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JEL Classification: E22, O16; N13; N14.

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Long-run Estimates of Physical Capital in Spain, 1850-2000 [1]

Abstract

In this paper, new series of Spain's capital stock and input are constructed for the last one-and-a-half centuries. Capital stock and input grew at average rates of 3.5 and 3.7 percent per year but not at a steady pace since rates accelerated dramatically during the 'Golden Age'. Two major structural changes accompanied this process. Composition of capital stock and remuneration changed gradually as the contribution of productive capital rose while that of structures declined. Spanish economy experienced capital deepening in the long-run. Although the capital-output ratio increased over time, in phases of accelerated growth the productivity of capital rose.

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This paper presents, for the first time, capital stock and input series for Spain from 1850 to 2000. In Section 1 we present the methods and data sources used to derive the new series of capital stock and input, while in Section 2 sensitivity tests for alternative methods to computing capital stock are provided including a comparison between our new estimates and earlier ones. Historical trends in capital stock and input are offered in Section 3. Finally, in Section 4, capital deepening and productivity in Spain are discussed in international perspective.

Methods and data sources

Our approach to measuring physical capital accumulation in Spain follows the method developed by Jorgenson (1989, 1990) and Hulten (1990) and, hence, our measure, capital input, is not necessarily identical to the one usually employed in national accounting.[2] Conventionally the stock of capital is defined 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 equipment).[3] The input of capital results, then, from the combination of the capital stock, and its service, which is the capital remuneration (property compensation) in production outlay.[4]

a) Capital stock

[2] OECD (1993). For applications of the Jorgenson/Hulten approach, cf. Christensen, Cummings, and Jorgenson (1980), Jorgenson, Gollop and Fraumeni (1987), Elías (1990), Young (1995) and, for the case of Spain, Myro (1983) and Cebrián (2001)

[3] Consequently, intangible goods (like licenses, patents and property rights), non-reproducible goods (like monuments, pieces of art and natural resources), consumer durables, military goods, inventories and intermediate products are not part of our capital stock measure.

[4] Major advantages of this method are that follows the concept of aggregate production function and, hence, is consistent with general equilibrium conditions and adjusts to changes in the composition or 'quality' of capital (defined as the ratio between capital input and stock) as we weight each of the capital input components by its marginal product. See Hulten (1992).

National accounts document flows of new capital to be added to actual stock in the year (I_t), but do not record the actual amount of capital stock in use (C_t). Since capital stocks result from the accumulation of investment flows, social accountants developed the Perpetual Inventory Method (PIM) to infer capital stock from past years additions of capital assets.[5]

Thus, the stock of capital, C_t, evolves according to the value, at constant prices, of the new investments during that year and depreciation and reposition rates.

(1) $$C_t = (1 - \delta t)\, C_{t-1} + I_t$$

Where the capital stock C in the year t equals the amount of existent capital at the year t-1 multiplied by 1 minus depreciation rate (δ) at the year t, plus gross fixed capital formation, I at the year t.

The use of the PIM method to computing capital stock series requires: (a) historical series of Gross Fixed Capital Formation (GFCF) by type of assets, at constant prices; (b) an initial benchmark for the stock of capital; and (c) the efficiency of each vintage of capital.

(a) Disaggregated volume and price series of GFCF by asset type (residential buildings; other constructions; transport equipment; and machinery and equipment) from 1850 to 2000 are available (Prados de la Escosura 2003).

b) However, there is no capital stock (C_0) for each type of asset j at the initial year 1850. In order to derive the initial stock we require information on investment levels and growth rates for the previous years, as well as depreciation rates.[6] More specifically, if investment at the year t is defined as:

[5] More specifically, the PIM approach produces an estimate of the stock of fixed assets in existence by estimating how many fixed assets installed have survived to the current period. Cf. Diewert (1980), Jorgenson (1973, 1980), and Hulten (1990)

[6] Alternative procedures to derive the initial level of capital stock include: the direct computation from the cumulative investment during the past years, surveys or censuses on the capital stock for a given year, and retrospective calculations as the one proposed by Feinstein (1972: 196-8).

(2) $$I_t = (\delta + r)\, C_{t-1}$$

Where δ is depreciation rate, r is the rate of variation for net investment, and C_{t-1} is capital stock in the previous year. Thus, solving for capital stock, the following expression is obtained:

(3) $$C_{t-1} = I_t / (\delta + r)$$

In order to compute C for the year 1849, investment levels (I_t) for 1850, depreciation rates (δ) for each asset type (see Table 2) are available, while the yearly rates of variation for capital stock (r) could be proxied by the average growth rate of GFCF in the 1850s.[7]

A caveat is necessary though. It seems plausible enough that the growth of investment was significantly slower in the early nineteenth century than in the 1850s (the decade in which railways construction started in Spain) and that, consequently, by following this procedure we may bias downwards the initial level of the stock of capital. As an alternative, we have arbitrarily assumed an initial capital stock twice as high the one derived with expression (3) (see next section for a sensitivity test).

We have also taken into account the destruction of capital assets as a consequence of the Spanish Civil War (1936-39). Capital series derived through the PIM method capture the decline in their level over 1935-40 for some assets. This is the case, for example, of machinery and equipment, merchant shipping, buildings, railways, and roads. Unfortunately, no exhaustive census on war destruction exists and, for this reason, we had to resort to many individual studies for the rest of them.[8] We started from the available estimates of destruction for specific assets that

[7] Following Young (1995: 651-2), we assumed that, for each type of asset, investment growth in the earlier years for which information is available (that is, the 1850s) are representative of investment growth rates in the pre-1850 period. Thus, we used the investment growth rates over 1850/54-1855/59 in our calculations. Baigès et al. (1987) also employed this approach.

[8] We tried to follow as closely as possible assessments of war destruction by Ros Hombravella et al. (1973), Barciela (1986) and, especially, Catalan (1995), together with specific estimates from a wide variety of sector studies. Thus, López Carrillo (1998), Appendix. 3, provides estimates of the

have been distributed at an annual cumulative rate over 1936-39.[9] The total war destruction was equivalent to 7 percent of the capital stock and to one-fourth of the productive capital (that is total capital excluding dwellings) in the 1935, because destruction was disproportionately concentrated in transport equipment (40 percent) and to lesser extent in machinery and equipment (13 percent), as opposed to buildings and infrastructures that escaped relatively unscathed (with 4 and 6 percent losses). Thus, the Civil War had a deeper impact on capital input, that is, the service provide to production by the stock of capital, than on the capital stock itself. Interestingly, the destruction of capital in Spain during the Civil War would be on the lower bound of World War II destruction: comparable to that of France (8 percent) but much lower than in Germany (16 percent) or Japan (26 percent) (Maddison 1991: 284-92).

c) Information on capital efficiency has rarely been observed and, hence, social accountants have resorted to indirect methods to infer the efficiency of capital units (Hulten 1990). A widely employed procedure is assuming that all efficiency patterns (Φ) follow a pattern determined by the observable lives (T) of capital goods. Among different Φ, the simplest one

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reduction in motor vehicles between 1935 an 1940. Railways' rolling stock destroyed can be deduced from Gómez Mendoza (1989) figures weighted by the prices of each type of asset. Muñoz Rubio (1995) presents estimates of structures and rolling stock of the two main railways companies, Norte and MZA. Nelson Álvarez kindly provided us with figures that allowed us to estimate the destruction of telephone networks (equipment and structures). Moreover, available data on installed electric power (Carreras 1989) and the number of urban dwellings (Tafunell 1989) allowed us to complete our crude assessment of capital destruction during the Civil War.

[9] An earlier attempt to estimate the destruction of capital stock during the Civil War was carried out by Cubel and Palafox (1997) who distributed linearly the destroyed assets during the war years to keep consistency with the arithmetic rate of depreciation they used to compute capital stock.

assumes that capital goods maintained their efficiency levels constant across their lives. The problem would, then, be reduced to estimate the useful lives of capital assets (T).

The useful lives assumed for each type of asset derive from available information for Spain, the United States and Britain (Table 1), are in line with those used in major historical works such as Feinstein (1972, 1988), and tend to be on the conservative (high) side when compared with available studies for the late twentieth century. In the case of 'productive' capital (namely, non-residential structures, equipment and machinery), as assets lives tend to shorten as one gets closer to the present[10], different service lives have been attributed to assets during three distinctive epochs (1850-1919, 1920-1959, and 1960-2000. In the years 1920-59, that included the interwar and the autarchic periods, the renewal of old capital vintages was hampered by restrictions to international trade and factor mobility, and war, and this helps to explain why useful lives were longer than from 1960 onwards, when the growing integration of Spain into the international economy justifies the assumed reduction in the service lives of assets.

[Table 1]

We have employed the so called modified geometric depreciation rates.[11] The depreciation rate (δ) is defined as $\delta = X/T$, where X is a parameter (*declining balance*) and T is the life of each type of asset. The parameter X is, according to Hulten and Wykoff (1981), 1.65 for machinery and

[10] Cf. Feinstein (1988), Blades (1993), and O'Mahony (1996: 173). Only in the case of buildings we have assumed a fixed useful life over the entire period considered.

[11] 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. Cf. Jorgenson (1990). See a comparison between alternative capital stock estimates derived by using arithmetic ($X = 1$) and modified geometric depreciation in Section 2 below.

equipment and 0.91 for buildings and structures.[12] Using the service lives presented in Table 1 we derived the depreciation rates to be used in our calculations, by asset type and period (Table 2).

[Table 2]

b) Capital input

The input of capital can be defined as the flow of services provided by the stock of capital to production. Thus, at year *t*, the capital input, *K*, is proportional to the stock of capital, *C*, at the end of the period *t*-1:

(4) $$K_t = \lambda \cdot C_{t-1},$$

Where a proportionality constant (λ) transforms capital stock into capital services.

Thus, in addition to the stock of capital, we need estimates of the rental price of capital (or price of capital services) and of total returns to capital (or value of capital services) in order to construct a single index of capital input by weighting the quantity of each asset with its share in total returns to capital.

Assuming that old a nd new vintages of capital are perfect substitutes (Jorgenson 1990), the rental price of capital (p_k) in year *(t)*, can be estimated, following Hall and Jorgenson (1967), as:

(5) $$p_k(t) = p_i(t-1)r(t) + \delta\, p_i(t) - [\, p_i(t) - p_i(t-1)]$$

Where p_i is the investment price of the capital good *i*, *r* is the nominal rate of return, and δ_i is the depreciation rate for the capital good *i*. The rental price of capital is, thus, the sum of the

[12] The values of the parameter were derived from a careful econometric exercise in which a large data base was used. Accepting the *X* parameter's values from Hulten and Wykoff (1981) for historical purposes is, nonetheless, arbitrary. It is worth noting that these parameters have been widely employed in empirical studies as they correspond to the technological frontier to which countries tend to converge. In his pioneer contribution, Myro (1983) employed also a modified geometric depreciation rate but assumed *X* = 1.5.

return per unit of capital, $p_i(t-1)r(t)$, the depreciation, $\delta\, p_i(t)$, and the negative of revaluation, $[\, p_i(t) - p_i(t-1)]$ (Jorgenson (1989: 10).

We have already established the depreciation rates[13] and the acquisition price of capital, but we do not know the rates of return (*r*). There are two alternative methods to impute the nominal rate of return. 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 property.[14] In order to maintain the consistency with our previous assumptions we have used the competitive rate of return.

We have approximated the competitive rate of return with the long-run interest rate. The internal rate of return of private liabilities (from the MOISSES and BDMORES databases (Dabán et al. 1998)), was used as a proxy for the long-term interest rate since 1954; the corporate rate of return was employed for 1880-1954 (Tafunell 2001); and, finally, the net rate of return on domestic public debt for 1857-1880 (Tafunell 1989), was projected backwards to 1850 with the interest rate of Banco de Barcelona (Tortella 1973).

Total returns to capital are, then, obtained, as the product of the rental price of capital by the quantity of capital stock, and are equal to capital property compensation. This way we can

[13] We have derived the aggregate depreciation rate weighting the specific rates of depreciation for each asset class by the corresponding amount of capital. The deflators of GFCF for each category of capital goods, conveniently de-trended with the Hodrick-Prescott filter, provide the remaining information.

[14] Under the assumption that rates-of-return are identical across all types of capital investment, *r* could be directly computed employing the same equation (5) given that the aggregate rental of capital goods is equivalent to property compensation; that is, the remuneration of capital in aggregate value added. Observable differences between the actual nominal rate of return, computed with property compensation, and competitive nominal rates of return, measured with long-run interest rates, provide a direct measure of monopolistic rents gained by proprietors.

derive the share of each type of asset in the total returns to capital that will be used as weights in the computation of the capital input index. It can be observed that a capital good with a higher amortization rate receives a larger weight in the index of capital input (machinery is, for example, allocated a higher weight than dwellings) than in the capital stock (compare Figures 5 and 7). The implication is that changes in the composition of the stock from long duration (and low rate of return) to short duration (and high rate of return) capital goods represent an increase in the quality of capital.

The final step is to construct a capital input index by combining the quantity of each asset with its share in total returns to capital. To construct yearly indices, we expressed capital input at year t (K_t), as a translogarithmic function of its four components (residential and non-residential structures, transport equipment, and machinery and equipment)). The corresponding translogarithmic capital input index, under the assumption of constant returns to scale, is:

$$(6) \qquad K = \exp\left[\begin{array}{l} \alpha_1^K \ln K_1 + \alpha_2^K \ln K_2 + ... + \alpha_n^K \ln K_n \\ + \frac{1}{2}\beta_{11}^K (\ln K_1)^2 + \beta_{12}^K (\ln K_1)(\ln K_2) + ... + \frac{1}{2}\beta_{nn}^K (\ln K_n)^2. \end{array}\right]$$

If we take log-first-differences in expression (7), we get the growth of aggregate capital input as a weighted average of its components' growth rates:

$$(7a) \qquad \ln\left(\frac{K(T)}{K(T-1)}\right) = \sum_i \overline{\theta}_{K_i} \ln\left(\frac{K(T)}{K(T-1)}\right),$$

and

$$(7b) \qquad \overline{\theta}_i = \frac{1}{2}\left[\theta_i(T) + \theta_i(T-1)\right].$$

Where θi denotes the elasticity of aggregate capital input with respect to each asset type and, under the assumption of perfect competition, equals the remuneration of each type of asset in GDP (property compensation). These series, expressed in first differences, can be converted into a yearly index by taking its exponential.

The ratio between the capital input and the capital stock provides a measure of capital's composition changes, or 'quality' of capital. The idea that technological change embodied in

capital is captured by increases in the 'quality' of capital lacks consensus and has been often rejected.[15]

Sensitivity tests

How robust are the new capital estimates to alternative computation methods? In particular, are they sensitive to alternative initial capital values, price indices, and depreciation rates?

Firstly, we tested the robustness of the capital stock series to alternative assumptions about the initial level of capital stock. Thus, following Young (1995), we assumed that the capital stock in 1850 was, alternatively, the one resulting from expression (3), double of such a level (the one we favour), and zero. We found that the effects derived from choosing these alternative initial capital levels fade away over time and the resulting series converge by 1890 (Figure 1). Thus, over the years 1850-83, the growth rate of capital stock would have been 5.3 percent assuming that its initial level (1850) was the one derived from expression (3), while with our favoured estimate, that is, assuming twice as much this initial level, the rate of growth becomes 3.6 percent. In the following long swing (1883-1920), the divergence is sharply reduced: with the alternative growth rates being 2.5 and 2.3 percent, respectively.

Since in the construction of yearly capital series through the PIM approach it is quite common to start from an independent capital stock estimate for a given year, a comparison between the capital stock estimate we obtained through the PIM method and the one resulting from *Universidad Comercial de Deusto* (UCD) (1968-1972) wealth survey for 1965, usually employed to anchor annual series of capital estimates, has been carried out in Table 3.[16] It can be

[15] Cf. Young (1995: 649) and Abramovitz and David (2001: 23). For a less sceptic view, see Hulten (1990: 134; 1992). Our historical estimates fit in the case exposed by Young (1995).

[16] The UCD capital estimate for 1965 has provided the initial benchmark for capital stock computations such as those by Myro (1983), Gómez Villegas (1988), Fundación BBV (1995), Dabán et al. (1998), and Mas, Pérez, and Uriel (2000, 2005a, 2006).

observed that the UCD estimates tend to exaggerate the size of capital stock, both for the economy as a whole, and by type of asset, with the exception of transport equipment.[17]

[Table 3]

How sensitive are capital stock estimates to the degree of de-aggregation of the GFCF series used in its construction? Since 1970 Spanish national accounts (CNE70) have distinguished four types of assets (dwellings, other construction –including non residential buildings-, transport equipment, and machinery and equipment) while previously national accounts (CNE58) allocated residential and non residential buildings to the same category. Thus, it was possible to obtain spliced homogeneous series for the four types of assets for the second half of the twentieth century employing the CNE70 criteria. Capital formation for 1850-1958 distinguishes a larger number of assets (Prados de la Escosura 2003). Therefore, a test of the robustness of the capital stock estimates to alternative degrees of de-aggregation in the underlying investment series for 1850-1958 can be developed.

An interesting result is that the average service lives for non-residential construction and for transport equipment differ between the alternative estimates as a result of assets' composition changes. Thus, the average useful lives for transport equipment rises to 36.9 and 27.9 years for 1850-1919 and 1920-59, respectively, from an average of 20 years assumed by Feinstein (1988).[18] Likewise the inclusion of non-residential buildings (for which, as for dwellings, we assume 70 years of useful life) in 'other constructions' increases average service life in non-residential

[17] Young (1995) pointed out similar situations in South Korea and Taiwan.

[18] For transport equipment we accepted Feinstein's (1988) service lives with slight modifications. Thus, Feinstein (1988) assumes 30 years for railway stock, 25 years for ships, and 10 for cars and trucks, with an average useful life of 10 to 20 years for the whole sector. In our case, we assume 40 years for railway stock up to 1919, and 30 for 1920-59, while we chose 30 and 10 for ships and cars and trucks, respectively, over the entire span 1850-1959. From 1960 onwards our choice of service lives matches the conventional estimates (see Table 1).

structures from 50 to 55.7 and 54.7 years for 1850-1919 and 1920-59, respectively. As a consequence, the resulting depreciation rates for these two kinds of assets are altered.

Although their long run trends do not differ significantly, the capital stock series constructed from more de-aggregated GFCF series cast a higher level as a consequence of the longer lives attributed to transport equipment and non-residential construction (Figure 2). In our computations we have used the service lives that result from taking into account assets' composition changes (Tables 1 and 2)

[Figure 2]

We also compared our "modified" geometric depreciation capital stock series with alternative series computed with arithmetic ($X = 1$) depreciation rates.[19] In Figure 3 and Table 4, we present series constructed with these two alternative methodologies. It can be appreciated that levels are higher in the straight-line depreciation series than in those computed with modified geometric depreciation rates. This is not an unexpected outcome given the fact that geometric-type depreciation results in a rapid decline during the early years of asset lives. Furthermore, the modified geometric depreciation series exhibit more intense growth during the phases of acceleration (the 1920s and the Golden Age, 1950-74) while the arithmetic depreciation estimates grew more intensively in phases of slower growth (with the exception of 1850-83). In the long-run, however, capital stocks derived through straight-line and modified-geometric depreciation grew at the same pace. This fact renders our estimates robust to alternative depreciation rates.

[Table 4]

[Figure 3]

[19] In the case of the arithmetic depreciation rate, gross capital stock for the period t is computed as: $GK_t = GK_{t-1} + I_t - R_t$, where I_t is real gross domestic capital formation, and R_t, retirements. Net capital stock, with straight-line depreciation, can be estimated with expression (2), but the depreciation rate will be $\delta = 1/T$.

How sensitive are the results obtained to choice of the benchmark year? Usually capital stock estimates are denominated in the currency of a given year, say, in 1995 US dollars, but is this the outcome of computing capital stock with fixed set of prices from a single year (1995, in our example), or is it just a 'numeraire' to express in homogeneous units the real value of a stock derived from spliced capital series constructed at different sets of relative prices for different periods? A single weighted index provides a good measure of real capital stock as long as the relative price structure of capital assets over the time span considered does not differ significantly from the one prevalent in base year. However, because of substantial over time changes in the relative prices of capital goods —largely traceable to rapidly declining prices of machinery and equipment—price weights for, say, 1995, would only be appropriate for a short period around this year. For earlier years, the use of fixed 1995 price weights would understate the growth of capital (the so called 'Gerschenkron effect'), since the most dynamic capital goods grew faster as a consequence (at least, in part) of the more intense decline in their relative prices. Conversely, the growth of capital would be exaggerated if the prices for an early benchmark year were chosen.

[Figure 4]

Thus, we have employed prices from as many benchmarks as possible (1958, 1965, 1970, 1980, 1985 and 1995) and, for the time span between each pair of adjacent benchmark years (say, 1970-1980), we computed alternative capital stock series at the relative prices of each one (say, at both 1970 and 1980 prices) and, then, spliced the two indices into a single one using a variable-weighted geometric average, in which the weight assigned to each benchmark year's series increases the closer benchmark *t* is to each of the years considered. However, as can be seen in Figure 4, the differences between fixed- and variable-weighted series are minimal, because the underlining real GFCF series had already been obtained through splicing volume indices series computed at the relative prices of different benchmark years (Prados de la Escosura 2003).

The comparison with available estimates for the last decades provides a final test for the congruence of our results. Although no official capital statistics exist for Spain, scholars have

conducted, with disparate methods, independent investigations on the capital stock, including the construction of long-term series.[20]

[Table 5]

Differences in growth rates among different series are not significant (Table 5). Alternative historical reconstructions share similar trends with our new series. Differences are noticeably, however, and for the first half of the twentieth century, Cubel and Palafox (1997) suggest a more intense growth in the 1920s, while, in Hofman's (1993) estimates, the faster growth during the 1950s is compensated by the slower expansion after 1975. This last remark also applies to the rest of the earlier estimates. Only the rates of growth for productive capital (that is, excluding residential structures) are similar to our capital input growth since Spain's admission into the European Union (1986). We can, then, conclude that trends in capital stock (and input) are quite robust to alternative computation methods and assumptions about depreciation rates and service lives of assets.

Trends in capital stock and input

Trends in capital stock and its components are shown in Figure 5, while their average rates of growth in each of the significant phases and long swings that can be distinguished in Spain's economic performance (Prados de la Escosura 2007) are presented in Table 6. Over the last 150 years, the capital stock grew, on average, at 3.5 percent per year, which implies that capital stock doubled every 20 years. Machinery and transport equipment grew faster than the rest of capital stock components and doubled every 14.5 years, while dwellings' expansion was, instead, the

[20] It is worth highlighting, in addition to the Universidad Comercial de Deusto (1968-1972) study on the national wealth for 1965, Myro's (1983) pioneering work in which the Jorgenson approach was applied to Spain for the first time, and the research conducted by Mas, Pérez, and Uriel (2005a, 2005b) at the Instituto Valenciano de Investigaciones Económicas (IVIE) under the sponsorship of the Fundación BBVA, during the last two decades. Historical series produced by Hofman (1993), Cebrián (2001) and, especially, Cubel and Palafox (1997) are worth mentioning.

slowest one doubling only every 22 years. This implies a deep change in the composition of capital stock over the long with a steady decline in the weight of the residential capital and an increasing contribution of infrastructure and equipment (Figure 6). The relative size of dwellings shrank from two thirds to over one third and, altogether, residential and non-residential structures went down from representing nearly all of the capital stock to four-fifths by the end of the twentieth century, while machinery and transport equipment increased their share by more than six-fold over the same period.

[Figure 5]

[Table 6]

[Figure 6]

Capital stock and input did not follow a steady path as Figure 6 and Table 7 show, with a more intense expansion during the Golden Age but not returning to the pre-1950 path of growth in the last quarter of the twentieth century. Different phases can be distinguished in the evolution of capital during the first hundred years of modern economic growth in Spain: an intense expansion between the 1850s and the early 1880s, followed by a slowdown until World War I; then, growth resumed briskly during the 1920s, was cut short in the early 1930s and remained sluggish until 1950. During the second half of the twentieth century capital accumulation grew at a faster and steadier pace, with a big spurt in the years 1959-74.

[Table 7]

[Figure 7]

Changes in the composition of capital from residential structures toward productive capital increased the service provided by the capital stock to production. This reflects into a growing gap between growth rates of capital input and stock (Table 7 and Figure 7). The relative changes in the capital stock implied modifications in the structure of capital compensation (Figure 8). By 1850, capital compensation (the sum of all capital rents) accrued overwhelmingly to residential structures (87 percent) while productive capital only received 13 percent of it. One and a half

centuries later, productive capital had increased its share to nearly 30 percent. In particular, the share of machinery and equipment in capital rents trebled.

[Figure 8]

The difference between capital input and stock, that captures composition changes, is sometimes identified with improvements in the 'quality' of capital stock.[21] Interestingly, the 'quality' of capital rose in periods of faster capital growth (Table 7 and Figure 9). More specifically, three periods in which capital 'quality' grew above its long-run trend stand out: from the mid-1850s to the early 1880s, a period of opening up in which foreign capital was invested in railways construction and in mining; the 1920s and early 1930s, that witnessed another episode of capital inflow from abroad and the first phase of Spanish electrification; and the "Golden Age" (1953-1974), in which Spain completed the process of electrification and replaced the old 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. It is worth nothing that in spite of the large influx of European funds since Spanish accession to the European Union (1986), the 'quality' of capital did not rise well above the historical trend rate over 1986-2000, which could suggest a delayed impact of ICT technologies on Spain (Timmer et al. 2005).

[Figure 9]

A glance at aggregate capital and its components shows a large variance in their rates of growth over different long swings and cycles (Tables 6-7).

Institutional reforms and opening up to foreign capital and international trade favoured an expansion during the first long swing, 1850-83. Inflows of foreign capital made it possible to break the close connection between investment and savings and contributed to the economic growth (Prados de la Escosura 2008). The capital stock grew at an average of 3.6 per annum, well above the nineteenth century's average but with irregular and pronounced cycles (Table 6, Panel

[21] Alas, our historical exercise fails to capture <u>all</u> the composition -or 'quality'- changes, as we cannot carry out a deeper de-aggregation by type of asset, but hints into the direction of composition changes.

C). The strong start (1855-66) was led by the railway construction, as evidenced by the dramatic increase in transport equipment, although the expansion affected all types of capital goods. The international crisis of 1866 reduced dramatically the influx of foreign capital that fuelled railways expansion, while political turmoil (with two changes of political regime, social turmoil, coups d'état and a civil conflict, the Carlist War) made Spanish economy less attractive for local and foreign investment over 1866-73. The subsequent political stabilization that followed the restoration of the Bourbon dynasty led to a recovery of capital stock growth rates, particularly in transport equipment and machinery that grew at respectable rates closed to 6 percent per annum.

The second long swing 1883-1920, covers most of the so called *Restauración* (1875-1923), an era of institutional stability that presumably provided a favourable environment for investment and growth and yet both permanent and temporary factors worked against it. The growth of capital stock slowed down to 2.3 percent per year with regular and mild cycles. Weak urbanization, resulting from sluggish industrial growth and a delayed demographic transition, slowed down the expansion of the stock of dwellings.[22] The closing of a large section of the railways network together with the disappointing financial results for railways companies hindered a further expansion of non-residential structures (Herranz-Loncán 2007). Nonetheless, a significant expansion occurred in machinery and equipment as industrialization proceeded steadily during this period.

The Cuban War of Independence, despite the weak economic flows between the metropolis and the colony, introduced macroeconomic instability that led to a contraction in

[22] Restrictions on both internal and external competition, according to Fraile Balbín (1998) counterweighted political and social stability. Cf. Tena (1999), Palafox (1999), and Pardos (1998) on tariff protection and its effects. On the pace of industrialization and the demographic transition, see Prados de la Escosura (2003) and Pérez Moreda (1999), respectively.

foreign investment and the depreciation of the peseta since 1891 that, interestingly, had been unaffected by the abandonment of the convertibility of Spain's peseta into gold in 1883.[23]

In spite of Spanish neutrality during World War I capital stock growth rates declined by about one third and, more prominently, machinery stock growth more than halved.[24] As Sudrià (1990) emphasized, the slowdown in the replacement of older vintages, associated to an increasing utilization of the installed capacity, led to a rapid obsolescence of the machinery stock in use.

The most intense growth of the period 1850-1950 was achieved in the 1920s. In this decade, the growth rates of capital stock were the highest since the 1860s. As such an intense growth took place under the dictatorship of Primo de Rivera (1923-1929), inevitably, economists and historians have tended to assume that state intervention through external protection and regulation, on the one hand, and investments in public infrastructure, on the other hand, made a decisive contribution to capital accumulation, and, subsequently, to growth (Velarde 1968). Against this view it has been argued that a) government intervention led to resource misallocation because it did not take into account its opportunity cost (Comín 1987); b) the increasing power of oligopolies reduced incentives for technological change (Fraile Balbín 1991); and c) the expansion of public spending (through the increase in money supply and government debt) fuelled inflation and increased currency volatility (Comín and Martin Aceña 1984, Palafox 1991). The emphasis on tariff protectionism has tended to neglect, however, that a significant inflow of

[23] Cf. Prados de la Escosura (2008) on the balance of payments; and Martín Aceña (1994) and Bordo and Rockoff (1996) on the gold standard. On the consequences of Cuba's war of independence, see the discussion in Fraile and Escribano (1998) and Maluquer de Motes (1999).

[24] This result is in stark contradiction with the conventional view that stresses its stimulating aggregate effects. Cf. Roldán and García Delgado (1973) for the conventional view on the positive impact of the Great War on Spain.

foreign capital allowed the purchase of capital goods (Tena 1999, Prados de la Escosura 2008).[25] A closer look at the evidence shows that growth rates in transport equipment, stimulated by the Dictatorship's infrastructure construction policy, exceeded largely those of the rest of capital components.

The period 1929-1952 is the fourth, and last, long swing of the 1850-1950 era. The growth rate of capital stock growth rate fell to 1.6 percent per year with irregular and severe cycles. A deceleration in the capital stock growth between 1929 and 1935 was followed by stagnation during the Civil and World Wars (1935-1944) and, then, a mild recovery up to 1952.

The first half of the 1930s represents a fracture in the intense capital stock expansion of the previous decade. Our results suggest a moderate impact of the Depression in capital stock growth. This result is not surprising and is in line with previous research (Comín, 1987; Prados de la Escosura 2003). However, the effects of the crisis in Spain, although less intense than in European countries until 1932, were most persistent, at least in comparison to those nations which managed to leave the gold standard soon (Eichengreen 1992). This broad picture is complicated by the disparate evolution of capital stock components. Uncertainty about a new political system, the II Republic (1931-36), seems to have been a major cause for the decline in the growth of residential structures, which returned to those prevalent before the 1920s. As a consequence of the restrictive budgetary policy and the interruption of public works (Palafox 1991), transport equipment growth declined to very low levels although, paradoxically, this was not the case of non-residential structures which remained at levels similar to those observed in the 1920s.[26] In a sharp contrast, the increase in machinery stock exceeded that of the 1920s, suggesting that the social unrest and

[25] 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 (Sudrià 1990).

[26] An alternative view sustaining that expansionary monetary and anti-cyclical fiscal policies were tried to compensate for the fall in private investment and exports (Comín and Martín Aceña 1984, García Santos and Martín Aceña 1990) could help explaining this apparent paradox.

political turmoil did not slow down the renewal of industrial machinery, a likely outcome of the electrification process that was taking place since the early 1920s.

Hardly any growth of aggregate capital stock took place during the Civil War and the subsequent post-war years (1935-1944), a period in which the destruction of transport equipment stands out. The impact of war destruction was very uneven, as was the immediate post-war reconstruction. As observed above, while the stock of houses and structures was hardly affected by the Civil War, the stock of machinery and, especially, of transport equipment fell significantly (about one-fourth altogether). In the immediate post-war a vigorous rise in machinery and equipment contrasted with none in transport equipment. In comparative perspective, western European economies recovered faster from capital destruction during World War II than Spain did from the Civil War (Maddison 1991).

The change in trend which began in the early1950s ushered in an exceptional phase of rapid growth which lasted until 1974. Despite the fact that the volatility of import capacity rendered investment risky and tended to penalise capital accumulation, while inflows of foreign capital and new technology were restricted (Prados de la Escosura and Sanz 1996), a dramatic change in trend occurred in the 1950s. Machinery and transport equipment grew at rates above 7 percent per year while structures did it around 4 percent. It can be hypothesised that the U.S.-Spanish cooperation agreements of 1953 triggered economic agents' confidence in the viability of Franco's dictatorship leading to an increase in capital accumulation and to imports of new vintage machinery and equipment (Calvo-González 2007).

The cautious move towards deregulation and opening up initiated in the mid-1950s intensified after the 1959 stabilisation and liberalisation plan resulting in accelerated capital accumulation during Spain's Golden Age (1959-74). Capital stock growth reached peak rates (7 percent on average) and was particularly intense in the case of productive capital (that is, excluding residential structures). The adoption of mass production techniques from abroad and the diffusion of road transport appear crucial for this accelerated capital accumulation.

A change in trajectory began in the late 1970s and reached to the end of the twentieth century in which capital growth rates returned to those of the 1950s and early 1960s. It is worth noting, nonetheless, that capital expansion maintained its Golden Age's pace until 1978. This was possibly due to the fact that relative prices did not adjusted immediately to the oil shocks as the government implemented a policy of subsidies to soften the political transition from Franco's dictatorship to democracy. The severe economic adjustment introduced by Moncloa agreements (1978) led to a deceleration in capital accumulation (Prados de la Escosura and Sanz 1996). The last quarter of the twentieth century can be split into two periods with Spain's accession to the European Union as a turning point. The first one (1975-1986) was marked by the transition to democracy and the re-organization of Spanish economy as capital equipment, largely obsolete and energy-intensive, needed to be replaced. Since 1986 European funds largely contributed to the construction of new infrastructures and the renewal of public transport equipment.

Capital deepening and productivity

How does the long-term rise in the stock and input of capital fit into the wider context of Spain's economic performance? A possible way to do it is by looking at capital intensity, which relates the amount of capital to other factors of production, especially labour. Since the use of capital makes labour more effective, rising capital intensity (or "capital deepening") pushes up the productivity of labour.

In Spain, a process of capital deepening took place over the period 1850-2000 (Table 8): the endowment of capital (stock and input) per hour worked, multiplied by 102 and 140, respectively, while the rates of the second half of the twentieth century practically doubled those prevailing in the previous hundred years. Also noticeable are the significant differences appeared between these two measures of capital intensity.

[Table 8]

[Figure 10]

Another measure of capital intensity: the capital to output ratio multiplied by 4.5 and 6.2 for the stock and input, respectively. Interestingly, and contrary to Kaldor's (1961: 178) stylised

fact, the capital-output ratio did not remain stable over the long run in Spain.[27] Different phases can be described in its evolution (Figure 10). The capital-output ratio grew significantly over the first hundred years considered (1850-1950) -with the exception of the 1920s- and, again, during the last a quarter of the twentieth century but decreased during the "Golden Age" (1950-1974), just at the time the growth of GDP was fastest. This exceptional situation in which the productivity of capital (that is, the inverse of the capital-output ratio) increased suggests a significant contribution of total factor productivity to Spanish economic growth over these years.

Spanish experience can be better assessed in international perspective. For different world regions in the late twentieth century Table 9 compares growth rates for capital deepening and capital productivity. In Panels A and B, our measures are constructed with inputs of capital and labour, that is, the service provided to production by these two factors, while in Panel C stocks are employed. The time spans considered are determined by the availability of international evidence, not matching, thus, our favoured periodization.

Some results emerge from the comparison. In the context of OECD countries during the Golden Age (1950-73) capital deepening does not appear to have increased particularly fast in Spain: although she was in its upper growth segment during the 1950s, fell behind in the 1960s and early 1970s, only remaining above North America. The productivity of capital increased mildly in Spain, at much slower pace in the 1950s than in countries that suffered World War II more profoundly. This raises the issue of Sapin's sluggish recovery after the Civil War (1936-39). For example, why starting from a lower level of capital did its productivity grow so slowly? Did it result from a low human capital endowment or from resource misallocation in an over-regulated autarchic economy? Conversely, during the years 1960-73 and after a cautious liberalisation and opening up capital productivity grew in Spain while declined in Western Europe and Japan.

Panel B shows some interesting similarities between the East Asian 'tigers' and Spain in the late twentieth century. In all of them, intense capital deepening went along with a significant

[27] Maddison (1995) already observed the variance of the ratio of capital stock to GDP.

decline in the productivity of capital. Finally, since 1960 Spain seems to be close to the top world regions in capital intensity and also in terms of capital productivity decline.

Finally, a long-run perspective is provided in Table 10 in which trends in capital deepening and productivity for Spain are compared to those in the United Kingdom and the United States. At first glance it seems that, in the three countries, a growth rate of the capital-labour ratio above 2 percent per year brings with it a decline in the productivity of capital.

A look at different phases or long swings suggests that capital intensity increased faster in late nineteenth and early twentieth century in Spain than in both the U.K. and the U.S. and, correspondingly, the efficiency in the use of capital fell more acutely. In the 1920s, Spain performed similarly to the U.S. (Panel B), with significant capital productivity gains while its intensification kept growing. Electrification has been suggested as a major element underlying capital productivity growth in the U.S. (David and Wright 1999) that, according to Field (2006), concentrated in manufacturing. A similar hypothesis can be entertained for the case of Spain, where the process of electrification, interrupted during the Civil War and its autarchic aftermath, was completed in the 1950s, also underlies capital productivity growth (Betrán 2000, Sanchis 2006). Moreover, during the 1950s the introduction of new capital vintages under the umbrella of the US-Spanish cooperation agreements, that stimulated investment and the acquisition of foreign technology (Calvo-González 2007), also contributed to capital efficiency. New capital and organizational improvements, together with increases in utilization rates, provided capital efficiency gains during the 1960s and early 1970s. Nonetheless, once the Golden Age was over, accelerated capital deepening was met again by declining capital efficiency in Spain.

Concluding Remarks

Our main results can be summarized as follows. First, our measurement of capital stock in the long-run yields only a range of best guess estimates. However, our sensitivity tests indicate that differences in alternative capital stock estimates are fairly small and do not change the overall picture. Capital stock estimation appears, then, much less problematic, and less sensitive to underlining assumptions, than it is commonly believed. Second, we point out that capital input

adjustments generate a slightly faster growth rates but do not change significantly long-run performance of capital. Third, Spanish capital stock grew over the entire period (1850-2000) but not at steady rates. Finally, Spain experienced a process of capital deepening and rising capital-output ratios, although in phases of acceleration (the 1920s and the Golden Age) efficiency gains in capital are found.

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Table 1
Assets Lives Estimates

		Dwellings	Non-residential structures	Transport Equipment	Machinery & Equipment
Myro (1983)	1965-1981	50	36	10	15
Hofman (1993)	1950-1992	50	40	15	15
IVIE (1995, 2002)	1964-2000	50		10	15
Cubel and Palafox (1997)	1901-1958	50	50	25	25
MOISSES (1996)	1954-1995	30	20	10	10
Jorgenson (1989) (U.S.)		70	40		
Feinstein (1988) (U.K.)	1850-1920	100	80	10-20	25-40
Prados de la Escosura & Rosés	1850-1919	70	55.7	36.9	30
	1920-1959	70	54.7	27.9	20
	1960-2000	70	40	15	15

Table 2
Depreciation Rates

	1850-1919	1920-1959	1960-2000
Dwellings	0.0130	0.0130	0.0130
Other Constructions	0.0163	0.0166	0.0228
Transport equipment	0.0447	0.0591	0.1100
Machinery and equipment	0.0550	0.0825	0.1100

Sources: See text

Table 3
Perpetual Inventory Method *versus* Direct Estimation
(000 million of 1966 PTA.)

	Prados de la Escosura & Rosés PIM	Universidad Comercial de Deusto (UCD)	Ratio (PIM/UCD)
Dwellings	994.1	1166.0	0.85
Other Constructions	961.8	1235.7	0.78
Transport Equipment	201.6	194.3	1.04
Machinery and Equipment	578.9	633.3	0.91
Capital Stock	2736.6	3229.3	0.85

Sources: PIM, see text; Universidad Comercial de Deusto (1968) derived by Myro (1983), Table 2.3.

Table 4
Alternative Capital Stock Measures, 1850-2000

	Modified Geometric Depreciation	Linear Depreciation (Gross stock)	Linear Depreciation (Net stock)
1850-2000	3.5	3.6	3.5
Long Periods			
1850-1950	2.7	2.8	2.8
1951-1974	6.0	5.4	5.4
1975-2000	4.5	4.6	4.6
Long Swings			
1850-1883	3.6	4.3	4.3
1884-1920	2.3	2.4	2.4
1921-1929	3.5	2.7	2.7
1930-1952	1.6	1.3	1.3
1953-1958	4.5	3.7	3.7
1959-1974	7.0	6.5	6.4
1975-1986	4.5	5.0	4.9
1987-2000	4.6	4.3	4.3
Cycles			
1855-1866	5.4	5.9	5.9
1867-1873	1.6	2.8	2.8
1874-1883	3.0	3.3	3.3
1884-1892	2.2	2.7	2.7
1893-1901	2.3	2.6	2.6
1902-1913	2.6	2.4	2.4
1914-1920	1.7	1.9	1.8
1921-1929	3.5	2.7	2.7
1930-1935	2.2	1.8	1.8
1936-1944	0.1	0.3	0.3
1945-1952	2.7	2.1	2.1
1953-1958	4.5	3.7	3.7
1959-1964	5.0	4.8	4.8
1965-1974	8.2	7.5	7.4
1975-1978	6.9	6.9	6.8
1979-1986	3.3	4.0	4.0
1987-1992	5.2	4.6	4.6
1993-2000	4.1	4.2	4.2

Table 5
Alternative Capital Estimates: Growth Rates (%)

	Prados de la Escosura and Rosés				Hofman	Hofman	Cubel/Palafox	Cebrián
	Stock	Input	Gross Stock	Net Stock	(Gross Stock)	(Net Stock)	(Net Stock)	
	(geometric depr)	(geometric depr)	(linear depr)	(linear depr)	(linear depr)	(linear depr)	(linear depr)	(geometric depr)
1951-1974	6.0	6.4	5.4	5.4	5.7	6.6		
1975-2000	4.5	4.7	4.6	4.6				
1921-1929	3.5	3.9	2.7	2.7			4.8	
1930-1952	1.6	1.5	1.3	1.3			0.9	
1953-1958	4.5	4.9	3.7	3.7	4.4	5.4	5.1	
1959-1974	7.0	7.4	6.5	6.4	6.5	7.4		
1975-1986	4.5	4.5	5.0	4.9	4.3	3.6		
1987-2000	4.6	4.8	4.3	4.3	4.1	3.9		
1902-1913	2.6	2.8	2.4	2.4			3.0	
1914-1920	1.7	2.0	1.9	1.8			1.3	
1921-1929	3.5	3.9	2.7	2.7			4.8	
1930-1935	2.2	2.7	1.8	1.8			2.0	
1936-1944	0.1	-0.4	0.3	0.3			-0.3	
1945-1952	2.7	2.7	2.1	2.1			1.3	
1953-1958	4.5	4.9	3.7	3.7			5.1	
1959-1964	5.0	5.4	4.8	4.8	5.0	6.0		
1965-1974	8.2	8.6	7.5	7.4	7.3	8.2		5.7
1975-1978	6.9	7.0	6.9	6.8	6.0	5.7		
1979-1986	3.3	3.2	4.0	4.0	3.5	2.5		
1987-1992	5.2	5.5	4.6	4.6	4.1	3.9		
1993-2000	4.1	4.3	4.2	4.2				
	Myro	**Baiges et al.**	**BDMORES**	**MOISSES**	**Mas et al.**	**Mas et al.**	**Mas et al.**	**Timmer et al**
					(Gross Stock)	**(Net Stock)**	**(Productive K)**	**(Gross Stock)**
	(geometric depr)	(linear depr)	(linear depr)	(linear depr)	(linear depr)	(linear depr)	(linear depr)	**(Productive K)**
1951-1974								
1975-2000					3.9	3.8	4.4	
1921-1929								
1930-1952								
1953-1958								
1959-1974				8.6				
1975-1986		2.4	2.7	3.2	3.8	3.7	3.9	
1987-2000				3.6	3.7	3.6	4.9	4.7
1902-1913								
1914-1920								
1921-1929								
1930-1935								
1936-1944								
1945-1952								
1953-1958								
1959-1964				7.8				
1965-1974	5.5	6.5	4.8	9.1	6.3	7.1	8.1	
1975-1978	4.4	4.3	4.0	5.2	5.1	5.1	6.0	
1979-1986			2.0	2.2	3.1	3.0	2.9	
1987-1992			3.3	4.2	4.0	4.1	5.5	5.6
1993-2000					3.5	3.3	4.5	4.0

Table 6
Capital Stock and its Components, 1850-2000: Growth Rates (%)

	Dwellings	Other Constructions	Transport Equipment	Machinery & Equipment	Capital Stock
1850-2000	3.1	3.7	4.6	4.8	3.5
Long Periods					
1850-1950	2.5	2.8	3.4	3.8	2.7
1951-1974	5.5	6.1	8.6	7.9	6.0
1975-2000	3.5	5.0	5.7	5.9	4.5
Long Swings					
1850-1883	3.5	3.7	7.7	3.8	3.6
1884-1920	2.1	2.5	2.2	4.1	2.3
1921-1929	3.1	3.6	6.6	4.7	3.5
1930-1952	1.4	1.8	-2.1	3.3	1.6
1953-1958	4.4	3.5	7.6	7.7	4.5
1959-1974	6.2	7.5	9.8	8.3	7.0
1975-1986	3.8	5.2	4.7	4.5	4.5
1987-2000	3.2	4.9	6.5	7.2	4.6
Cycles					
1855-1866	4.9	5.9	14.6	3.9	5.4
1867-1873	1.7	1.5	-1.1	1.9	1.6
1874-1883	2.8	3.0	5.2	5.7	3.0
1884-1892	1.9	3.1	-0.8	4.7	2.2
1893-1901	2.3	2.2	2.6	4.1	2.3
1902-1913	2.4	2.6	2.6	4.9	2.6
1914-1920	1.5	1.8	4.9	1.8	1.7
1921-1929	3.1	3.6	6.6	4.7	3.5
1930-1935	1.3	3.2	0.7	7.1	2.2
1936-1944	0.4	0.4	-5.9	-0.2	0.1
1945-1952	2.7	2.4	0.1	4.4	2.7
1953-1958	4.4	3.5	7.6	7.7	4.5
1959-1964	5.1	4.3	8.6	6.1	5.0
1965-1974	6.9	9.4	10.5	9.6	8.2
1975-1978	5.8	7.6	10.6	7.4	6.9
1979-1986	2.8	4.0	1.8	3.0	3.3
1987-1992	3.3	5.9	5.4	9.5	5.2
1993-2000	3.1	4.1	7.4	5.5	4.1

Table 7
Growth Rates of Capital Stock, Quality and Input, 1850-2000 (%)

	Capital Stock	Capital Quality	Capital Input
1850-2000	3.5	0.2	3.7
Long Periods			
1850-1950	2.7	0.1	2.8
1951-1974	6.0	0.4	6.4
1975-2000	4.5	0.2	4.7
Long Swings			
1850-1883	3.6	0.3	4.0
1884-1920	2.3	0.1	2.4
1921-1929	3.5	0.4	3.9
1930-1952	1.6	-0.1	1.5
1953-1958	4.5	0.5	4.9
1959-1974	7.0	0.4	7.4
1975-1986	4.5	0.0	4.5
1987-2000	4.6	0.2	4.8
Cycles			
1855-1866	5.4	0.8	6.3
1867-1873	1.6	-0.3	1.2
1874-1883	3.0	0.4	3.4
1884-1892	2.2	-0.1	2.2
1893-1901	2.3	0.1	2.4
1902-1913	2.6	0.2	2.8
1914-1920	1.7	0.2	2.0
1921-1929	3.5	0.4	3.9
1930-1935	2.2	0.5	2.7
1936-1944	0.1	-0.5	-0.4
1945-1952	2.7	0.0	2.7
1953-1958	4.5	0.5	4.9
1959-1964	5.0	0.4	5.4
1965-1974	8.2	0.4	8.6
1975-1978	6.9	0.2	7.0
1979-1986	3.3	0.0	3.2
1987-1992	5.2	0.3	5.5
1993-2000	4.1	0.2	4.3

Table 8

Capital Intensity and Productivity, 1850-2000: Growth Rates (%)

	Capital Stock/ Hour Worked	Capital Input/ Hour Worked	GDP/ Capital Stock	GDP/ Capital Input
1850-2000	3.1	3.3	-1.0	-1.2
Long Periods				
1850-1950	2.1	2.3	-1.2	-1.4
1951-1974	5.0	5.4	0.5	0.1
1975-2000	4.9	5.1	-1.5	-1.7
Long Swings				
1850-1883	3.0	3.3	-1.8	-2.2
1884-1920	2.1	2.2	-1.0	-1.1
1921-1929	1.7	2.1	0.3	-0.1
1930-1952	0.7	0.7	-0.7	-0.7
1953-1958	4.1	4.6	0.2	-0.2
1959-1974	6.4	6.8	-0.1	-0.5
1975-1986	8.1	8.1	-2.0	-2.0
1987-2000	2.2	2.5	-1.1	-1.4
Cycles				
1855-1866	4.5	5.4	-4.1	-4.9
1867-1873	0.0	-0.3	1.8	2.1
1874-1883	3.6	3.9	-1.9	-2.3
1884-1892	1.8	1.7	-1.5	-1.4
1893-1901	1.8	1.9	-1.1	-1.2
1902-1913	2.4	2.6	-1.3	-1.5
1914-1920	2.2	2.4	0.0	-0.2
1921-1929	1.7	2.1	0.3	-0.1
1930-1935	0.5	1.0	-2.0	-2.5
1936-1944	0.0	-0.5	-0.4	0.1
1945-1952	1.7	1.7	-0.1	-0.1
1953-1958	4.1	4.6	0.2	-0.2
1959-1964	5.5	5.9	1.4	1.0
1965-1974	7.0	7.4	-1.1	-1.5
1975-1978	9.9	10.1	-3.1	-3.3
1979-1986	7.2	7.1	-1.4	-1.4
1987-1992	2.0	2.2	-1.1	-1.3
1993-2000	2.4	2.7	-1.2	-1.4

Table 9

An International Comparison of Capital Deepening and Productivity: Growth Rates (%)

Panel A*

	1950-1960		1960-1973	
	Capital-Labour	**GDP/Capital**	**Capital-Labour**	**GDP/Capital**
Canada	5.7	-1.6	2.9	0.2
France	4.4	0.2	5.9	-0.4
Germany	5.3	1.3	7.7	-1.6
Italy	1.7	2.7	6.1	-0.6
Japan	-0.3	3.6	8.8	-0.6
Netherlands	2.6	1.0	6.3	-1.0
U.K.	4.3	-1.2	4.6	-0.8
U.S.A.	3.5	-0.8	1.8	0.3
Spain*	4.1	0.3	4.5	0.2

Panel B*

	1966-1990	
	Capital-Labour	**GDP/Capital**
Hong Kong	5.1	-0.4
Singapore	6.3	-2.1
South Korea	7.5	-2.6
Taiwan	7.2	-2.4
Spain	5.6	-1.6

Panel C**

	1960-2000	
	Capital-Labour	**GDP/Capital**
World	2.9	-0.6
Industrial Countries	2.6	-0.4
China	4.9	-0.1
East Asia (except China)	6.6	-2.7
South Asia	2.9	-0.6
Latin America	1.7	-0.6
Africa	1.4	-0.8
Middle East	3.1	-1.0
Spain	5.3	-0.9

Notes: * Capital Input-Labour Input and GDP-Capital Input Ratios
** Capital Stock-Labour Quantity and GDP-Capital Stock Ratios
Sources: All countries but Spain, Panel A, Christensen et al. (1980); Panel B, Young (1995); Panel C, Bosworth and Collins (2003). Spain, for capital, see the text, and for labour, Prados de la Escosura and Rosés (2007).

Table 10

Long-run Capital Deepening and Productivity in the U.K., the U.S. and Spain: Growth Rates (%)

	Capital-Labour	GDP/Capital	Capital-Labour	GDP/Capital
	U.K.		**Spain**	
Panel A*				
1856-1873	1.9	0.3	3.1	-2.1
1873-1913	1.0	-0.1	2.4	-1.4
1913-1924	3.2	-1.0	2.2	0.2
1924-1937	0.3	0.4	2.9	-3.1
1937-1951	1.0	0.7	-0.9	1.4
1951-1973	3.7	-0.4	5.4	0.3
	U.S.A.		**Spain**	
Panel B*				
1889-1901	1.7	0.5	1.3	-0.7
1901-1919	1.7	0.0	2.6	-1.1
1919-1929	1.2	1.1	1.2	0.9
1929-1941	-0.2	2.5	0.8	-1.9
1941-1948	0.4	1.3	1.0	-0.4
1948-1973	2.7	0.2	4.8	0.4
1973-1989	2.6	-1.2	6.4	-1.5
1989-2000	2.5	-0.6	3.0	-1.5
Panel C**				
1871-1891	0.4	-0.1	2.1	-0.8
1891-1913	0.5	0.6	1.7	-1.0
1913-1928	0.2	0.9	1.7	-0.2
1928-1950	-0.2	1.6	1.1	-1.2
1950-1964	1.9	0.4	3.2	1.3
1964-1972	3.5	-0.9	6.4	-1.4
1972-1979	2.3	-0.9	8.1	-2.9
1979-1988	2.4	-1.6	3.7	-0.7
1988-1996	-0.1	-0.4	3.9	-2.0

Notes: * Capital Stock-Labour Quantity and GDP-Capital Stock Ratios
** Capital Input-Labour Input and GDP-Capital Input Ratios
Sources: All countries but Spain, Panel A, Matthews et al. (1982);
Panel B, Field (2006); Panel C, Gordon (1999). Spain, for capital, see the text
and for labour, Prados de la Escosura and Rosés (2007)

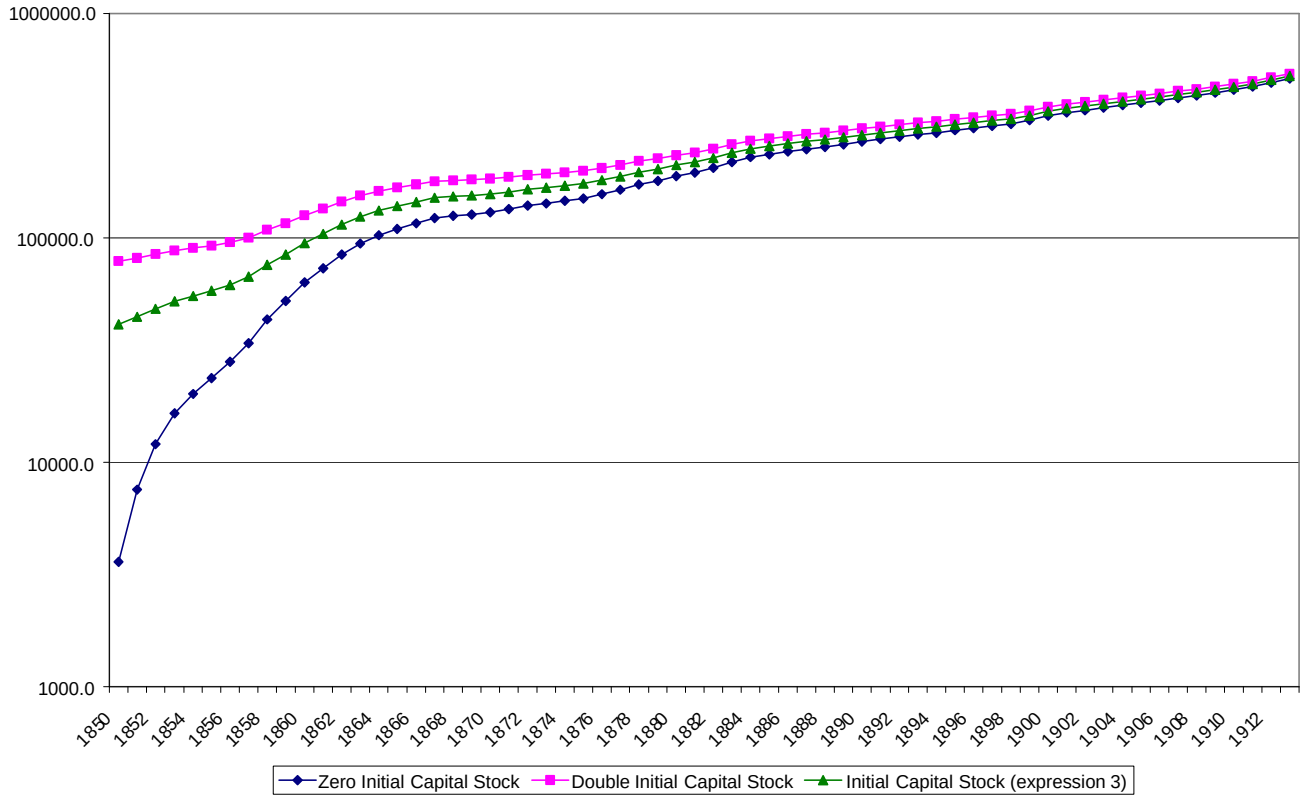

Figure 1: Capital Stock Estimates with Alternative Initial Levels, 1850-1913 (1958 million Pesetas) (semilog scale)

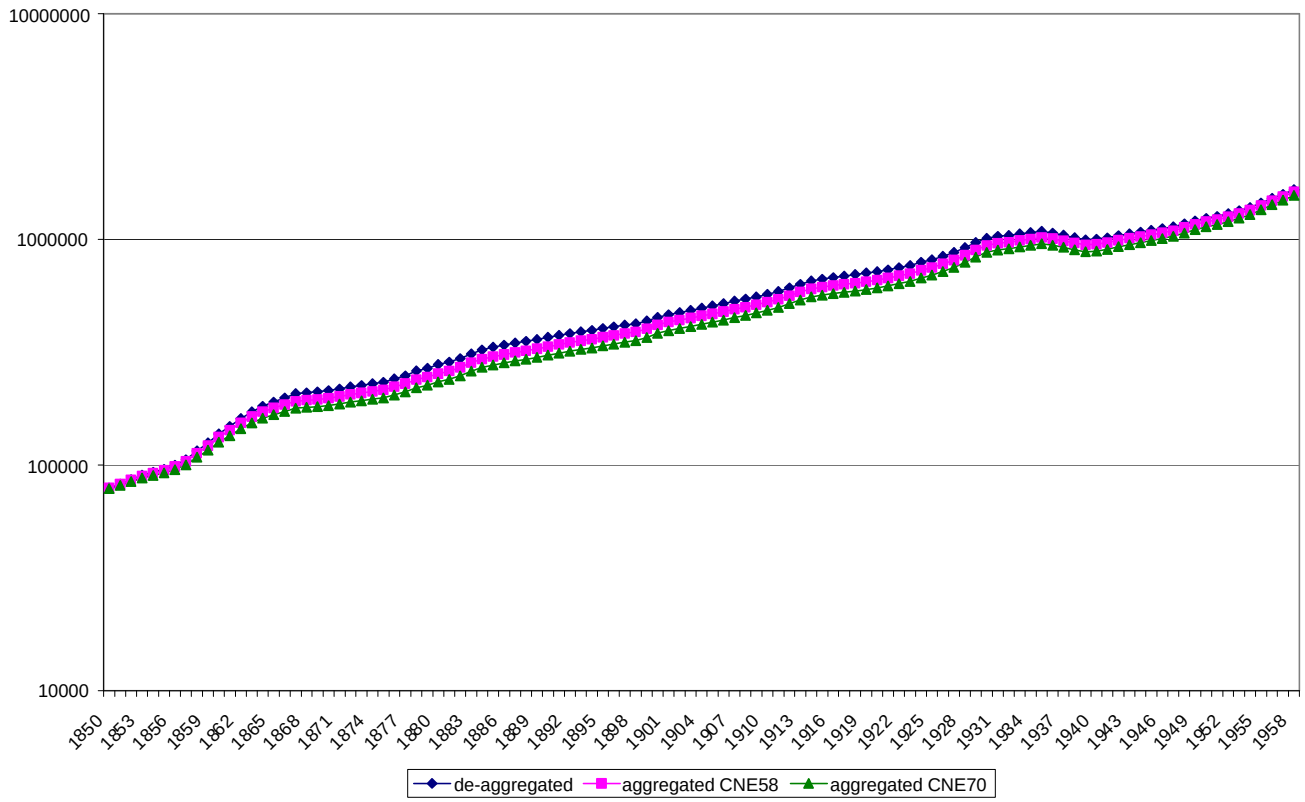

Figure 2: Capital Stock Estimates Constructed with Alternative De-aggregation of GFCF Series

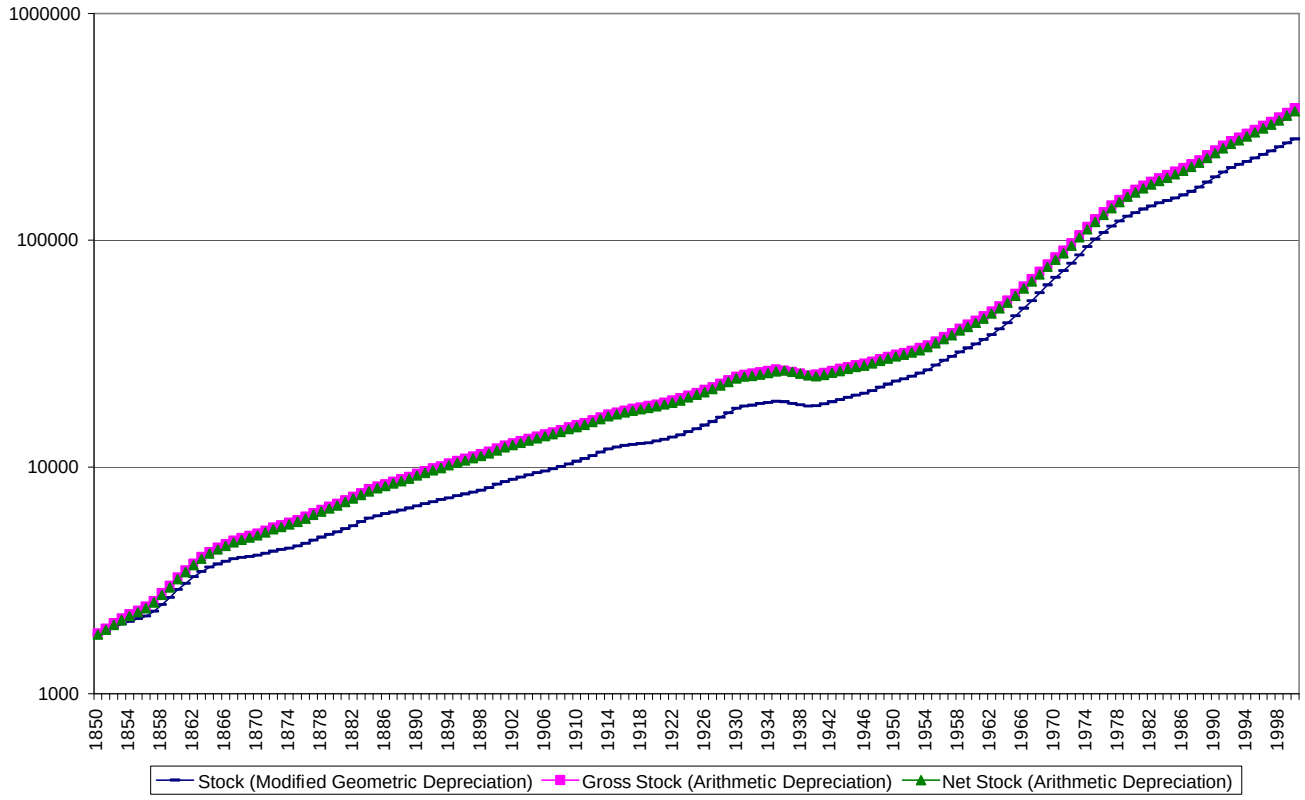

Figure 3: Capital Stock Estimates with Alternative Depreciation Rates

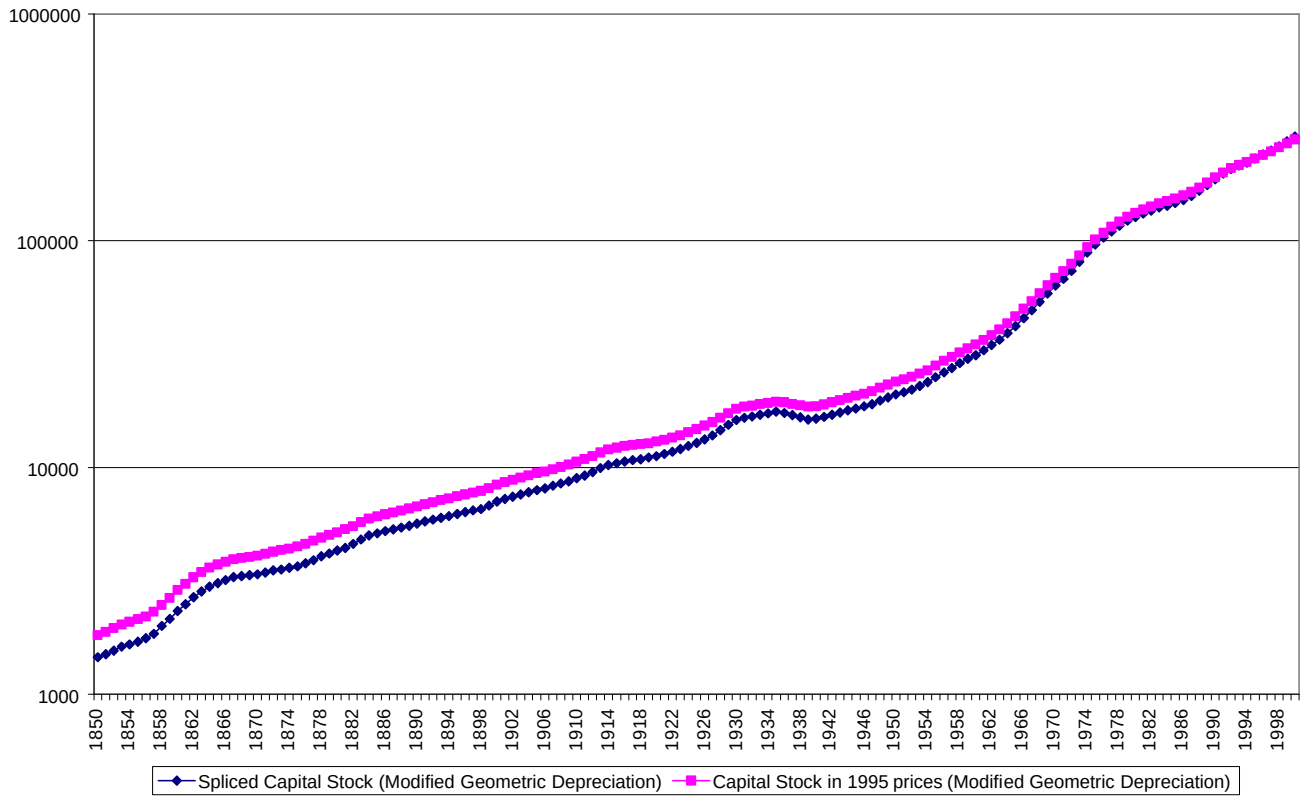

Figure 4: Single (at 1990 prices) and Variable Weighted (Spliced) Capital Stock

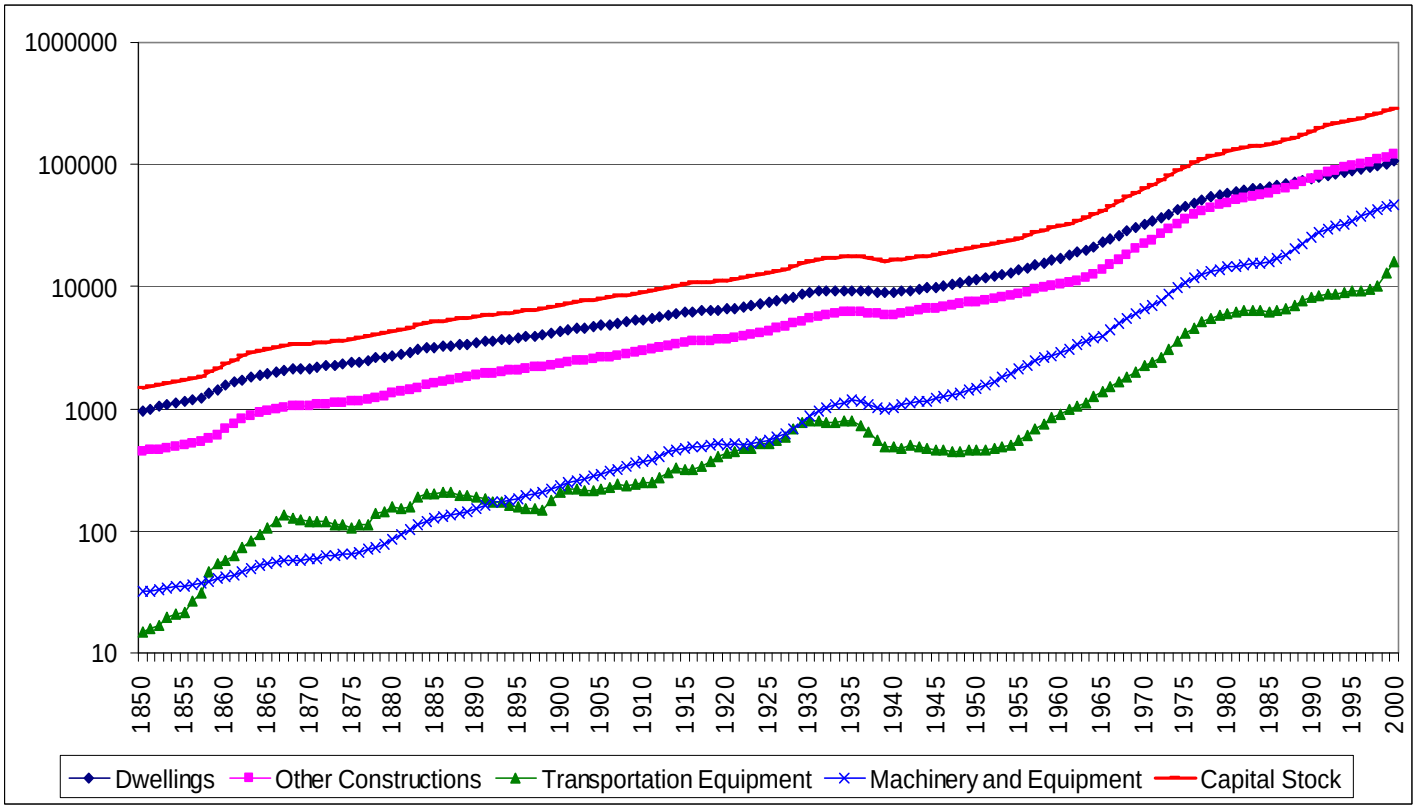

Figure 5: Trends in Capital Stock and its Components (semilog scale)

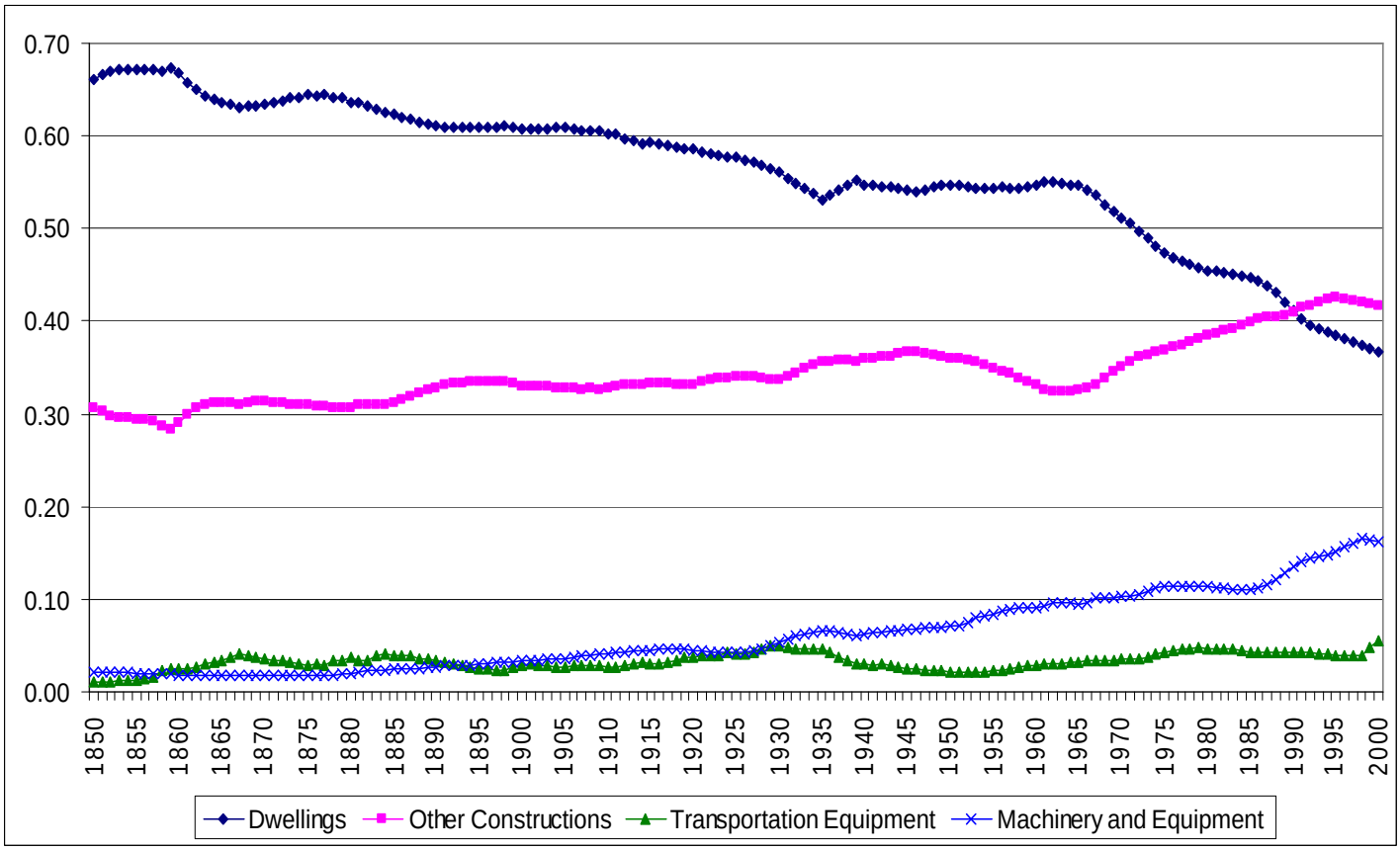

Figure 6: Composition of Capital Stock (%) (1995 prices)

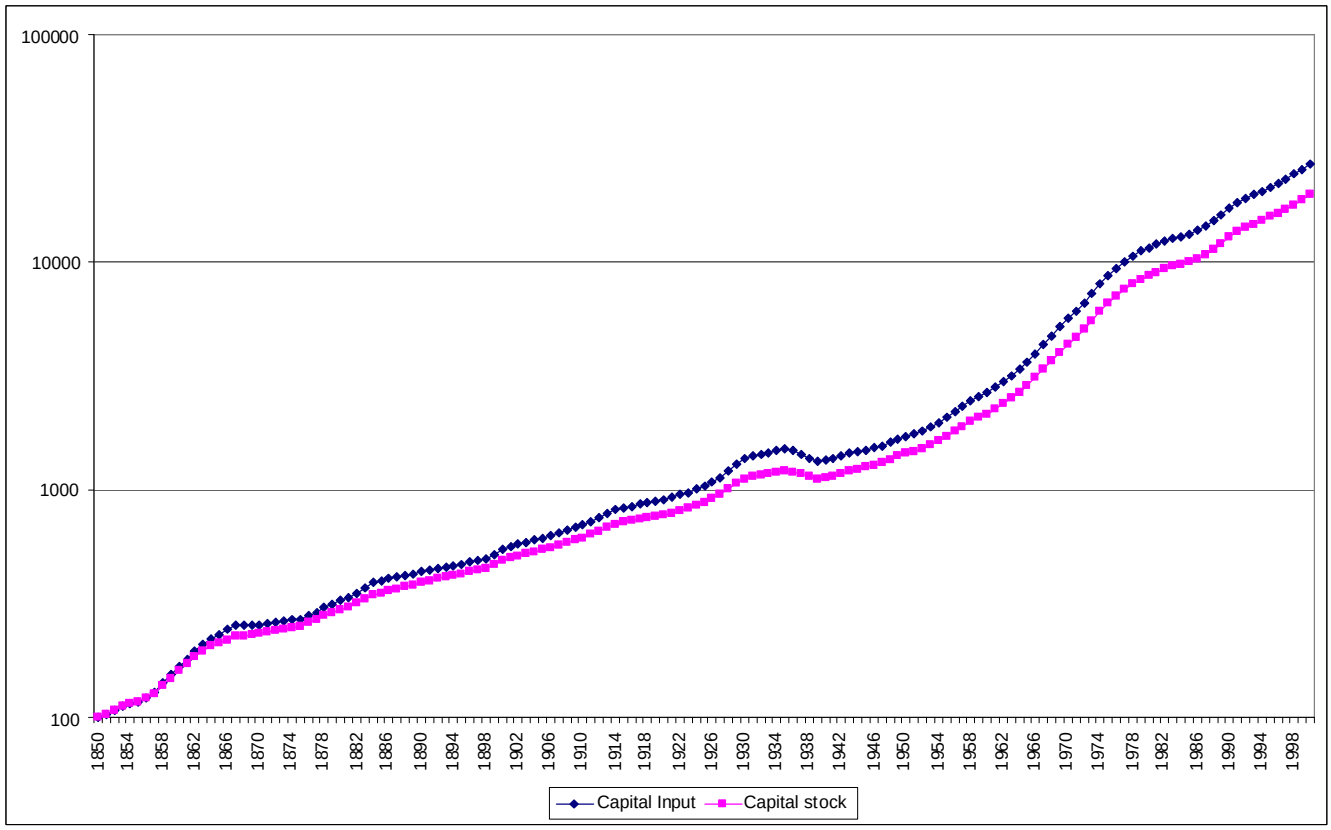

Figure 7: Indices of Capital Stock and Input (1850 = 100)

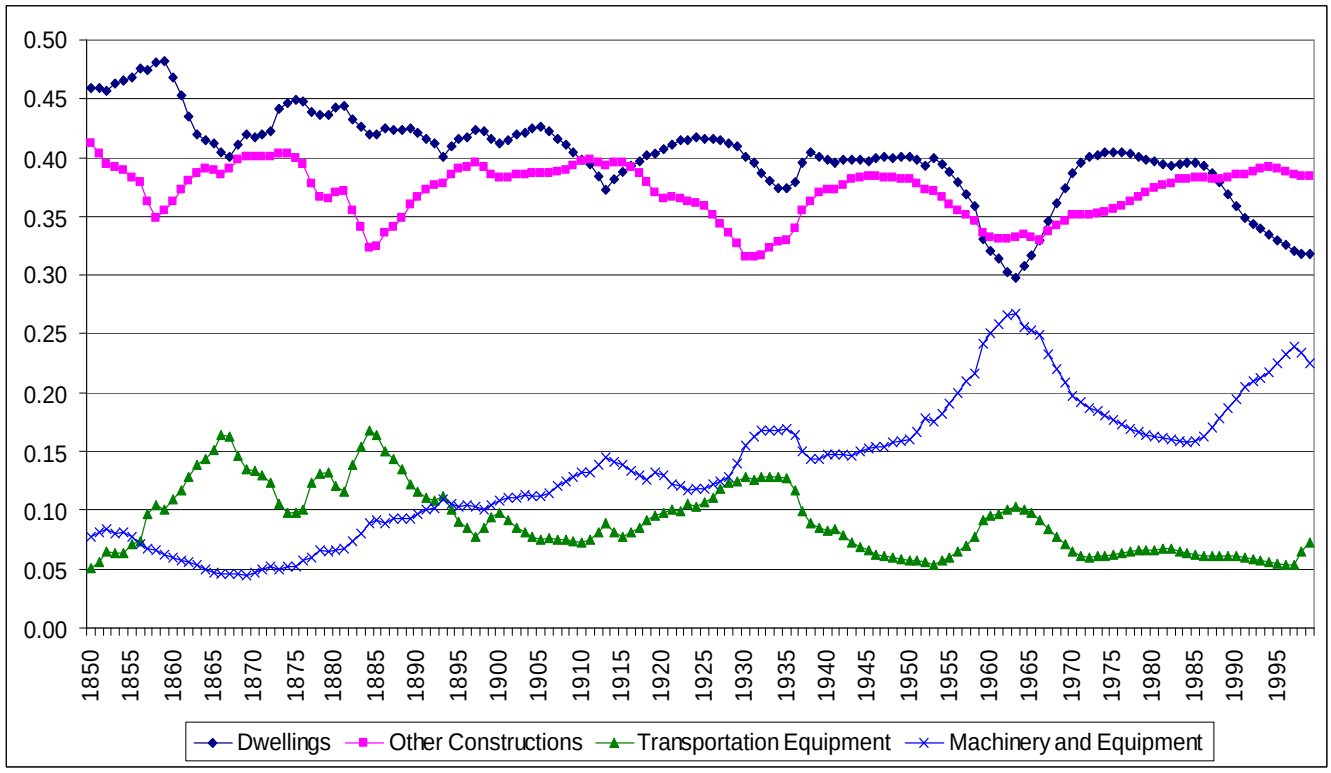

Figure 8: Capital Input. Shares of Rental Value

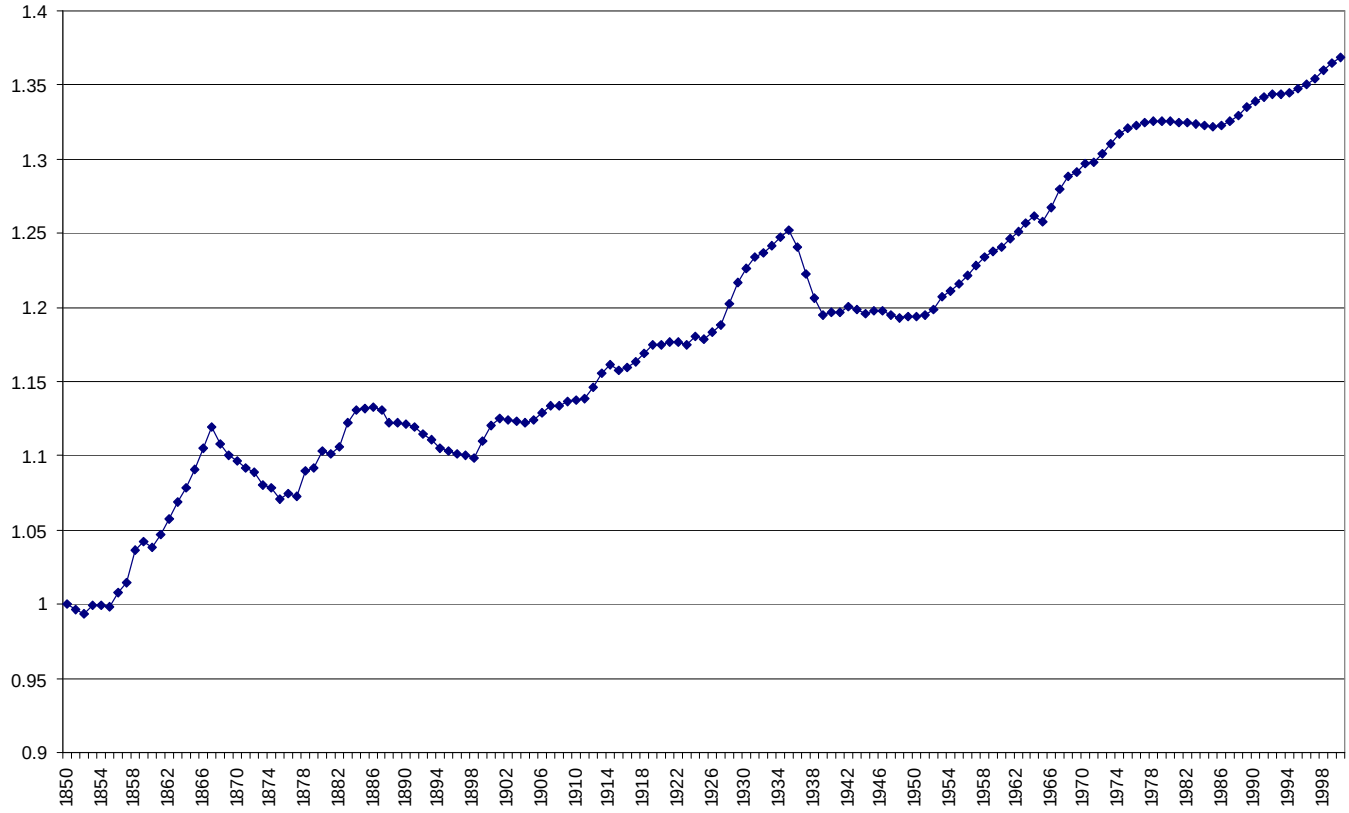

Figure 9: Index of 'Quality' of Capital (1850 = 100)

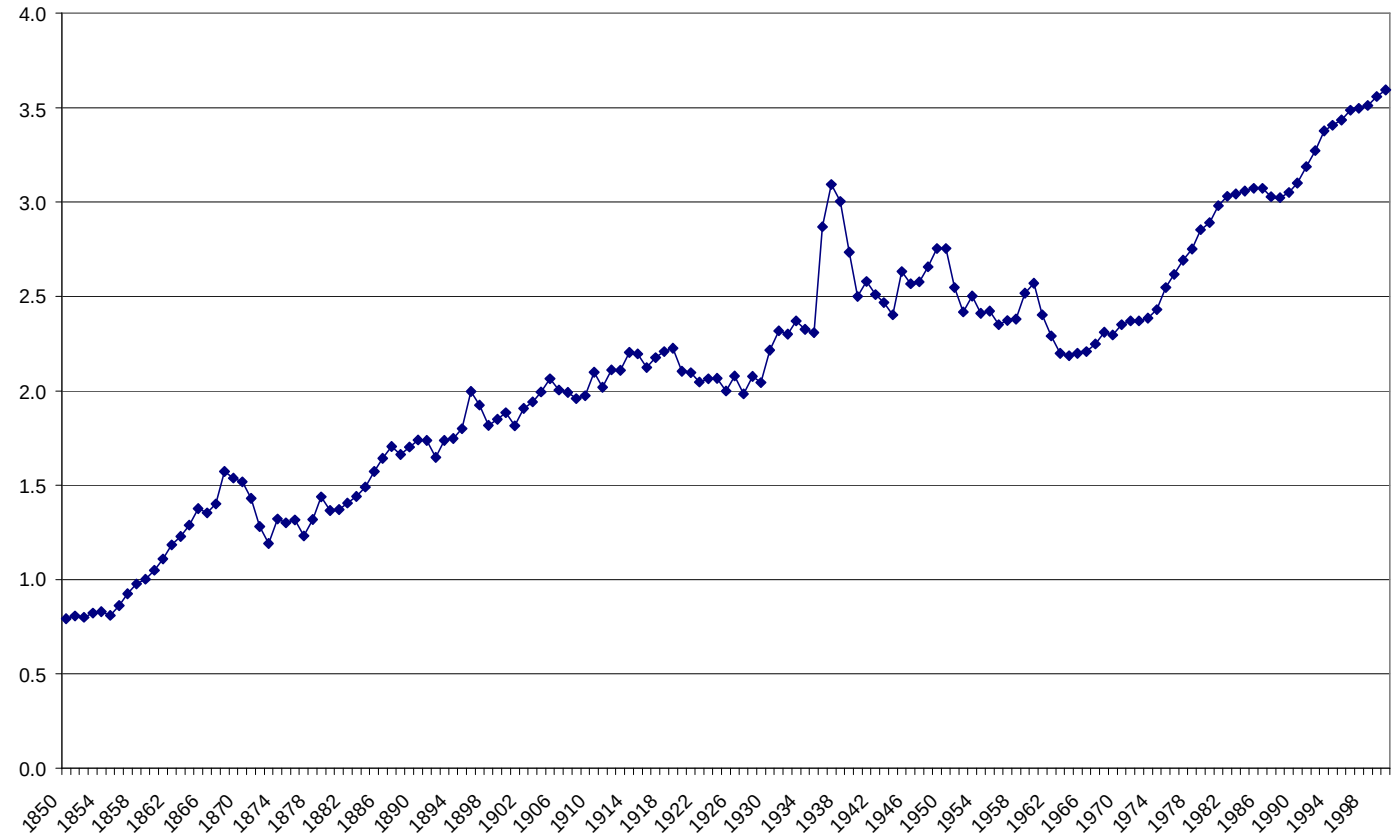

Figure 10: Capital Stock / Output Ratio