then, hours worked per year, for the period 1850-1954. We assumed that each full-time worker was occupied 270 days per annum in industry and services. Such figure results from deducting Sundays and religious holidays and an allowance for illness.[48] This assumption is consistent with contemporary testimonies and supported by the available evidence.[49] In agriculture, however, contemporary and historians' estimates point to a lower annual number of days per worker.[50] Throughout most of the period considered, full employment among peasants only occurred during the summer period and, consequently, workers were idle for three or four months every year. 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.[51] Spanish

[47] Employment data on mining and construction is drawn from G. Chastagnaret *L'Espagne* and Prados de la Escosura *Progreso económico*, respectively.

[48] Interestingly enough a similar number of days is obtained for the 1960s and early 1970s. For example, Conference Board, on the basis of OECD data, estimated the number of hours worked per person in Spain was 2005 in 1973, while ILO estimated 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.

[49] A. Soto Carmona (*Trabajo industrial*: 608) reckons that, on average, the number of days worked per occupied up to 1919 ranged between 240 and 270.

[50] Day laborers, according to A. García Sanz ("Jornales Agrícolas": 63), worked an average of 242 days per year in mid-nineteenth century Spain. A. Gómez Mendoza (*Railways*: 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. J.A. Vandellós ("Richesse et Revenue") reckoned that, in 1914, the average number of days worked per year in agriculture was 250. James Simpson, "Technical change", estimates labor requirements in Andalusian agriculture between 1886 and 1930 and casts even lower figures, ranging from 108 to 130 days, which he considers to be on the low side.

[51] Pérez Moreda ("Población y economía": 57) mentions a contemporary estimate for 1960 that puts hidden unemployment at 1.8 million in a potential agricultural workforce of over 5 million people.

population censuses tend to include only information about people's main occupation, and given the common presence of 'pluriactivity' in agriculture, non-agricultural occupations performed by peasants tend to be underestimated. We, then, made the safe assumption that in the countryside the labor force was occupied 270 days that were distributed between agriculture (240 days)[52] and services (30 days).

As regards the numbers of hours worked per day, we observed that there was not only a long-run reduction 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.[53] We decided to accept 10 hours per day for 1850-1911 and to interpolate these two figures exponentially over 1912-35, while we maintained unaltered 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.[54] 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.[55] Álvaro Soto Carmona (*Trabajo industrial*: 596-613) provides some construction and services figures for the Interwar years.[56] The next period for which we had quantitative evidence on hours worked was the early 1950s. We found that often the number of hours per worked was 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' increasing 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

[52] We have applied Simpson's labor requirements per hectare to Spain's agricultural land at different benchmarks between 1891 and 1958 under the astringent assumption of constant technology. Assuming, that we underestimated employment by 25 percent, we re-scaled the number of working days and obtained a range from a minimum of 167 days per male worker in 1891/95 to a maximum of 246 days in 1929/33.

[53] Caballero (1864). 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.

[54] Huberman, "Working Hours".

[55] Doménech, "Working Hours"; Silvestre, *Migraciones interirores*: 190.

[56] Soto Carmona, *Trabajo industrial*: 596-613.

1936-53, and exponentially interpolate the figures for 1919 and 1936 in order to derive estimates for the period 1920-35.

For the post-1954 period, labor force data comes from the MOISSES base for the period 1954-1963,[57] from *Encuesta de Población Activa* (thereafter EPA)[58] for 1964-1980, and from official national accounts for 1980-2000.[59] The distribution of overall labor force across the different industries was based on *Banco de Bilbao*'s studies.[60] Then, we distributed workers for each industry into four occupational categories (unskilled, 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.[61]

[FIGURE 5]

Figure 5 reflects the evolution of hours worked over these 150 years that from 2,800 at mid-nineteenth century shrank to 1,800 by the end of the twentieth century. One can observe up to six long phases in their evolution. From 1850 to First World War, the amount of hours worked decreased slightly. In the following period, from 1914 up to 1936, the reduction of working hours was more dramatic due to the gradual adoption of 8-hours journey. During the early decades of the Franco's regime, worked hours remained stable.[62] Then, a dramatic fall took place between the mid-1950s and mid-1960s. The last push

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

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

[59] The different segments have been spliced using the "gap" distribution procedure for those years in which the different estimates overlap employed in Prados de la Escosura, *Progreso económico*. Official national accounts, CNE80, CNE85, CNE95, and CNE2000 have been used for 1980-1985, 1985-1995 and 1995-2000, respectively.

[60] These are collected at Fundación BBV, *Renta nacional.*

[61] Sanchis (private communication), furnished us with data on hours per economically active population for the 1950s. We used J. Maluquer de Motes and M. 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.

[62] This result is obtained by construction as on the basis of scattered data and qualitative evidence we assumed that the number of hours per occupied remained unaltered between 1936 and 1954.

downwards happened during the oil shocks that coincided with the so-called 'transition to democracy' decade (1976-85), to stabilize thereafter. The reduction in working hours between the mid-1950s and mid-1980s resulted from a combination of structural and institutional changes: employment shifts favoring several sectors in industry and services like government and metal with less working time, the generalization of the less than 8-hours journey, the two-day week-end and the diffusion of paid holydays.

The amount of labor, measured by both workers and total hours worked, presents a slow increase over the long run (see Figure 6 below). Labor force growth was moderate up to World War I and rose considerable from 1920 to 1935. The demographic transition, mass migration, and the rise in female participation rates brought about the increase in labor force. Labor declined dramatically during Civil War as a consequence of demographic losses and exile.[63] Then, it rose considerably over 1951-74 as a consequence of demographic expansion and increasing female participation rates though it was counterbalanced by external migration and declining male participation rates. The 'transition to democracy' (1975-86) witnessed a dramatic employment destruction driven by the oil shocks and the exposition of traditionally sheltered industrial sectors to international competition. The favorable environment for employment resulting from partial labor deregulation, a spectacular increase of female participation rates, and, lately, the arrival of immigrants are beneath the rise in employment during the 1990s.

The third phase in the construction of the labor input is to weight each category of workers by its average nominal earnings.[64] The quality and availability of wage data necessary to construct these estimates vary enormously over the period considered 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.[65] From 1908 to 1920, we employed in our calculations the detailed wage enquires

[63] J.A. Ortega and Silvestre, "Consecuencias demográficas".

[64] 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 (Prados de la Escosura and Rosés, "Wages and Labour").

[65] Agricultural wages were taken from M.A. Bringas, *Productividad de los factores*. Wages in construction (Madrid unskilled wages) and services were obtained from Reher and E. Ballesteros ("Precios y salarios") although they have been re-scaled to the national levels provided by Rosés and Blanca Sánchez-Alonso ("Regional Wage Convergence"). G. Chastagneret (*L'Espagne*) and A. Escudero (*Minería*) provided wages for

conducted by the *Instituto de Reformas Sociales*.[66] Their reports (*Memorias Generales de la Inspección de Trabajo*) contained information by gender on minimum, maximum and average wages for twenty branches of industry.[67] The quality of wage data decreases dramatically for the period 1920-1954.[68] In 1920 *Instituto de Reformas Sociales* disappeared ,being replaced by the *Ministerio de Trabajo*, and such a change represented that wage data was collection was interrupted. Subsequently, wage data for only nine occupations and fifty Spanish provinces was published at 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.[69] By combining the wage levels from the Ministerio de Trabajo's survey for 1930 and their rates of variation from *AEE*, we constructed our nominal wage series, classified by industry, for the period 1920-1936. Difficulties to obtain wages increase since Civil War. During the early years of General Franco's Dictatorship –the so called Autarchy-, 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*.[70] We, then, combined by means of a Fisher index yearly variations from the *AEE* data with wage levels for 1930 and 1955 in order to derive annual series. From 1954 onwards, we employed labor costs by sectors of economic activity from

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mining. Levels of manufacturing wages in all industry and services sectors at different dates (1850, 1880, 1905) were obtained, respectively, from I. Cerdá (*Teoría General*), U.S. Department of Labor (*Fifteenth Annual Report*), and *Anuario Estadístico de Barcelona.* Annual variations among benchmarks were derived by means of Fisher indices with data drawn from E. Camps, *Formación del Mercado de trabajo*; Llonch, "Jornada, salarios"; and R. Soler, "Evolución del salario" in the case of consumer industries and Escudero, *Minería*; and P.M. Pérez Castroviejo, *Clase obrera* in the remaining industries.

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

[67] 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.

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

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

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

Banco de Bilbao.[71] These series include average labor cost but do not provide a breakdown by occupational categories that had to be obtained, then, from the official enquiries on wage, labor costs, and wage structure,[72] which were later re-scaled to match aggregate figures in *Banco de Bilbao*'s statistics.

[FIGURE 6]

Figure 6 reports the evolution of labor input and labor quantity (unweighted hours worked) from 1850 to 2000. Broadly speaking, the evolution of labor input parallels that of labor quantity. Labor input expanded significantly in three periods (though not during the nineteenth century): in the interwar years (1920-35), the Golden Age, and since the late 1980s. The faster growth of labor input was due to shifts in labor quality. Labor quality grew significantly in the interwar years (1920-35) and between the early 1950s and the mid-1980s (Figure 7). Labor quality provides a measure of human capital in so far it captures improvements in workers' skills.[73]

[FIGURE 7]

d) Factor shares

In order to compute the sources of growth, in addition to the real factor inputs described above, we need to know the elasticity of output with respect to each input (Θ_i). Under the astringent assumption of perfect competition and constant returns to scale, these elasticities can be proxy by the share of each factor in national income. Such an assumption could be hard to accept by those familiar with Spanish economic history in which restrictions to competition and monopolistic practices have been common. However, if there were competitive monopolistic rents, our 'naïve' results, obtained under the assumption of perfect competition, would bias TFP growth downwards, as the capital share in GDP –by including competitive monopoly profits- would overstate the elasticity output with respect to capital.[74] This would be hardly a problem for us since it is our hypothesis that TFP was the leading force behind GDP growth in Spain. In fact, by following a 'naïve´' approach we just act

[71] Collected in Fundación BBV, *Renta nacional*; and J. Alcaide and P. Alcaide, *Renta nacional*.

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

[73] A sensibility test of our measure is provided at the appendix.

[74] Young, "Tyranny of Numbers": 648.

according to what has become the standard practice in economic history, that is, biasing the estimates against the hypothesis to be tested.[75]

Up to 1954, labor returns were directly estimated as shown above (sub-section c). The well-known difficulties to separate land rent from returns to capital in agriculture led us to include land rent in the returns of property (together with those of capital).[76] The share of capital was obtained as a residual after deducting labor returns from GDP at factor cost.

From 1954 onwards, we derived factor shares from labor and property compensation provided by the different sets of national accounts that we previously spliced.[77] To measure labor income correctly it is crucial, however, to establish which proportion of the income of proprietors, unpaid family workers, self-employed, and retired workers represent returns to labor.[78] We have attributed to entrepreneurs and self-employed workers a labor income per head equal to the average compensation of employees in their corresponding industry.[79] Dividing total labor (including self-employed) compensation by GDP at factor costs, we obtained the share of labor. The capital share is obtained, in turn, as one less the labor share.

[FIGURE 8]

[75] Relaxing the assumption of constant returns to scale would also impinge on our TFP estimates. If Spanish aggregate production function featured increasing returns to scale, our 'residual' would over-exaggerate TFP growth (Young, "Tyranny of Numbers": 648). Nonetheless, J. Suárez, "Economías de escala" rejected the increasing returns hypothesis for the case of Spain between 1965 and 1990.

[76] Ministerio de Agricultura, "Cuentas del sector agrario": 46-50. A sensitivity test is provided in Appendix C in which the sources of growth are computed using three factors of production: capital, labor, and land.

[77] We followed the same procedure employed for linking GDP and its components, and labor force in Prados de la Escosura (*Progreso económico*: chapter 4), in which instead of just simply re-scaling earlier national accounts by their differential ratio for the overlapping year, an alternative linkage procedure was used in which the gap was distributed over time at a constant annual rate.

[78] See Prados de la Escosura and Rosés, "Wages and Labour".

[79] Simon Kuznets, *Modern Economic Growth*. This is a common procedure in growth accounting (Jorgenson, "Productivity").

Figure 8 shows the evolution of the shares of capital and labor in GDP. The relative instability of productive factors' shares in GDP stands out against the conventional stability assumption.[80] Distinctive phases can be distinguished. Between mid-nineteenth century and World War I a relative increase in the capital share occurred while the labor share tended to decrease. The growing importance of capital can be attributed, among other causes, to rising investment rates and technological change favoring capital. In the interwar years, the labor share grew significantly. Two elements could have influenced the expansion of labor: institutional labor market reforms favoring workers and the increase of human capital endowments in workforce. The early years of the Franco's regime witnessed a sharp decrease in the labor share, probably an outcome of dictatorship's economic policy. Since the mid-1950s a rapid increase in labor share took place that peaked by the late 1960s when pre-Civil War levels were recovered. This labor share gains can be attributed to an expansion of human capital endowments and to the more liberal economic policies of the late Francoist regime. Since early 1970s, however, capital as share of GDP has tented to grow at expenses of labor. More specifically, if one compares the late 1960s and the late 1990s, it can be observed that capital share more than doubled, jumping from 15 to 36 percent. It can be argued that such capital share increase was an outcome of technological change and globalization forces. However, all these thoughts are only preliminary and would merit a more in-depth analysis and discussion in the future.

MAIN TRENDS IN TOTAL FACTOR PRODUCTIVITY

A first computation of the sources of long-run growth in Spain, in which no adjustments for composition or quality changes in labor and capital have been carried out, is presented in Table 4.[81] In this case, labor is measured as total hours worked and capital by the total capital stock (without allocating a different weighting to structures and equipment).

[TABLE 2]

[80] See the survey of the relevant literature in Prados de la Escosura and Rosés, "Wages and Labour".

[81] Thus, we follow a growth accounting method similar to that employed by E.F. Denison, *Sources of Economic Growth*; and Maddison, "Growth and Slowdown", although we use semi-geometric depreciation rates for capital assets that accelerated their growth rates.

From this exercise TFP and capital come out as the leading forces underlying Spain's economic performance during the last one and a half centuries: ninety percent of Spanish long-run growth is due to capital accumulation and efficiency gains in equal proportions. Distinctive epochs are observed in which capital and TFP lead alternatively. TFP explained over seventy percent of growth in the second half of the twentieth century but practically none in the previous hundred years. Capital, instead, accounts for three-fourths of GDP growth between 1850 and 1950 but less than one-third from 1950 to 2000. Episodes of TFP acceleration took place, nonetheless, from the late 1860s to the mid-1880s, between World War I and the Great Depression, and from the early-1950s to the mid-1980s. The Golden Age (1953-74) success is largely determined by TFP growth, but during the sluggish growth of the 'transition to democracy' years (1975-86) TFP also played a major role, as efficiency gains more than offset the negative impact on growth of employment destruction and sluggish capital accumulation and prevented a fall in living standards. Conversely, the last one and a half decades of the twentieth century, which includes Spain's accession to the European Union, presents a sharp reduction of TFP role only partly offset by employment creation and the recovery of capital formation.[82]

In this first crude approach, however, quality improvements in capital and labor are not separately computed and appear, therefore, as a part of the residual. That is why a growth accounting exercise in which factors are measured as inputs, that is the service provided to production by factors, is offered in Table 5.[83] With this alternative method, TFP growth is reduced (see Figure 9 below). Overall, TFP contributes 31 percent of GDP long-run growth, while capital with 48 percent is the prevailing force. Prior to 1950, capital accounts for almost four-fifths of GDP growth with a negative contribution by TFP (except for the 1920s in which it supplied one-fifth of GDP growth). However, in the second half of the twentieth century TFP provided more than half of GDP growth: it was the overwhelming force during the Golden Age (1953-1974) and accounts for all the (sluggish) growth exhibited during the 'transition to democracy' decade (1975-

[82] Spain is not the only case in Europe. Bart 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. See also M. Mas and J. Quesada, "ICT and Economic Growth"; and M. P. Timmer and Van Ark, "Information and Communication Technology".

[83] Hence, we apply the "second" generation of growth accounting methodology (Jorgenson, "Productivity").

1986). Lastly, the weak role that TFP played since Spain's admission in the European Union, down to one-tenth of GDP growth, stands out. A consistent contribution by capital, around two-fifths of GDP growth, is, in turn, observed since 1975. However, we should be aware that the ratio of TFP to GDP growth is not enough to measure of the importance of TFP as a source of growth because it ignores the additional capital accumulation that results from a productivity increase.[84]

[TABLE 3]

The data in tables 2 and 3 reveal several an important 'stylized facts' regarding Spanish economic growth. It easy to appreciate the strong differences between the pre-1950 and post-1950 periods: the former characterized by slow GDP growth, in which TFP played no role,[85] while in the second half of the twentieth century (with the post-1987 exception) TFP growth led economic progress. Moreover, economic growth was not steady over time. It is far from easy, then, to tell the story of Spanish economic growth within the framework of a cumulative-growth model.[86]

[FIGURE 9]

It is interesting, perhaps, to place the case of Spain within the international debate about the sources of growth. Growth was predominantly extensive during the early stages of growth in Spain (1850-1950) as it was in Britain at the time of the First Industrial Revolution, in the United States for most of the nineteenth century, in the East Asian NICs between the mid-1960s and 1990, and, more recently, in China.[87] Thus, abstention, rather than ingenuity[88] dominated early economic growth, as it was heavily dependent on capital accumulation and –to a lesser extent in the Spanish case– on labor. In a second phase, TFP growth, that 'free lunch' in Joel Mokyr's words,[89] led the way to a modern society. Such a result makes sense as it appears

[84] Hulten and S. Srinivasan, "Indian Manufacturing".

[85] In Appendix C we have replicated the exercise including land among factors of production and the outcome is more favourable for TFP contribution to growth prior to 1950.

[86] Such as the AK model, cf. Rebelo "Long-run Policy".

[87] Crafts, "Exogenous or Endogenous": 752; Abramovitz and David, "Two centuries": 35; Young, "Tyranny of Numbers": 657-61; and Young, "Razor's Edge".

[88] In D.N. McCloskey's expression, "Industrial Revolution": 108.

[89] Mokyr, *Level of Riches*: 3.

easier to grow by differing present consumption and allocating more labor effort in an early stage and, later, by becoming more efficient in the use of available resources.[90]

CONCLUSIONS AND RESEARCH AGENDA

The Spanish economy passed through three successive phases: the initial from 1850 to 1950s characterized by slow growth mainly driven by factor accumulation, the following period from 1953 to 1986, in which explosive growth and large productivity gains predominated, and the later (from 1987 onwards) that can be depicted as period of substantial GDP growth but sluggish productivity growth. Some lessons can be derived from our historical investigation. First, while our measurement of growth yields only a range of best guest estimates, our results are robust as alternative methodologies used for the post-1960s era lead to similar results. Second, TFP seems to drive Spanish economic growth in the long run. Lastly, the importance of taking into account factor quality accumulation and variations in factor shares in measuring TFP growth needs to be stressed.

Among the many possible routes for new research, we would like to underline three of them. First, we should devote more research to institutions as they are central to long run economic performance and shape the incentives of key economic actors. In particular, they decide investments in physical and human capital and technology, and the organization of production. The relation between institutional changes and Spanish growth, and hence TFP, upsurges is also uneven. More specifically, liberal reforms that modified the structure of the Spanish economy during the early nineteenth century did not translate into large TFP growth rates but into extensive growth. Conversely, the timid liberation of foreign transactions during the 1920s, which was accompanied by a favorable international situation, went along with a large TFP upsurge. Similarly, economic reforms of the 1950s and the 1960s under Franco's dictatorship led to dramatic growth and TFP explosion. In turn, the transition of democracy and the more profound liberalization of markets led, first, to a productivity upsurge accompanied by a dramatic increase in unemployment and conversely, in a

[90] It should be noted that under alternative growth accounting computations productivity growth accounts for a fairly significant portion of total output growth over 1950s-1980s, and explains little thereafter. Such a coincidence renders the results robust. Moreover, when available, our results are not contradictory with previous studies (See Appendix A, Table 1).

next phase, to a rapid increase in employment without substantial TFP growth. In sum, given the dependence on foreign technologies, institutional reforms in Spain had larger impact on economic growth when international conditions were favorable. Moreover, it appears that openness is closely linked to TFP growth.

Second, the sources of TFP growth also merit our attention. On the one hand, in endogenous growth models,[91] productivity growth results from spillovers from human capital accumulation or inventive activity and this is what generates long run growth in per capita income. Unlike the neoclassical model, the accumulation of capital and labor will increase the long-run rate of economic growth if this capital embodies more sophisticated technology and if workers are more skilled. The endogenous growth models' emphasis is on accumulation of inputs of superior quality and, therefore, technological change is not assumed to be exogenous. On the other hand, the development of new technologies and their diffusion across countries are critical components of TFP growth. Clearly, a country that is able to adopt new technologies faster is also able to grow faster. Across the last one-and-half century, up to four different big technological waves, each with its own General Purpose Technology,[92] were developed in the most advances economies and transmitted to the follower countries: namely, the steam engine technology in the early and mid-nineteenth century, electricity in the late nineteenth and early twentieth century, the mass production from the 1920s to the 1970s, and, most recently, the Information and Communication Technology (ICT). Spain hardly participated in the practical expression and commercial development of these innovations and, thus, the

[91] There are two broad strands in the endogenous growth literature. Seminal articles of Paul Romer "Increasing Returns" and R.E. Lucas "Mechanics of Economic Development" led to the first variety of endogenous growth models which knowledge is assumed to be an input of production with increasing returns to scale. The second variety of endogenous growth models (sometimes called Schumpeterian growth Models) also takes its departure from an article by Romer "Endogenous Technological Change" but has been extended by other economists such as G.M. Grossman and E. Helpman, *Innovation and Growth*; P. Aghion and P. Howitt, "Model of Growth"; and C. Jones, "R&D Based-models". In these models, growth is driven by technological change that results from the research and development efforts of profit-maximizing agents.

[92] According to the criteria proposed by R.G. Lipsey, C. Bekar, and K. Carlaw, "What Requires Explanation", GPT share the following characteristics: (1) wide scope for improvement and elaboration; (2) applicability across a broad range of uses; (3) potential for use in a wide variety of products and processes; (4) strong complementarities with existing or potential new technologies.

dependence of Spanish economy from foreign technology and innovation has been practically total last one and a half centuries. Therefore, the extent to which increases of capital and TFP growth was connected in Spain to the introduction of GPT from abroad deserves further investigation.

Third, it is worth exploring the apparent two steps structure of economic growth: an early one characterized by factor accumulation followed, then, by TFP growth. We need to widen our analysis of the sources of long-run growth to countries with different levels of development to put this hypothesis to the test.

Appendix A: Comparison with previous estimates

[APPENDIX: TABLE 1]

Appendix B: Sensitivity test of our Labor Quality Measure

A source of concern is whether we are able to capture improvements in human capital affecting labor force with our labor input measure. Following Jorgenson, we argue that labor quality provides a measure of human capital in so far it captures improvements in workers' skills. However, conventionally, human capital in Spain (and elsewhere) is approximated through education measures.[93]

[APPENDIX: FIGURE 1]

Figure A-1 solves the conundrum by comparing our labor input series with other new index where occupational categories were replaced by educational categories and workers were weighted by average remuneration of their education level in their respective industries. The procedure for calculating this index has been the following. We substituted five educational categories (illiterate, primary schooling, secondary schooling, previous to tertiary, tertiary) for our occupational categories over 1985-2000 (when data is available) in the original series from Mas *et al*. study on human capital.[94] Then, we employ the regression estimates of average educational premium for 1990[95] to weight each category by its relative value (wage) but maintaining the congruence with the total remuneration of the industry. Thus, the relative remuneration of different educational categories is identical within all industries but average wages differed across industries. The resulting new index measures education not in terms of production but in terms of use (as the growth accounting requires). As the reader can observe, the differences between the two approaches are not substantial. Therefore, we can conclude that our labor input measures are not biased against human capital and captures quite accurately the impact of human capital on labor quality.

[93] For Spain, see Mas, F. Pérez, E. Uriel, L. Serrano and A. Soler *et al*. *Capital Humano*; and R. Doménech and A. de la Fuente, "Human Capital".

[94] Mas *et al. Capital Humano.*

[95] A. Alba and M.J. San Segundo, "Returns to Education".

Appendix C: Sensitivity test of our TFP Estimates: An Alternative Estimate including Land

The point of departure in our estimate of the sources of growth in Spain between 1850 and 2000 is the same production function in which we include land as a separate factor, given by:

(12) $$Q = F(X, K, L)$$

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

The appropriate measure of land input is the flow of services emanating from this factor.[96] In order to develop our measure of land input we, firstly, constructed the stock of land; we, then, estimated the prices (rents) of the different types of asset and, finally, we combined prices and quantities of land into a single index.

Our main goal is to estimate agricultural land cross-classified in as many attributes as possible to capture the heterogeneity of land input. Ideally, one should estimate the amount of land classified by quality and type of cultivation. The first step, thus, is to elaborate yearly land figures. Unfortunately, data for distant periods do not contain such information and we had to derive a very crude approximation. In fact, only the amount of land with a highly aggregate distribution at given benchmarks is available. Thus, prior to the late 1950s aggregate agricultural land estimates exist for 1834, 1860, 1891/95, 1897/1901, 1909/13, 1920/22, 1929/33, 1950, and 1958, so we interpolated them to derive annual figures and, as in the case of labor stock, we adjusted them for the economic cycle by superimposing on them the deviations from the Hodrick-Prescott trend in agricultural output.[97]

The second step is converting hectares of land into a stock of land by weighting each kind of land by its price at a given benchmark. Since land prices are so far available for 1850-1935 and 1983-2000, we

[96] It can be assumed that such a flow is proportional to the amount of land involved. This requires that,

(13) $$Xi_t = \lambda_{Xi} Ti_t,$$

where, X is land input, λ_{Xi} is a constant, and T measured land hectares.

[97] The sources from which our estimates have been constructed are R. Garrabou and J. Sanz, *Historia Agraria*, for 1834 and 1860; Simpson, *Spanish Agriculture*, for 1891/95-1929/33; Banco Urquijo, *La riqueza*, for 1920; and P.K. O'Brien and Prados de la Escosura, "Agricultural Productivity", background computations, for 1891-1980; Y. Hayami and V.W. Ruttan, *Agricultural Development* and D.S. Prasada Rao *Inter-Country Comparisons* provide international comparable aggregate land estimates for 1960 and at five year benchmarks for 1970-90, respectively. Fortunately for main crops (major cereals, roots, fruit trees, vine and olive) annual figures are available (C. Barciela *et al.*, "Sector agrario").

decided to construct a spliced Laspeyres index of the stock of land for the whole time span considered, 1850-2000.[98] Later, as Bringas provides prices for five categories of land: dry farming, irrigated land, vines, olive, and pasture, at eleven benchmarks for 1858-1935, we interpolated them annually and constructed a Divisia index for 1850-1935.[99] Next, rental prices were constructed for each category. In competitive equilibrium, the cost of a unit of land is equal to its price and its expected rent during its life:

$$p_k(T) = p_i(T-1)r(T) - [p_i(T) - p_i(T-1)] \quad (14)$$

Where $p_X(T)$ is the rental rate, $p_i(T)$ is the price, and $r(T)$ is the nominal rate of return between (T) and $(T-1)$ years. The price of the land input is, thus, the nominal price less revaluation. Lastly, we derived the land input with rental prices and quantities of land using equations (6) and (7).

Some features of the land stock and input are worth highlighting. In the first place, there are minor differences in the stock estimates alternatively obtained with Divisia, Laspeyres or just number of hectares index at least until the 1960s, which suggests that only minor composition changes took place over the first hundred years considered. Moreover, no significant difference is found between stock and input indices, that is, no major quality improvements appear to have occurred in Spain prior to the Civil War (1936-39), except for the early 1930s (Appendix Table 2).

[APPENDIX: TABLE 2]

Finally, we need to compute the share of land returns in GDP in order to derive factor shares. Unfortunately, the lack of information on land rent led us to deriving the land share as the residual obtained after deducting labor outlays from agricultural gross value added. This method implies the unrealistic assumption of no return to capital from agriculture and, hence, tends to overstate the share of land in GDP.[100]

[98] Indices with fixed weights (land prices) for 1931 and 1985 were respectively constructed for 1850-1958 and 1958-2000 and, then, spliced into a single quantity index of the stock of agricultural land. Land prices for 1931 and 1985 come from Bringas, *Productividad de los Factores* and Ministerio de Agricultura, *Estadística Agroalimentaria*, respectively.

[99] Bringas, *Productividad de los Factores*.

[100] Nonetheless, given that the size of agriculture in GDP shrank during the second half of the twentieth century the resulting (upwards) bias in our TFP growth estimates should not be large. Furthermore, the highly volatile evolution of the land share in GDP results, despite its apparent inaccuracy, very illuminating. Distinctive phases

[APPENDIX: FIGURE 2]

We have replicated the exercises carried out in Tables 2 and 3 but now including land as a third factor of production. Here there are our results. Firstly, we have computed the sources of long-run growth without adjustments for composition or quality changes in labor and capital (see Appendix Table 3).

[APPENDIX: TABLE 3]

TFP comes out as the leading force underlying Spain's economic performance during the last one and a half centuries: over one half of Spanish long-run growth is due to efficiency gains. Distinctive epochs are observed. TFP explained roughly three-fourths of growth in the second half of the twentieth century but roughly one-fourth of growth in the previous hundred years. Episodes of TFP acceleration took place, nonetheless, from the late 1860s to the mid-1880s, between World War I and the Great Depression, and from the early-1950s to the mid-1980s.

We, then, introduced quality improvements in capital and labor and now production factors are measured as inputs (Appendix Table 4). Using this alternative methodology reduces TFP growth (Figure 4). Overall, TFP contributes 41 percent of GDP long-run growth, while capital does 37 percent. Prior to 1950, TFP only accounts for 13 percent of growth while still provides more than half of GDP growth in the second half of the twentieth century. A closer look reveals that, TFP amounts to less than one-fifth of GDP growth over 1850-1920, reaches over one-fourth in the 1920s, and remains negative during the turmoil of the 1930s and the autarchy of the 1940s and early 1950s. Nonetheless, TFP remains the overwhelming force during the Golden Age (1953-1974) and accounts for all the (sluggish) growth exhibited during the 'transition to democracy' decade (1975-1986).

[APPENDIX: TABLE 4]

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are clearly observable. After the 1855 peak, usually associated to the Crimean War boom, the land share fell till 1866. From the late 1860s to the mid- 1880s, the land share recovered as exports expanded and the economy grew rapidly. The so called 'agricultural depression' appears to have had an impact on returns to land in the late eighties with a trough in 1892, just by the time when the Cánovas protectionist tariff was introduced. Land rents recovery peaked during First World War to decline in its aftermath, and more severely in the years of the Great Depression and the Civil War. The autarchy years in early Franco's Regime witnessed a recovery of land rents that was reverted since the early 1950s when Spain started a sustained process of accelerated growth.

[APPENDIX: FIGURE 3]

Finally, in Figure 5 we compare alternative quality adjusted TFP estimates including and excluding land as a factor of production. It can be observed that the inclusion of land, as a third factor of production, increases the contribution of TFP to growth. Such difference is particularly noticeable for the 1850-1950 period, when TFP contribution to growth turns to be positive.

[APPENDIX: FIGURE 4]

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TABLE 1
GDP, PER CAPITA GDP, PER WORKER GDP AND PER HOUR WORKED GDP GROWTH, 1850-2000
(Percent yearly log-rates)

	GDP at factor cost	GDP per capita	GDP per worker	GDP per Hour worked
	(1)	(2)	(3)	(4)
1850-2000	2.5	1.9	1.8	2.1
Panel A.				
1850-1950	1.4	0.8	0.8	0.9
1951-1974	6.5	5.5	5.1	5.5
1975-2000	3.0	2.6	2.7	3.4
Panel B.				
1850-1883	1.8	1.4	1.1	1.2
1884-1920	1.3	0.7	0.9	1.0
1921-1929	3.8	2.8	1.7	2.0
1930-1952	0.8	0.0	-0.1	0.0
1953-1958	4.7	3.9	3.7	4.3
1959-1974	6.9	5.8	5.8	6.3
1975-1986	2.5	1.8	4.6	6.1
1987-2000	3.5	3.3	1.0	1.1

Sources: Prados de la Escosura (2006)

TABLE 2
GROWTH ACCOUNTING WITHOUT QUALITY ADJUSTMENTS, 1850-2000

	Growth rates (Percent yearly log-rates)				**Contribution** (Share of total growth)		
	GDP	**Labor**	**Capital**	**TFP**	**Labor**	**Capital**	**TFP**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1850-2000	2.5	0.4	3.9	1.1	0.10	0.45	0.45
Panel A:							
1850-1950	1.4	0.5	3.3	0.0	0.24	0.74	0.02
1951-1974	6.5	1.0	5.9	4.4	0.10	0.23	0.67
1975-2000	3.0	-0.4	4.1	2.3	-0.15	0.38	0.76
Panel B:							
1850-1883	1.8	0.6	5.3	-0.1	0.27	0.76	-0.03
1884-1920	1.3	0.2	2.5	0.2	0.11	0.75	0.14
1921-1929	3.8	1.8	3.6	1.3	0.29	0.36	0.34
1930-1952	0.8	0.8	1.6	-0.2	0.46	0.74	-0.20
1953-1958	4.7	0.4	4.5	2.7	0.05	0.37	0.58
1959-1974	6.9	0.6	6.9	5.0	0.07	0.20	0.72
1975-1986	2.5	-3.6	4.3	4.3	-1.12	0.40	1.71
1987-2000	3.5	2.4	3.9	0.6	0.45	0.37	0.18

Sources: See text.

TABLE 3
GROWTH ACCOUNTING WITH "QUALITY" ADJUSTMENTS,
1850-2000

	Growth rates (Percent yearly log-rates)							
			Labor			Capital		
	GDP	Quantity	Quality	Input	Stock	Quality	Input	TFP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1850-2000	2.5	0.4	0.4	0.8	3.9	0.2	4.1	0.8
Panel A:								
1850-1950	1.4	0.5	0.2	0.7	3.3	0.2	3.5	-0.1
1951-1974	6.5	1.0	1.0	2.0	5.9	0.4	6.3	3.5
1975-2000	3.0	-0.4	0.7	0.3	4.1	0.3	4.4	1.7
Panel B.								
1850-1883	1.8	0.6	0.1	0.7	5.3	0.4	5.8	-0.2
1884-1920	1.3	0.2	0.1	0.4	2.5	0.1	2.6	0.0
1921-1929	3.8	1.8	0.8	2.6	3.6	0.4	4.0	0.7
1930-1952	0.8	0.8	0.0	0.8	1.6	-0.1	1.5	-0.2
1953-1958	4.7	0.4	1.2	1.6	4.5	0.5	5.0	1.7
1959-1974	6.9	0.6	1.1	1.7	6.9	0.4	7.3	4.0
1975-1986	2.5	-3.6	1.2	-2.4	4.3	0.0	4.3	3.3
1987-2000	3.5	2.4	0.2	2.6	3.9	0.5	4.5	0.4

Sources: See text.

TABLE 3 (Cont.)
GROWTH ACCOUNTING WITH "QUALITY" ADJUSTMENTS,
1850-2000

	Growth Weighted Rates (Percent yearly log-rates)				Contribution (Share of total growth)				
	Labor		Capital		Labor		Capital		
	Quantity	Quality	Stock	Quality	Quantity	Quality	Stock	Quality	TFP
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1850-2000	0.3	0.3	1.1	0.1	0.10	0.11	0.45	0.03	0.31
Panel A:									
1850-1950	0.3	0.1	1.0	0.1	0.24	0.07	0.74	0.04	-0.09
1951-1974	0.7	0.8	1.5	0.1	0.10	0.12	0.23	0.02	0.54
1975-2000	-0.4	0.5	1.2	0.0	-0.15	0.17	0.38	0.02	0.58
Panel B:									
1850-1883	0.5	0.0	1.4	0.1	0.27	0.02	0.76	0.06	-0.11
1884-1920	0.1	0.1	0.9	0.0	0.11	0.07	0.75	0.03	0.03
1921-1929	1.1	0.5	1.4	0.1	0.29	0.12	0.36	0.04	0.19
1930-1952	0.4	0.0	0.6	0.0	0.46	0.01	0.74	0.01	-0.22
1953-1958	0.2	0.8	1.7	0.2	0.05	0.17	0.37	0.04	0.37
1959-1974	0.5	0.9	1.4	0.1	0.07	0.13	0.20	0.01	0.58
1975-1986	-2.8	0.9	1.0	0.0	-1.12	0.37	0.40	0.00	1.34
1987-2000	1.6	0.2	1.3	0.1	0.45	0.05	0.37	0.02	0.11

Sources: See text.

APPENDIX TABLE 1
GDP AND TFP GROWTH: ALTERNATIVE ESTIMATES
(Percent yearly log-rates)

		GDP	TFP	TFP contribution to GDP (Percent)
Panel A. Without Quality Adjustment				
1965-1974	Prados de la Escosura and Rosés	7.1	4.7	66
1965-1974	Suárez (1992)	6.5	3.8	59
1975-1986	Prados de la Escosura and Rosés	2.5	4.3	171
1975-1985	Suárez (1992)	1.4	1.6	118
1973-1980	Hofman (1993)	2.1	1.5	73
1987-1992	Prados de la Escosura and Rosés	4.2	0.5	13
1986-1990	Suárez (1992)	4.4	1.3	30
1980-1989	Hofman (1993)	2.9	1.6	57
1979-2000	Prados de la Escosura and Rosés	2.9	1.9	64
	Pérez (2006)	2.7	1.4	52
Panel B. With Quality Adjustment				
1965-1974	Prados de la Escosura and Rosés	7.1	3.6	50
1966-1974	Myro (1983)	7.1	4.1	58
1964-1973	Cebrián (2001)	7.0	4.2	60
1975-1986	Prados de la Escosura and Rosés	2.5	3.3	134
1975-1981	Myro (1983)	2.2	2.6	117
1973-1980	Hofman (1993)	2.1	0.5	25
1987-1992	Prados de la Escosura and Rosés	4.2	0.1	2
1980-1989	Hofman (1993)	2.9	0.2	8
1987-2000	Prados de la Escosura and Rosés	3.5	0.4	11
	Timmer and van Ark (2006)*	3.4	0.0	0
1985-2002	Prados de la Escosura and Rosés	3.4	0.4	13
	Mas and Quesada (2005)	3.0	-0.6	-18

Notes: * Excluding residential structures from capital
Sources: Suárez, "Economías de escala"; Hofman, "Capital stock of Spain"; Pérez, *Productividad e internacionalización*; Myro, "Evolución de la productividad"; Cebrián, "Fuentes del crecimiento"; Timmer and Van Ark, "Information and Communications Technology"; Mas and Quesada, "ICT and Economic Growth", and text.

APPENDIX TABLE 2
GROWTH OF LAND QUANTITY AND INPUT, 1850-2000
(Percent yearly log-rates)

	Land Stock Laspeyres	**Land Stock** Divisia	**Land Input**	**Land Quality**
1850-2000	0.2			
Panel A:				
1850-1950	0.2			
1951-1974	1.0			
1975-2000	-0.4			
Panel B.				
1850-1883	0.1	0.1	0.1	0.0
1884-1920	0.8	0.6	0.7	0.0
1921-1929	1.0	1.0	1.0	0.0
1930-1952	0.2			
1953-1958	-2.2			
1959-1974	1.0			
1975-1986	-1.0			
1987-2000	0.1			

Sources: See text.

APPENDIX. TABLE 3
SOURCES OF GROWTH: WITHOUT "QUALITY" ADJUSTMENTS (1850-2000)
(Percent yearly log-rates)

	GDP	**Labor**		**Capital**		**Land**		**TFP**	
	Rate	Rate	Contribution	Rate	Contribution	Rate	Contribution	Rate	Contribution
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1850-2000	2.5	0.4	(0.10)	3.9	(0.35)	0.2	(0.01)	1.4	(0.54)
Panel A									
1850-1950	1.4	0.5	(0.24)	3.3	(0.51)	0.2	(0.02)	0.3	(0.23)
1951-1974	6.5	1.0	(0.10)	5.9	(0.18)	1.0	(0.01)	4.6	(0.70)
1975-2000	3.0	-0.4	(-0.15)	4.1	(0.37)	-0.4	(0.00)	2.3	(0.78)
Panel B									
1850-1883	1.8	0.6	(0.27)	5.3	(0.49)	0.1	(-0.01)	0.5	(0.25)
1884-1920	1.3	0.2	(0.11)	2.5	(0.55)	0.8	(0.08)	0.3	(0.26)
1921-1929	3.8	1.8	(0.29)	3.6	(0.26)	1.0	(0.03)	1.6	(0.42)
1930-1952	0.8	0.8	(0.46)	1.6	(0.55)	0.2	(0.11)	-0.1	(-0.12)
1953-1958	4.7	0.4	(0.05)	4.5	(0.28)	-2.2	(-0.05	3.4	(0.72)
1959-1974	6.9	0.6	(0.07)	6.9	(0.17)	1.0	(0.01)	5.2	(0.75)
1975-1986	2.5	-3.6	(-1.12)	4.3	(0.38)	-1.0	(0.00)	4.3	(1.74)
1987-2000	3.5	2.4	(0.45)	3.9	(0.36)	0.1	(0.00)	0.6	(0.18)

APPENDIX. TABLE 4
SOURCES OF GROWTH: WITH "QUALITY" ADJUSTMENTS (1850-2000)
(Percent yearly log-rates)

	GDP	Labor Input		Capital Input		Land Input		TFP	
	Rate	Rate	Contribution	Rate	Contribution	Rate	Contribution	Rate	Contribution
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1850-2000	2.5	0.8	(0.21)	4.1	(0.37)	0.2	(0.01)	1.0	(0.41)
Panel A									
1850-1950	1.4	0.7	(0.31)	3.5	(0.54)	0.2	(0.02)	0.2	(0.13)
1951-1974	6.5	2.0	(0.22)	6.3	(0.20)	1.0	(0.01)	3.7	(0.57)
1975-2000	3.0	0.3	(0.02)	4.4	(0.39)	-0.4	(0.00)	1.8	(0.59)
Panel B									
1850-1883	1.8	0.7	(0.29)	5.8	(0.53)	0.1	(-0.01)	0.4	(0.20)
1884-1920	1.3	0.4	(0.19)	2.6	(0.57)	0.8	(0.08)	0.2	(0.16)
1921-1929	3.8	2.6	(0.41)	4.0	(0.29)	1.0	(0.03)	1.0	(0.27)
1930-1952	0.8	0.8	(0.47)	1.5	(0.54)	0.2	(0.11)	-0.1	(-0.13)
1953-1958	4.7	1.6	(0.22)	5.0	(0.31)	-2.2	(-0.05)	2.4	(0.52)
1959-1974	6.9	1.7	(0.20)	7.3	(0.18)	1.0	(0.01)	4.2	(0.61)
1975-1986	2.5	-2.4	(-0.74)	4.3	(0.38)	-1.0	(0.00)	3.4	(1.36)
1987-2000	3.5	4.3	(0.50)	4.5	(0.39)	0.1	(0.00)	0.4	(0.12)

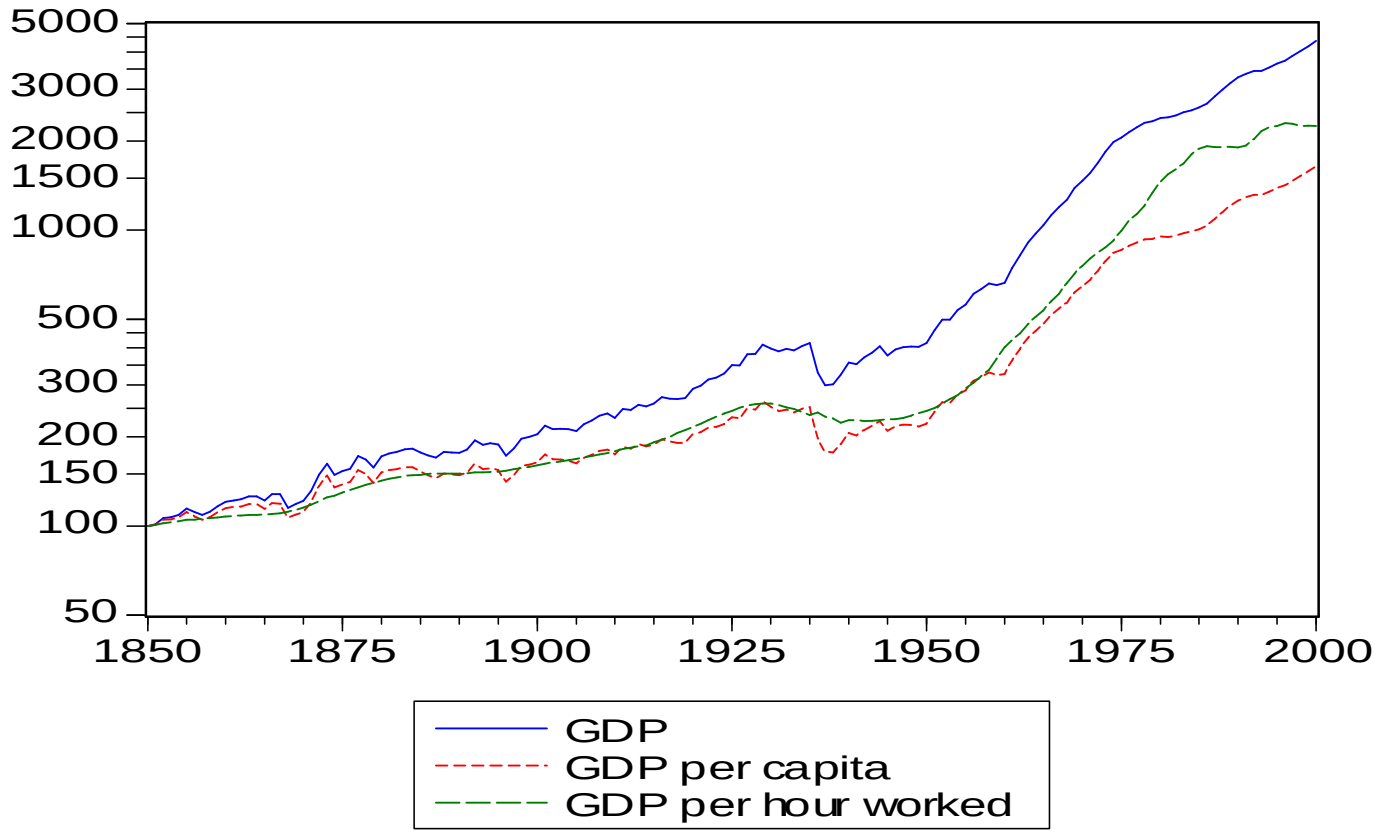


FIGURE 1
GDP, GDP PER CAPITA AND PER HOUR WORKED, 1850-2000 (1850 = 100) (semilog scale)

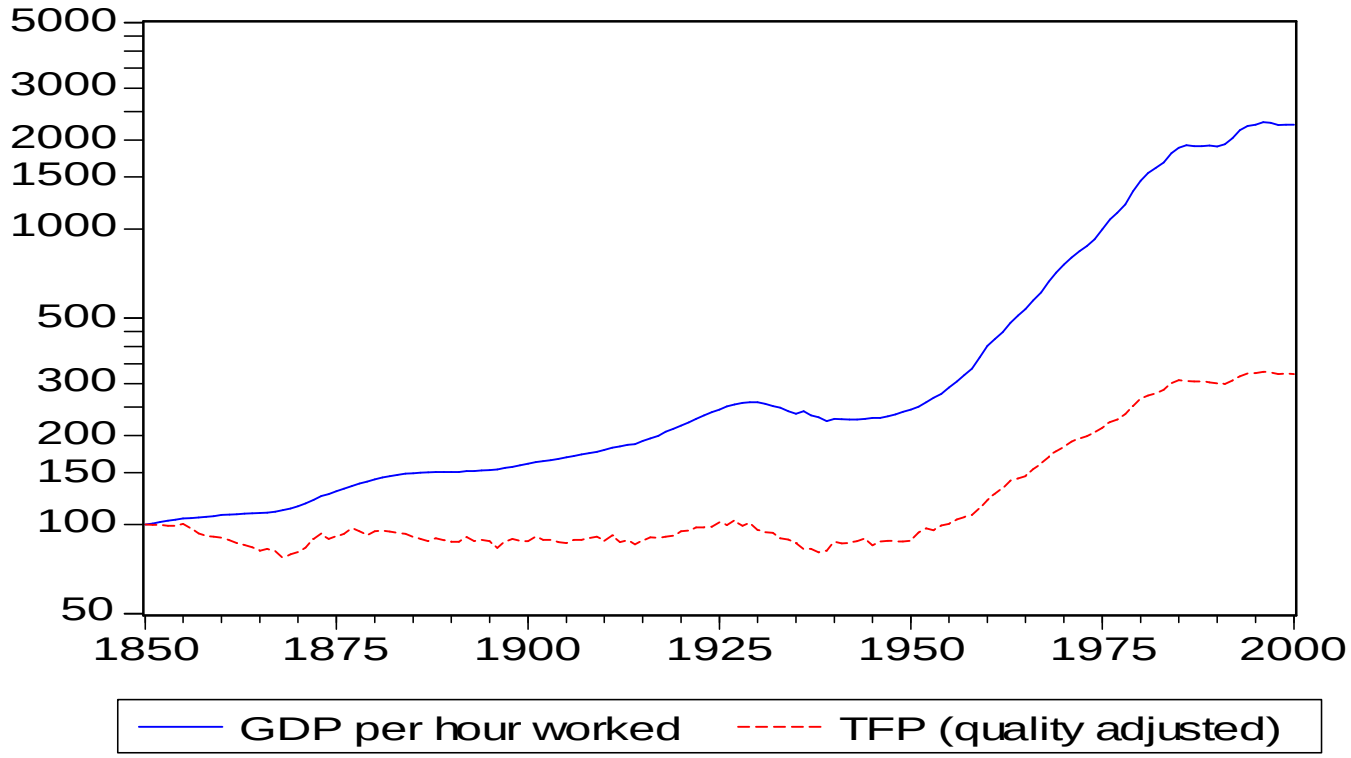


FIGURE 2
GDP PER HOUR WORKED AND TFP, 1850-2000 (1850=100) (semilog scale)

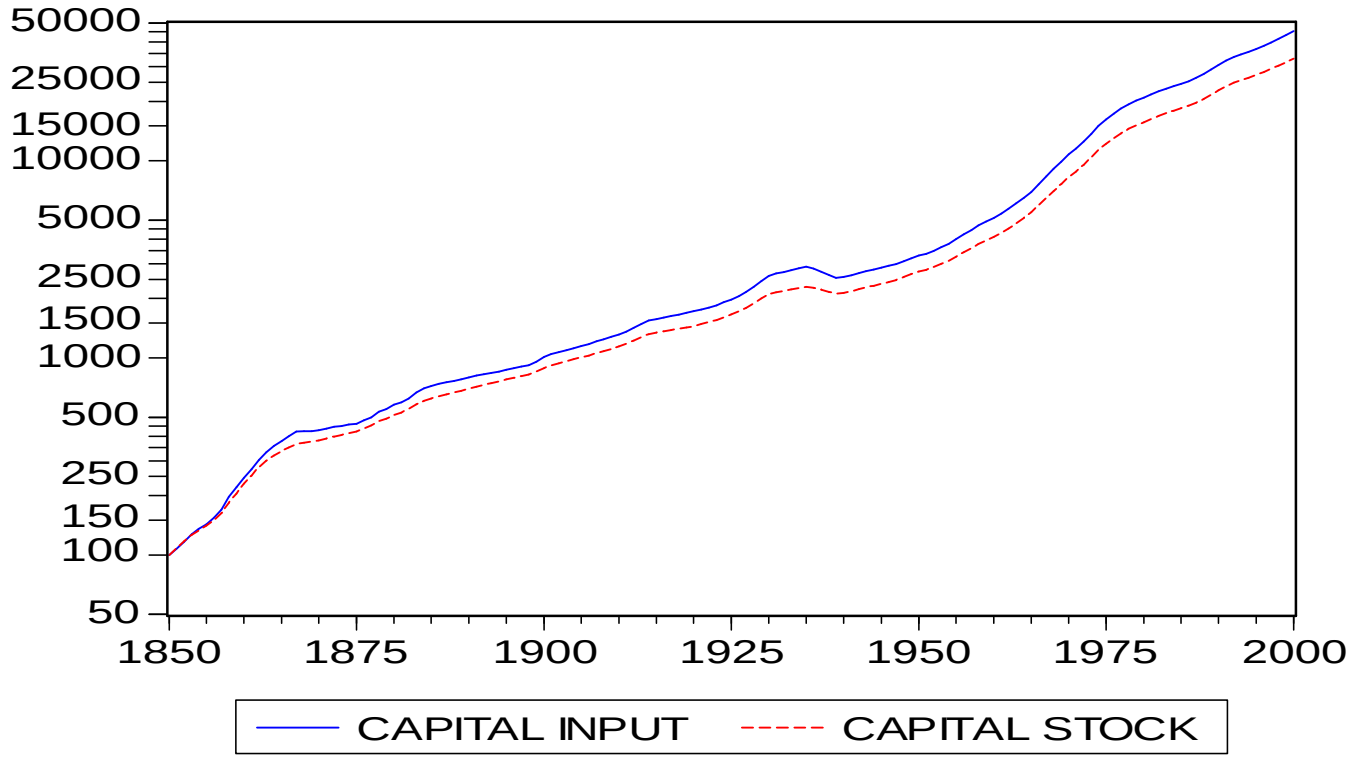


FIGURE 3
CAPITAL STOCK AND INPUT, 1850-2000 (1850 = 100) (semilog scale)

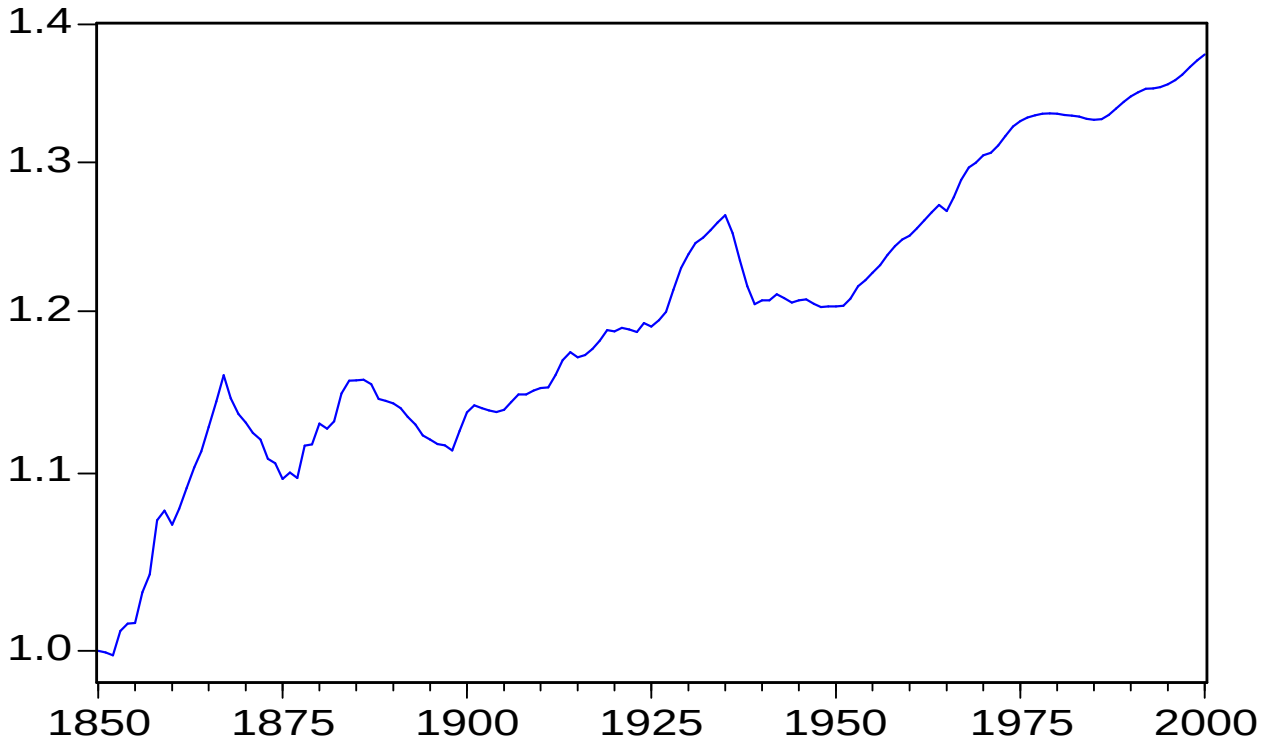


FIGURE 4
QUALITY OF CAPITAL, 1850-2000 (1850 = 1) (semilog scale)

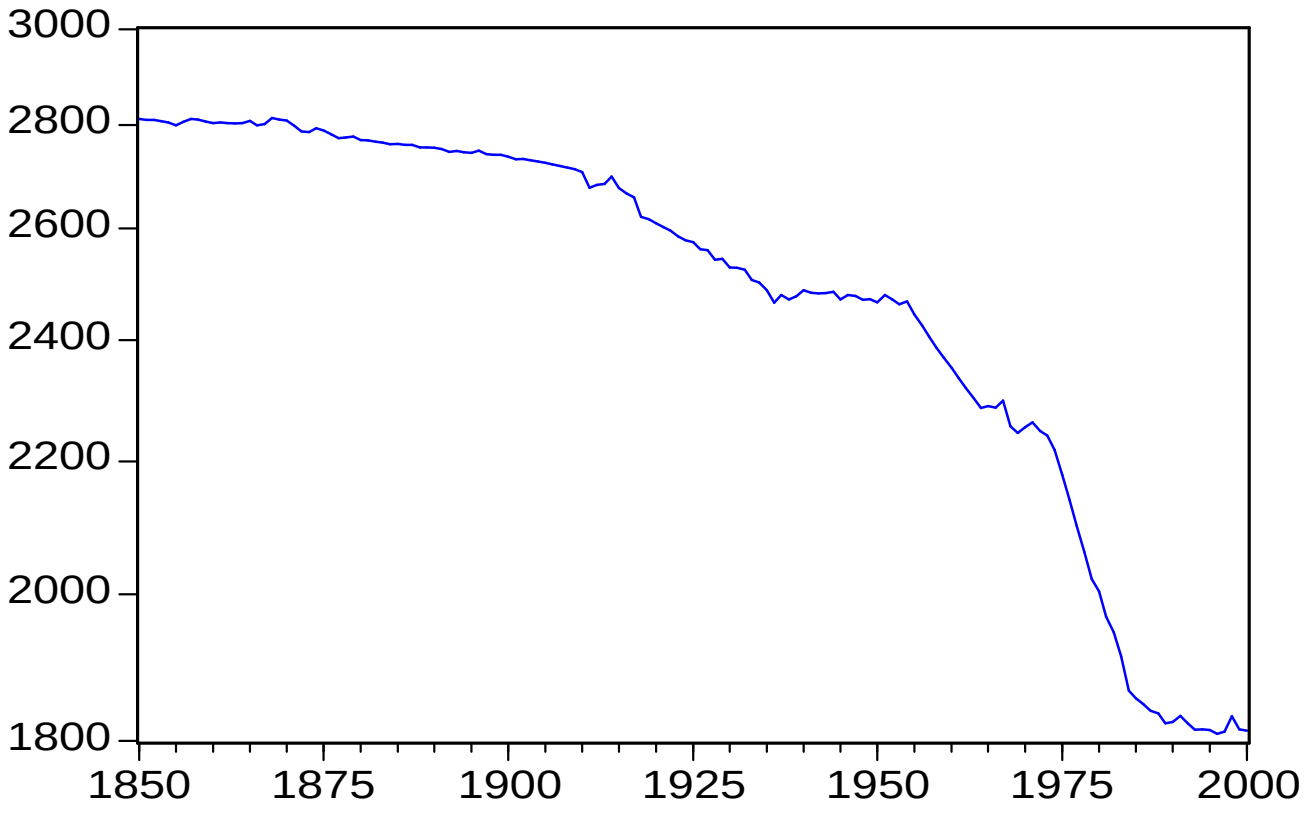


FIGURE 5
HOURS PER WORKER-YEAR, 1850-2000 (semilog scale)

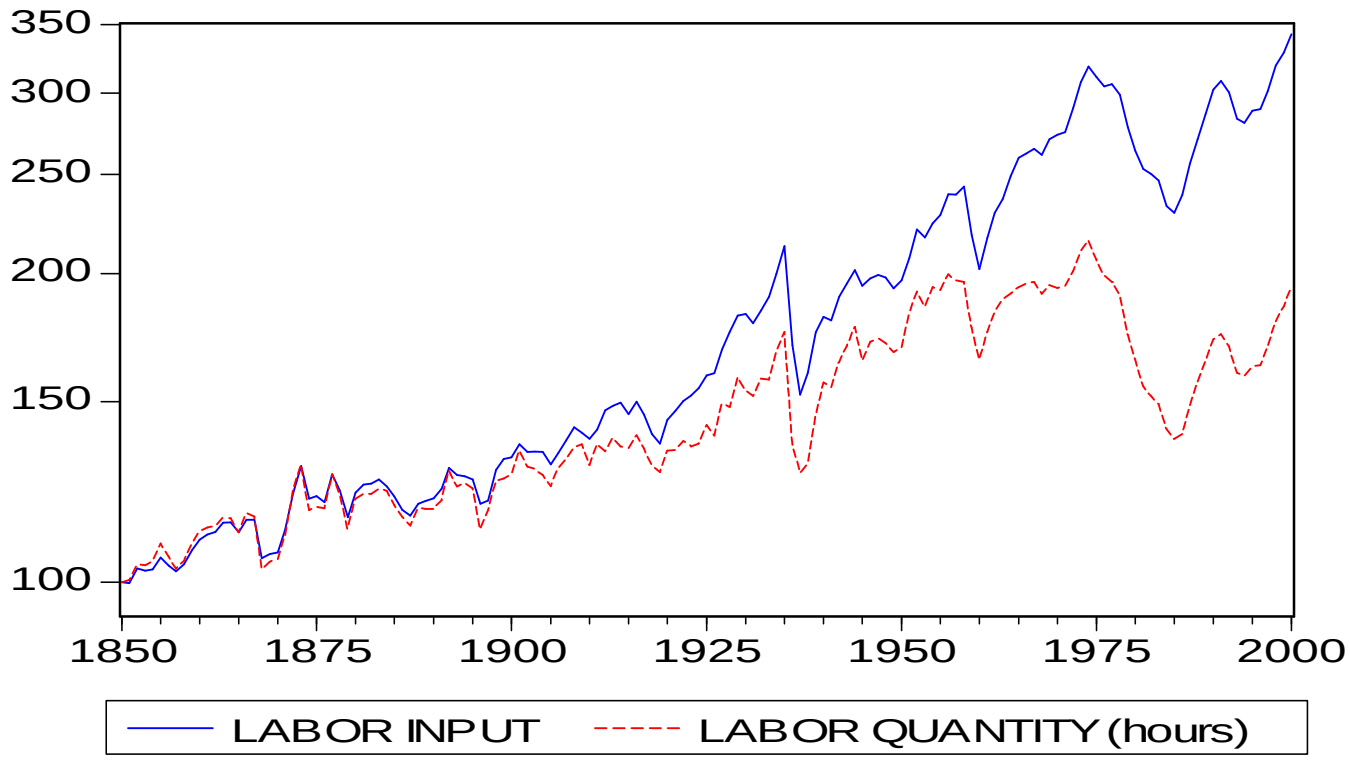


FIGURE 6
LABOR INPUT AND QUANTITY, 1850-2000 (1850=100) (semilog scale)

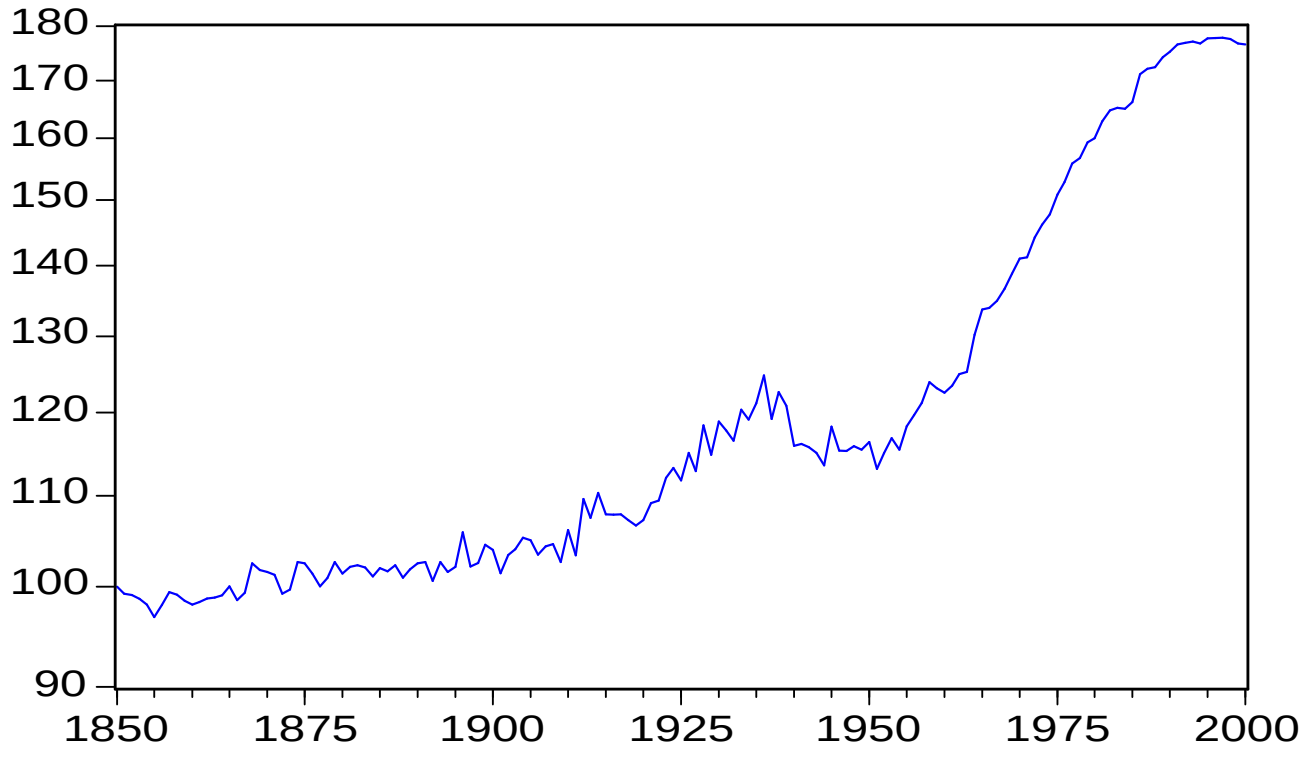


FIGURE 7
LABOR QUALITY, 1850-2000 (1850=100) (semilog scale)

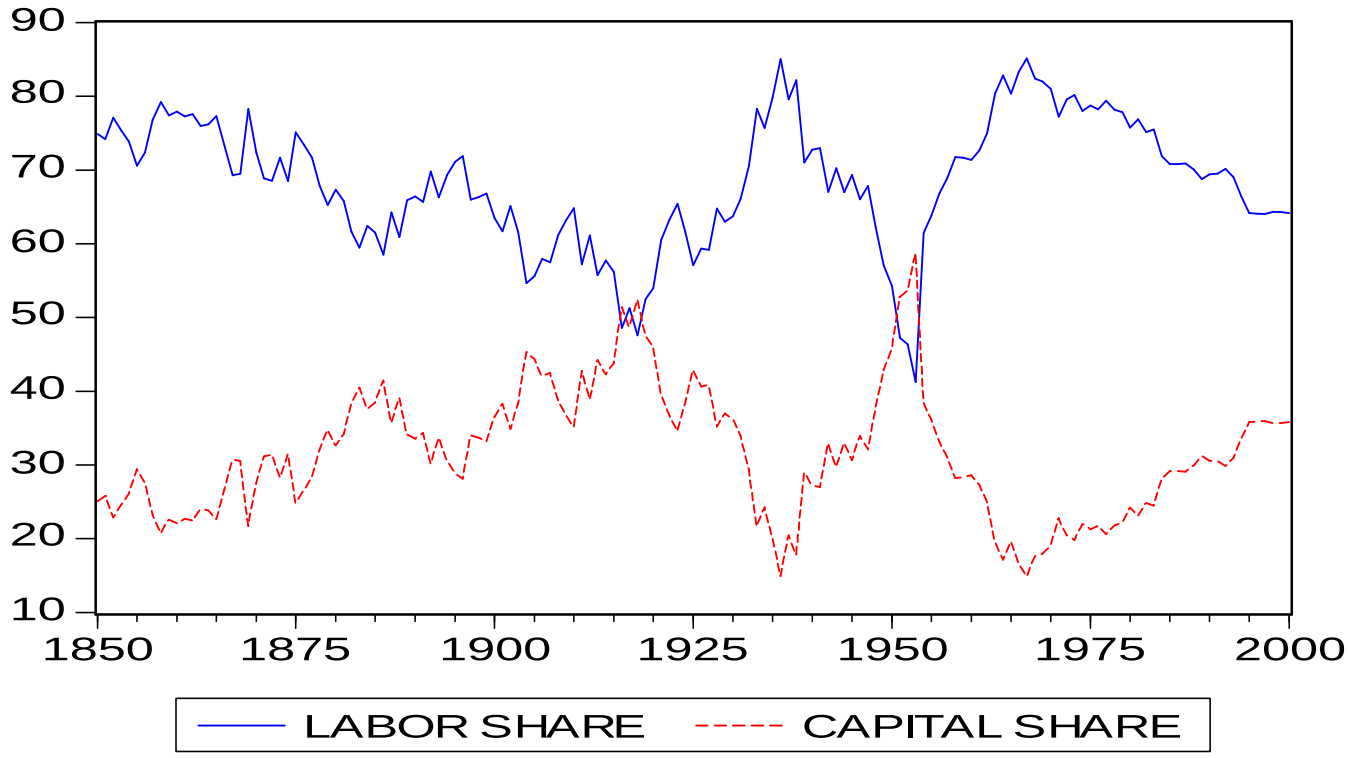


FIGURE 8
FACTOR SHARES IN GDP, 1850-2000 (%)

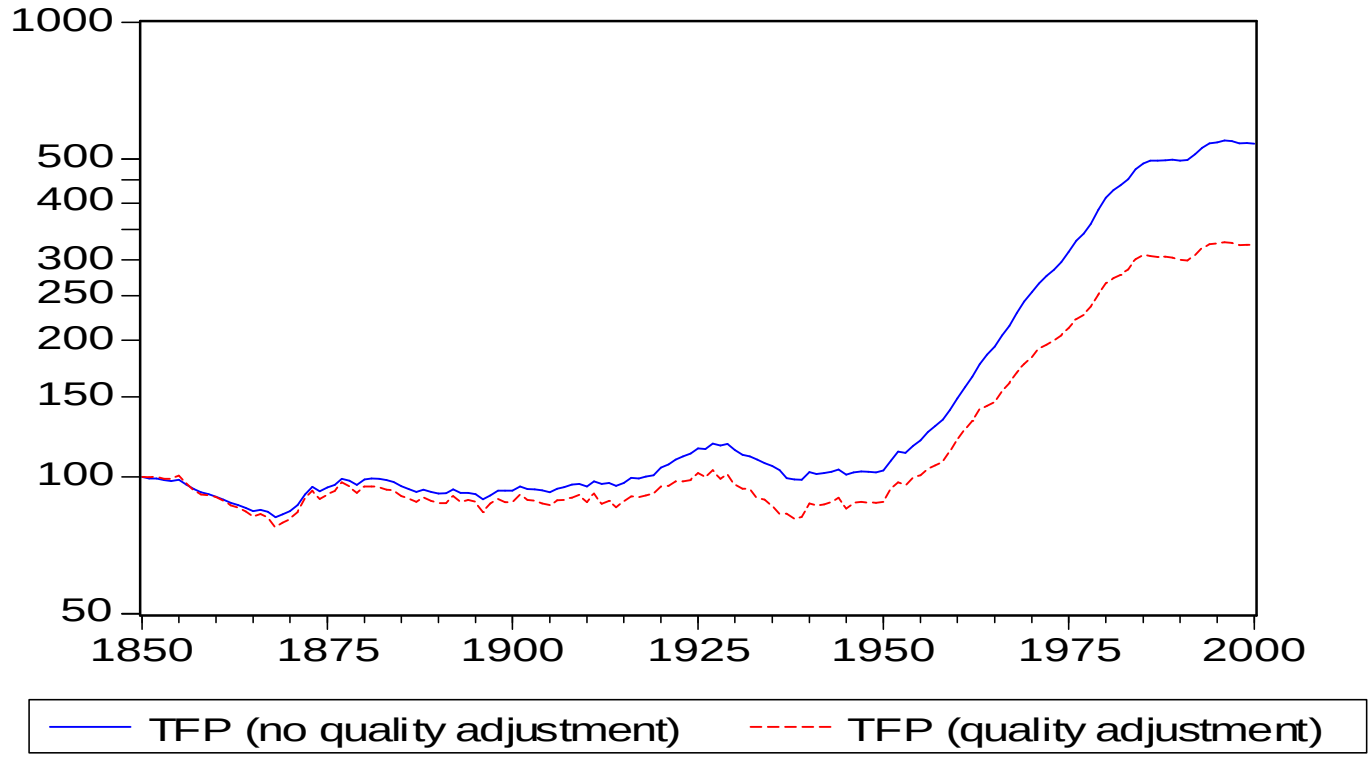
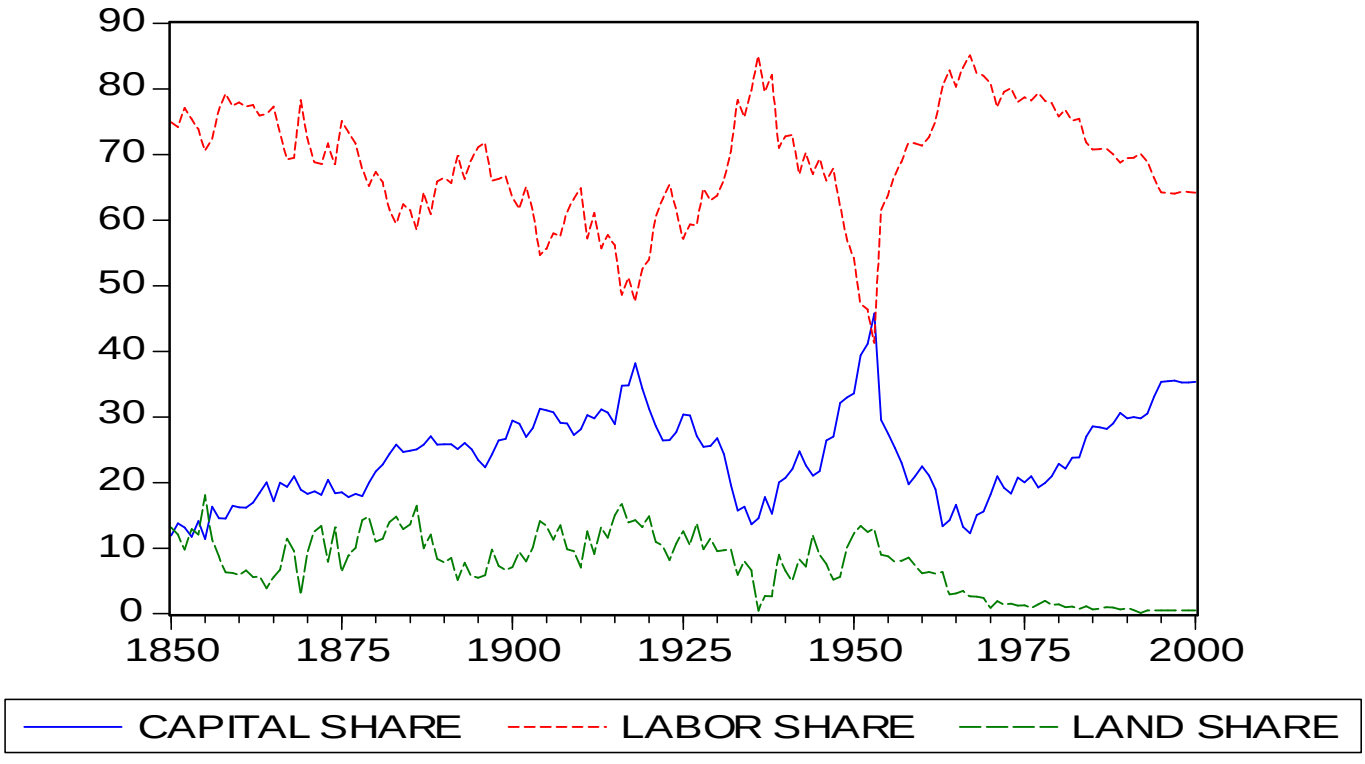
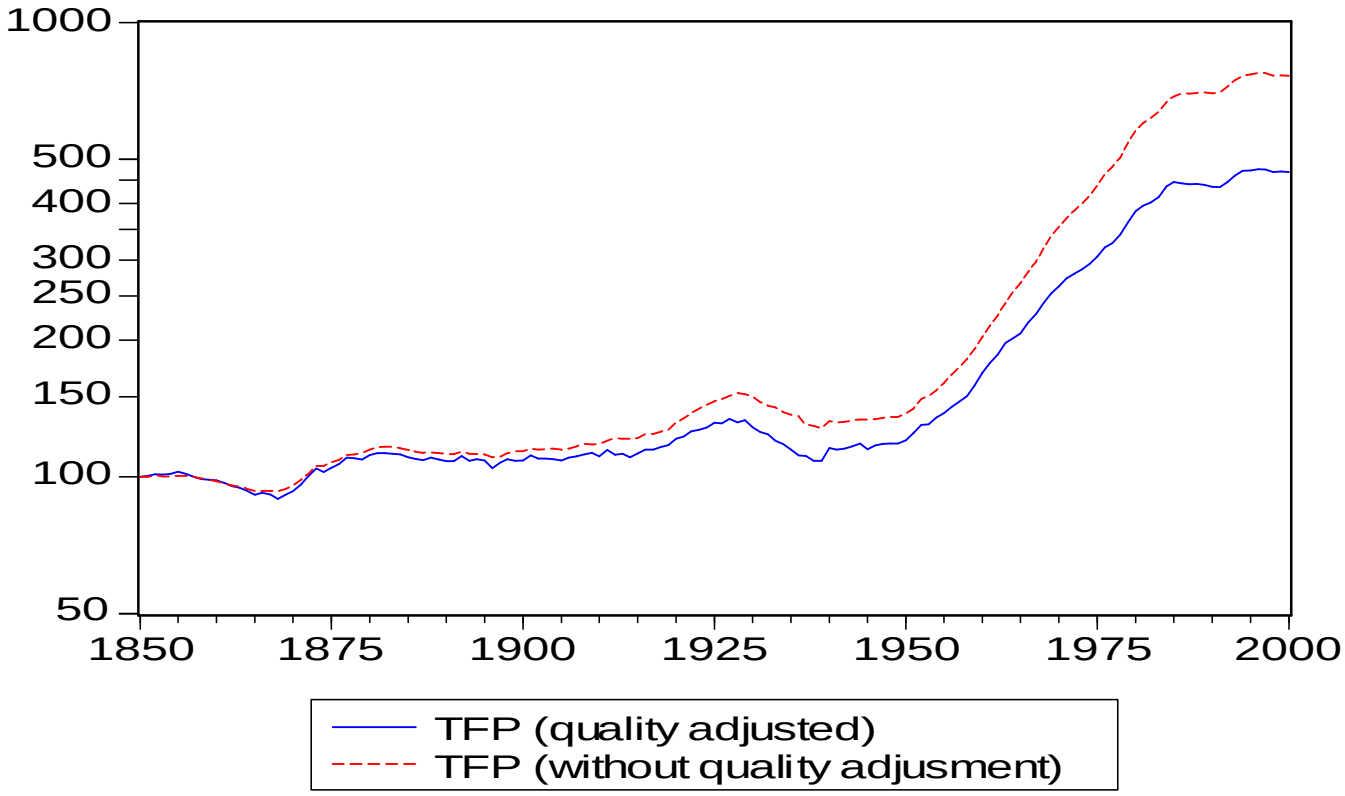


FIGURE 9
TFP ALTERNATIVE MEASURES, 1850-2000 (1850=100) (semilog scale)

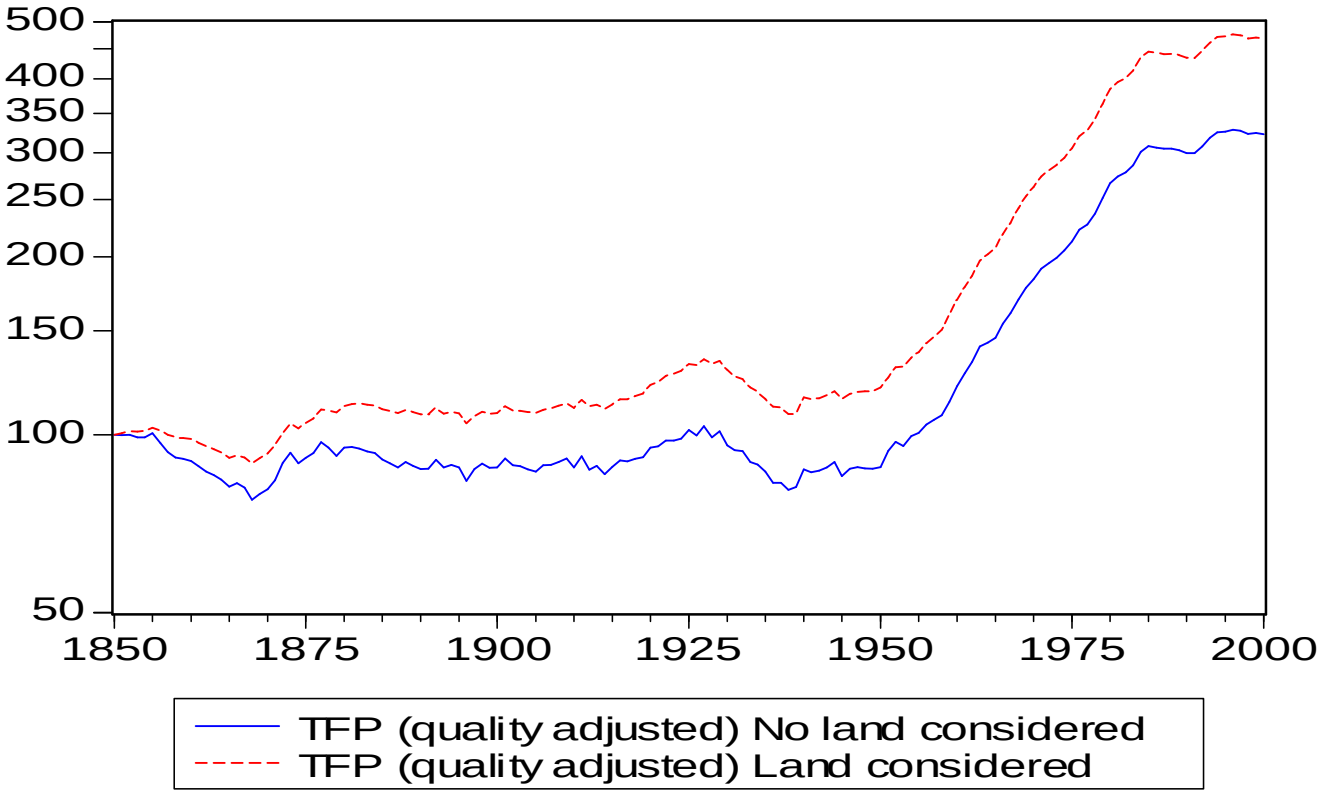
APPENDIX. FIGURE 1
ALTERNATIVE MEASURES OF LABOR INPUT, 1964-2000 (1964=100)



APPENDIX. FIGURE 2
FACTOR SHARES IN GDP, 1850-2000 (%)



APPENDIX. FIGURE 3
TFP ALTERNATIVE MEASURES, 1850-2000 (1850=100) (semilog scale)



APPENDIX. FIGURE 4
QUALITY ADJUSTED TFP WITH AND WITHOUT LAND FACTOR, 1850-2000 (1850=100)
(semilog scale)