DISCUSSION PAPER SERIES

DP15364

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ECONOMIC HISTORY

ISSN 0265-8003

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Discussion Paper DP15364
Published 13 October 2020
Submitted 12 October 2020

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Abstract

The rising trend in the capital-output ratio and the productivity slowdown have put capital back in the economist's agenda. This paper contributes to the debate by providing new estimates of net capital stock and services for Spain over the last 170 years. The net capital (wealth) stock-GDP ratio rose over time and doubled in the last half-a-century. Capital services grew fast over the long-run accelerating in the 1920s and from the mid-1950s to 2007. Until 1975 its acceleration was helped by an increase in the 'quality' of capital. Capital deepening proceeded steadily, accelerating during 1955-1985, and slowing down thereafter for expanding sectors attracted less investment-specific technological progress. Although capital consumption rose over time, the rate of depreciation fell from 1970 to 2007 as new capital goods' relative prices declined due to embodied technological change.

JEL Classification: D24, E01, E22, N33, N34

Keywords: Capital Stock and Services, Capital Deepening, Capital-output ratio, Spain

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Acknowledgements
I thank Eva Benages, Juan Carlos Robledo, Lorenzo Serrano, Ezequiel Uriel, and, especially, Matilde Mas and Ilya Voskoboynikov for their most valuable comments. Juan Carlos Robledo and Eva Benages kindly provided me with Ivie's detailed capital stock and capital services dataset. A research grant from Fundación Rafael del Pino is gratefully acknowledged.

I. Introduction

Capital is back in the economist's agenda. Thomas Piketty's (2014) claim of rising capital-output ratio over time has triggered an interest in historical research. The debate on the productivity slowdown has also stimulated the search for its historical roots and, in particular, the role played by capital accumulation.

By providing new estimates of net capital stock and capital services for Spain over the last 170 years this paper aims at contributing to both debates. Using OECD (2009) methodology consistent and integrated estimates of net capital (wealth) stock, relevant for welfare and distribution, and a volume index of capital services, relevant for productivity growth, have been constructed.[1] The main findings can be summarised as follows.

1) Capital input (namely, the flow of capital services into production) grew at 3.6% during the last 170 years accelerating in the 1920s and from the mid-1950s to the onset of the Global Financial Crisis (2008). Until 1975 the acceleration of capital input growth was helped by an increase in the 'quality' of capital, that is, a compositional shift towards more productive assets.

2) Capital deepening (that is, capital services per hour worked) grew steadily up to 1930, accelerating between the mid-1950s and mid-1980s, and slowing down thereafter, as expanding economic sectors attracted less investment-specific technological progress.

3) The net capital (wealth) stock-GDP ratio, at current prices, rose over time, with a 4-fold increase between 1886 and 2013, contradicting one of Kaldor's (1957) stylised facts, and doubled during the last half-a-century, in line with Piketty and Zucman (2014) findings for western Europe's wealth-income ratio.

4) The consumption of fixed capital (CFC) in terms of GDP increased over time, shadowing the capital-output ratio but, as a proportion of the net capital stock (that is, the rate of depreciation), only rose up to the 1960s, falling from 1970 to 2007 as the relative prices of new capital goods declined due to embodied technological change.

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[1] By consistent and integrated estimates Oulton and Wallis (2016) mean a common dataset and a common set of assumptions in the construction of long run estimates of capital stock and capital services.

The paper is organized as follows. In section I the concepts, method, and sources used are discussed. Section II presents new estimates of net capital stock and productive capital stock derived with the Perpetual Inventory Method, tests its sensitivity, and compares the results to available series of capital stock. In Section III, a volume index of capital services, in which the user cost of capital is derived with an ex-ante exogenous rate of return, is provided. Then, the volume index of capital services (VICS) is compared to the productive capital stock, as a growing gap between them reveals the shift from low return and long live assets to higher return but shorter live assets, that is, an increase in the "quality" of capital. Next, trends in VICs and capital deepening are offered and weighed against available estimates. Lastly, Section IV offers the evolution of the capital-output ratio, as well as the consumption of fixed capital (% of GDP) and the depreciation rate (% net capital stock).

II. Capital Stock: Concept, Method, and Sources

The publication of the OECD Manual in 2009 (OECD, 2009) provided a unified methodology to measuring capital stock and services that builds bridges between OECD previous methodology and the one pioneered by Jorgenson (1963) and further developed by Jorgenson (1989, 1990) and Hulten (1990).[2] This paper follows the OECD approach and distinguish between net capital stock, also labelled wealth, which measures capital assets at their market price, and productive stock, an intermediate stage to derive a volume index of capital services (capital input), that is, the flow of capital services into production.

In the construction of net capital stock estimates, the Perpetual inventory Method (PIM) is used, cumulating flows of investment, corrected for retirement and depreciation, for each asset. Implementing the PIM requires, by type of asset, a) investment volumes and deflators; b) average service lives; c) depreciation rates; and d) an initial benchmark level of capital stock.

a) Four different types of asset have been distinguished: dwellings, other construction, transport equipment, and machinery and equipment, to which biological resources and intellectual property products have been added as information on these

[2] OECD (1993, 2001). For developments and applications of the Jorgenson approach, cf. Jorgenson and Griliches (1967), Hall and Jorgenson (1967), Christensen, Cummings, and Jorgenson (1980), Jorgenson, Gollop, and Fraumeni (1987), Elías (1978), and Young (1995).

two assets is only available in national accounts since 1980.[3] No distinction has been made between ICT and non-ICT assets due to dearth of data in national accounts and to the aim of providing homogeneous long-run series of capital stock.[4]

Gross fixed capital formation (GFCF) volume series for each type of asset are obtained by deflating current values, and expressed in 2010 Euro. GFCF current value and deflator series come from Prados de la Escosura (2017, updated to 2019). GFCF series are derived from spliced national accounts for 1958-2019 (see Appendix A), and through the commodity flow method (CFM), that is, production and trade data to proxy investment by asset type, for 1850-1958.[5]

It is worth noting that the GFCF deflator series have been smoothed using a Hodrick-Prescott filter in order to avoid negative values for the unit user costs. The same smoothing procedure has been applied to the general price index used that, in our case, is the GDP deflator.[6]

b) The choice of average services lives, that is, the length of time that assets are retained in the capital stock, presents a challenge. Although choosing different average lives for different periods represents the usual historical practice (Feinstein, 1988; Prados de la Escosura and Rosés, 2010) a single set of average service lives is used here in order to facilitate comparisons with other estimates, as services lives for each asset type are kept constant in most country studies. Moreover, there is no concluding evidence that service lives fall over the long run, as offsetting tendencies are at work.[7] Thus, dwellings and other construction are assigned average service lives of 60 and 40 years, respectively, while transport and machinery equipment are attributed 15 years

[3] Conference Board (2020) follows the same practice. As a sensitivity test, we have replicated the estimates of net capital stock using six, rather than four types of assets (that is, considering, biological resources and intellectual property products separately) from 1980 onwards. No trend discrepancies are found between the two set of estimates even though the 6 assets estimates exhibit a slightly lower level (See Figures A5 and A10 in Appendix C).
[4] See Pérez et al. (2019) and Conference Board (2020) for estimates for Spain which distinguish between ICT and non-ICT of assets.
[5] The CFM approach is widely used to reconstruct GFCF series in present-day developing countries (Conference Board, 2017). Also, in the Penn World Tables 9.1, in the absence of direct estimates, investment in an asset is assumed to vary with the economy-wide supply (production + imports - exports) (Feenstra et al., 2015, updated).
[6] Alternative estimates using the private consumption deflator provide similar results.
[7] On the one hand, service lives tend to fall as “product cycles” become shorter and capital goods face higher rates of obsolescence but, on the other, some assets become more durable (OECD, 2009). Maddison (1995) used fixed average lives for his historical estimates.

each one.[8] Nonetheless, compositional changes in the capital stock imply that the average service life of total capital varies over time and, in so far a shift towards more productive assets takes place, it declines.

c) As regards depreciation rates, a declining balance is chosen, that is, a geometric rate, $\delta = R/T$, being T the asset's average service life and R the selected parameter. Geometric depreciation rates differ across assets but are constant over time. Following US Bureau of Economic Analysis (Fraumeni, 1997) Hulten and Wykoff's (1981) directly computed depreciation rates and implicit R values, 1.65 for transport equipment and machinery and 0.91 for structures, have been accepted. The resulting depreciation rates are, thus, 1.52%, 2.28%, 11.0%, and 11.0% for dwellings, other constructions, transport equipment, and machinery and equipment (plus intellectual property and biological resources since 1980), respectively.[9]

d) In the absence of an initial stock of capital, two main approaches have been used to derive it. One assumes, after Harberger (1978), that the economy is at its steady-state and derives it for each asset type as,

$$W^{t0} = I^{t0} / (\delta + \theta) \qquad (1)$$

being I, real investment; δ, the rate of depreciation; and θ, the growth rate of investment in early years.

An alternative to the steady state assumption approach is to estimate a functional relationship between real GFCF and GDP and, supposing that such a relationship is stable over time, to derive volume GFCF series for the previous period

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[8] These service lives are in line with those used by Pérez et al. (2019). Alternative estimates have been computed with another set of longer average service lives: 70 years (dwellings), 50 years (other construction), and 20 years (transport equipment and machinery). Although longer service lives increase the gross stock and reduce depreciation and, hence, deliver a larger net capital stock, the comparison between the two set of estimates reveals minor differences over time. A third set of estimates has been derived by combining the longer average lives set for 1850-1958 and the shorter average lives set for 1959-2019. Interestingly, the result is lower growth of aggregate capital stock than when the shorter lives set is employed for the entire time span. This finding may be attributed to the fact that the set of average assets lives for the pre-1958 period assigns larger weight to slower growing assets and, consequently, result in lower net capital stock. (See the resulting alternative Net Capital Stock/GDP ratios in Figure A11 in Appendix C).

[9] Hulten and Wykoff (1981) implicit R values were also used in Prados de la Escosura and Rosés (2010). Alternative estimates have been obtained using a double declining balance (T=2) and the same average service lives, with the resulting depreciation rates of 3.3%, 5.0%, 13.3%, and 13.3% for each of the four asset types. Figure A12 in Appendix C compares the net capital stock derived alternatively with the double declining balance and Hulten and Wykoff's R values, revealing that the net capital stock derived with the double declining balance is lower as the depreciation rates are larger for the same average lives of assets, and so is the consumption of fixed capital (Figure A13).

on the basis of available GDP series. Here the relationship between each asset type and GDP has been estimated for 1850-1920 and the regression coefficients applied to the available real GDP estimates to produce GFCF volume series for each type of asset between 1780 and 1850.[10]

The initial (1850) level for each capital asset type has been derived with the PIM and the average lives and depreciation rates accepted for the post-1850 period with each approach. Figure 1 compares the results of the two approaches. It can be observed that their difference disappears by 1880. As the alternative option to the steady state approach seems to be less stringent, it has been preferred here.

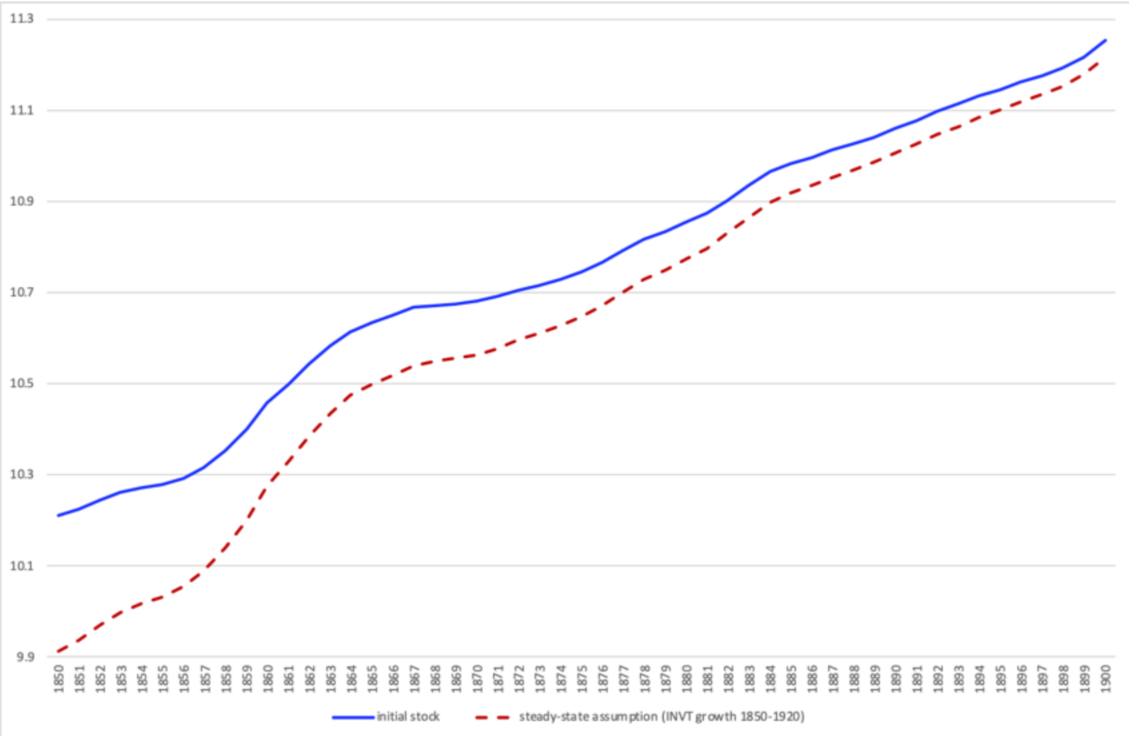

Figure 1. Initial Net Capital Stock: Alternatives Estimates, 1850-1900 (2010 Million Euro) (natural logs)

Another important issue is how sensitive are the net capital stock series to the choice of its initial level. Thus, the estimates have been replicated adopting as initial

[10] The OLS regression results are (with standard error in parentheses),

ln(Dwellings)= -5.75 + 1.23 ln(GDP)
(0.995) (0.095) Adj. R^2 = 0.70

ln(Other Construction) = -11.23 + 1.70 ln(GDP)
(1.271) (0.121) Adj. R^2= 0.74

ln(Machinery) = -29.07 + 3.19 ln(GDP)
(1.062) (0.101) Adj. R^2 = 0.93

ln(Transport Equipment) = -17.18 + 2.07 ln(GDP)
(2.755) (0.263) Adj. R^2 = 0.47

capital both half and twice the level obtained in the favoured option. Figure 2 shows that differences diminish as time goes by and fade away by the 1920s. Thus, the estimates seem to be robust to alternative ways of computing the initial level for, at least, the last hundred years.

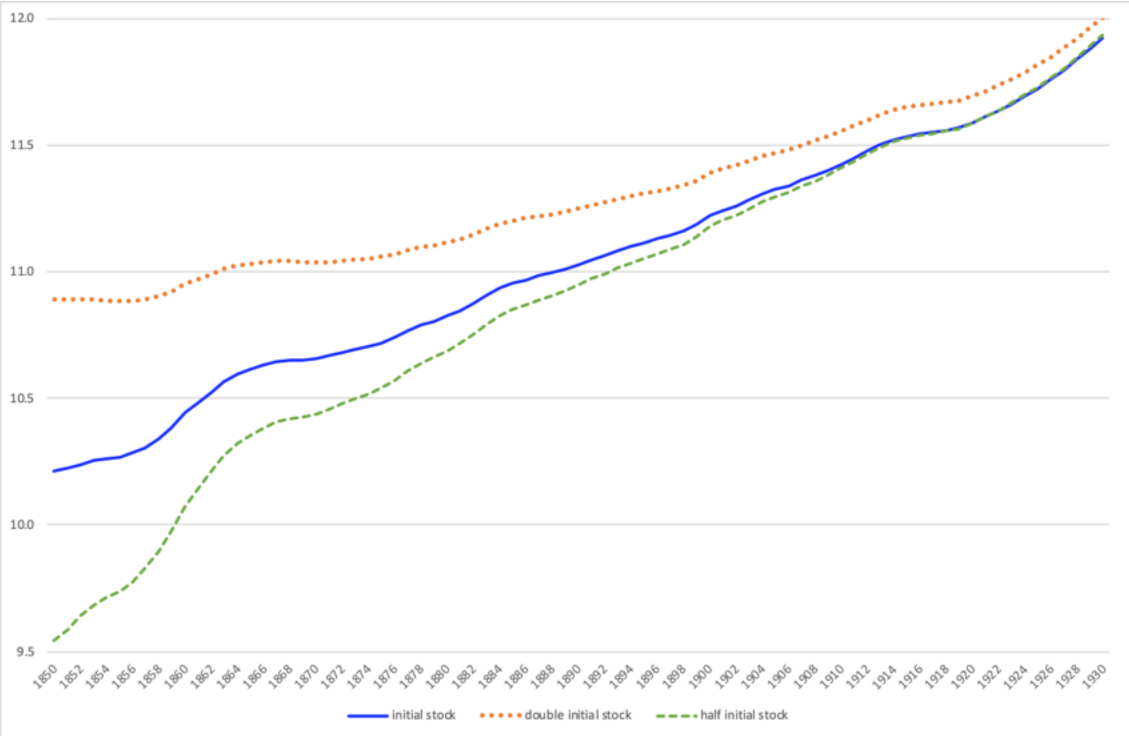

Figure 2. Initial Net Capital Stock: Sensitivity to Alternative Options, 1850-1930 (2010 Million Euro) (natural logs)

Next, the Net Capital Stock has been computed for 1850-2019 using the stock-flow relationship (PIM). If we define the net stock at the beginning (^{B}) of the first year, 1850, as $W^{1850,B}$, end-year (^{E}) net stocks for each asset in all consecutive years are,

$$W^{tE} = W^{tB} + I^{t} - \delta(I^{t}/2+W^{tB}) \qquad (2)$$

being I^{t}, real yearly gross fixed capital formation and δ, the rate of depreciation. All stocks are valued at average prices of 2010 and adding them up the Net Capital Stock in 2010 Euro is obtained.

The value of the consumption of fixed capital (depreciation) for each asset at 2010 prices, D^{t}/P_{0}^{t}, results from applying the rate of depreciation to the net stock at the beginning of the period plus half the current period's investment,

$$D^{t}/P_{0}^{t} = \delta[I^{t}/2 + W^{tB}]. \qquad (3)$$

The net (wealth) capital stock at current prices, $P_0^tW^t$, is obtained by reflating the average of the net capital stock at the beginning and the end of each year with the average yearly price index for each asset, P_0^t and, then, adding them up.

$$P_0^tW^t = P_0^t\,(W^{tB} + W^{tE})/2 \qquad (4)$$

Similarly, the current value of the consumption of fixed capital, D^t, has been derived by revaluing its constant price value with the deflator for each asset, P_0^t.

$$D^t = \delta[I^t/2 + W^{tB}]\,P_0^t \qquad (5)$$

A last step is to consider the destruction of capital stock resulting from the Spanish Civil War (1936-39). Although capital assets in transport equipment and dwellings derived through PIM appear to capture war damage, it does not seem to be the case for other construction and machinery as destruction estimates in the historical literature appear to be larger than those resulting from the PIM exercise. Hence, the historical estimates of asset destruction have been accepted and distributed it at constant yearly rates over 1936-39.[11] The resulting figures imply a 4.9% contraction of the total net capital stock between 1935 and 1939 which, by asset type, represent a fall of 2.0% (dwellings), 6.8% (other construction), 13.7% (machinery and equipment), and 30.4% (transport equipment), much lower than Maddison's (1995: 138) guesstimates for World War II destruction in belligerent European countries, except the UK.

How do the new estimates compare to the established Ivie's figures (Pérez et al., 2019) and to the recent computations of the net stock of fixed capital by the Spanish official statistical office, Instituto Nacional de Estadística (INE)? Figure 3a presents the logarithmic deviations between the new estimates and these two sets at current prices and expressed in percentages.[12] The new estimates match rather closely INE's figures, with lower levels in the 2000s and higher ones in the 2010s, and an average absolute difference of 8.2% (standard deviation 3.8).

[11] The yearly rates assumed are -2.75% for other construction and -5.8% for machinery, following Prados de la Escosura and Rosés (2010). Although the destruction, as a share of net capital stock, is lower in the new estimates, 5% versus 7%, a fact that derives from the use of different asset average service lives and from methodological differences in the computation of the capital stock.

[12] The formula used is 100*(natural log X– natural log Y), being X the new estimates and Y, Ivie and INE figures, alternatively.

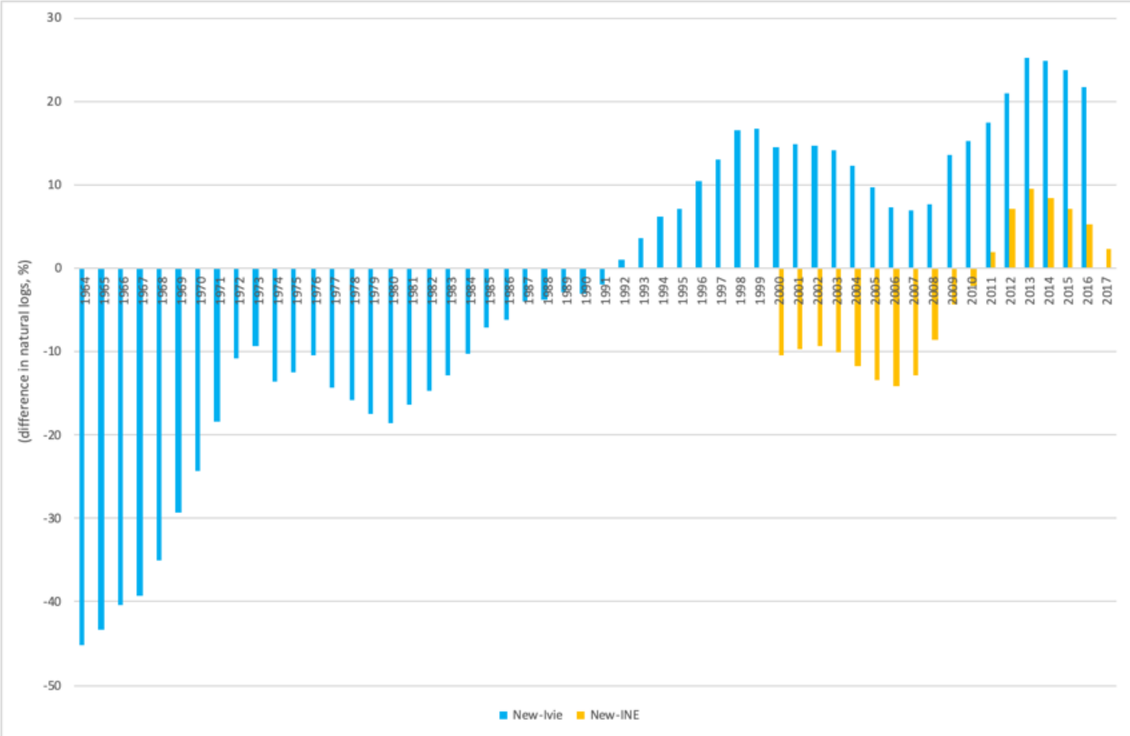

Figure 3a. Net Capital Stock*: Differences with INE and Ivie Estimates, 1964-2017 (natural logs %) (current prices) * computed with Interpolated GFCF and declining balance.

However, with Ivie's figures the average (absolute) difference is almost double, 15.6% (s.d. 6.0) during a similar time span, 2000-2016, and also for the entire period covered by Ivie's estimates, 1964-2016, 15.5% (s.d. 10.5), although from the early 1990s onwards, the difference is positive, that is, the new estimates are larger, and negative, that is, smaller, in the three previous decades. Furthermore, Ivie figures are lower than INE's and their average absolute (log) difference is 19.5% (s.d. 3.9).

Why such a discrepancy exist between the new historical estimates and Ivie's? Two differential features may explain it. One is that although Ivie also uses geometric depreciation, it is double declining balance (that is, R=2), while following Fraumeni (1997), the new estimates adopt Hulten and Wykoff's (1981) empirically obtained R. Another difference is that the GFCF series for the period 1965-1995 employed by Ivie have been spliced using the retropolation method, not through interpolation as in our case (See Appendix A). In Figure 3b we have replicated the comparison but, now, the new net capital stock estimates are computed with retropolated GFCF series and double declining balance geometric depreciation. The resulting gap between the two series narrows down remarkably with the average (absolute) difference shrinking to

7.1% (s.d. 8.0). Therefore, methodological differences explain about half of the discrepancy between the two set of estimates.

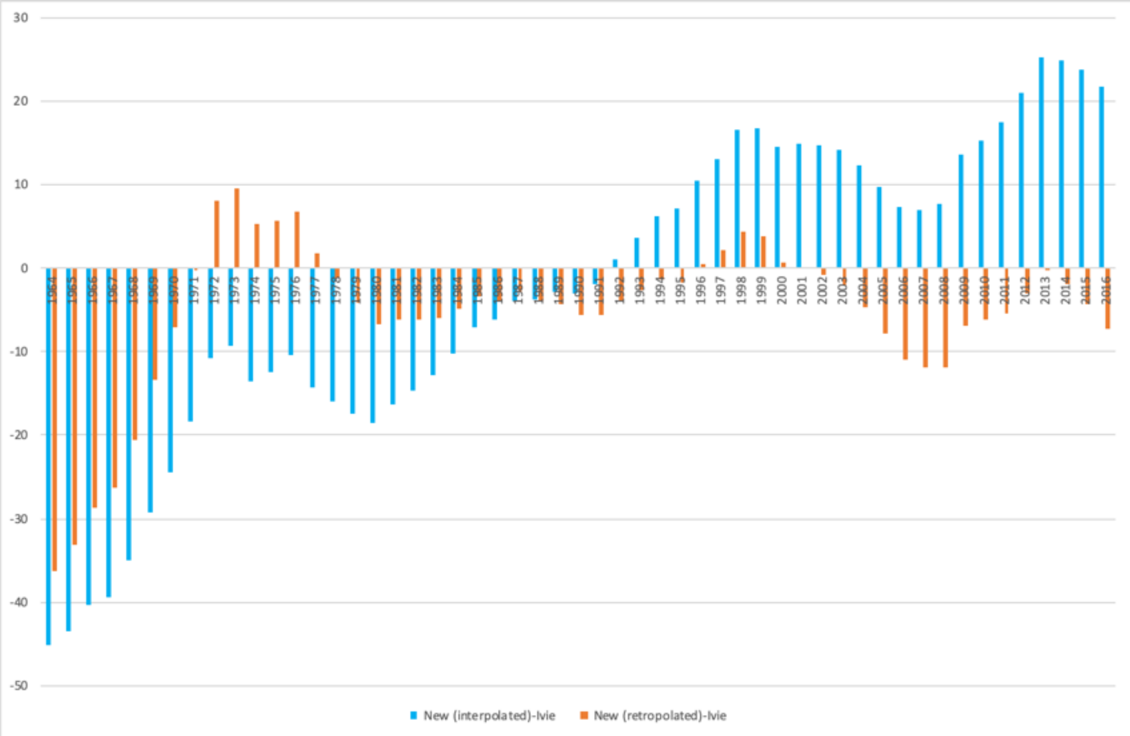

Figure 3b. Net Capital Stock computed with Interpolated GFCF and declining balance and with retropolated GFCF and Double Declining Balance: Differences with Ivie Estimates, 1964-2016 (natural logs %) (current prices)

Another test results from comparing the estimates obtained with the PIM and the capital stock derived from a wealth survey for 1965 (Universidad Comercial de Deusto, 1968-1972), often used to initialise capital stock series.[13] It can be observed that the wealth survey exaggerates the size of the capital stock (Table 1).[14]

Table 1. Wealth Survey and Perpetual Inventory Method Estimates in 1965
(000 million Peseta)

	(I)	(II)	(III)
	Wealth Survey	**PIM Estimate**	**[(II)/(I)]**
Dwellings	1166	1006	0.86
Other Structures	1236	827	0.67
Machinery and Equipment	633	352	0.56
Transport Equipment	194	146	0.75
Total Capital Stock	3229	2330	0.72

Sources: Universidad Comercial de Deusto (1968-72), reproduced in Myro (1983) Table 2.3; PIM estimates, see text.

[13] For example, in Myro (1983) and Mas et al. (2000).
[14] Cf. Young (1995: 650-1) for similar results in the cases of South Korea and Taiwan.

Lastly, productive stock, K^t, has been obtained by adding investment in the latest period to the net capital (wealth) stock,

$$K^t = I^t/2 + W^{tB} \quad (6)$$

It is worth noting that while to derive the net capital stock the cumulating flow of investment is corrected for retirement and depreciation, in the case of productive capital only efficiency losses are detracted. In practical terms, their difference results from the fact that the net capital is valued at the end of the year and the productive capital represents the average value in the year. Moreover, productive stocks for each type of asset are computed at constant prices only and used to derive capital service flows.

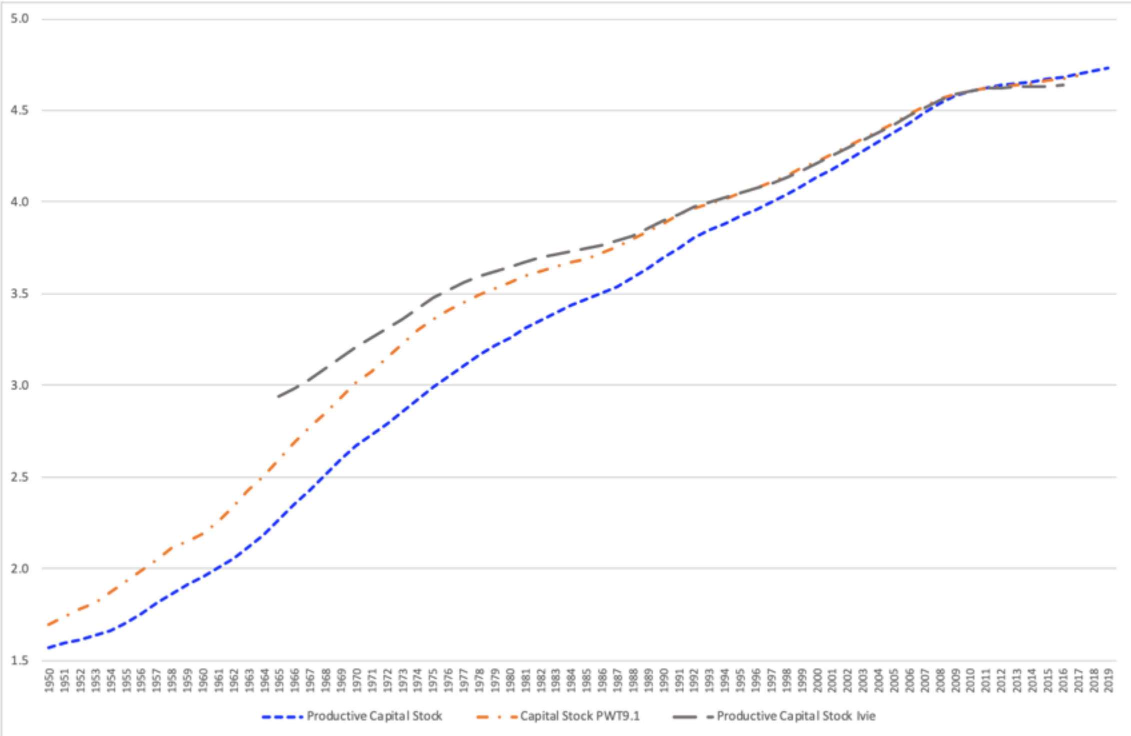

Figure 4a. Productive Capital Stock, 1950-2019: Comparison with PWT9.1 and Ivie Estimates (2010=100) (natural logs)

It is worth comparing our results for the productive capital stock (PKS) to those already available. Figure 4a presents the new estimates along those provided for Spain by the Penn World Tables 9.1 (PWT 9.1) (Feenstra et al., 2015, updated) and Ivie (Pérez et al., 2019) since 1950 and 1964, respectively. Although the three series present similar trends, the new estimates exhibit a steeper trend, that is, grow at a faster pace. The explanation of the differential partly lies in the use of retropolated GFCF series before 1995 and the double declining balance geometric depreciation, particularly in the case of the PWT9.1 series, since the difference narrows down sharply when the new PKS estimates are replicated with retropolated GFCF series and double declining balance (Figure 4b). In the case of Ivie's series, however, other elements also contribute to explain it (i.e., its initial level derived from the 1965 wealth survey and a more detailed breakdown by asset type).

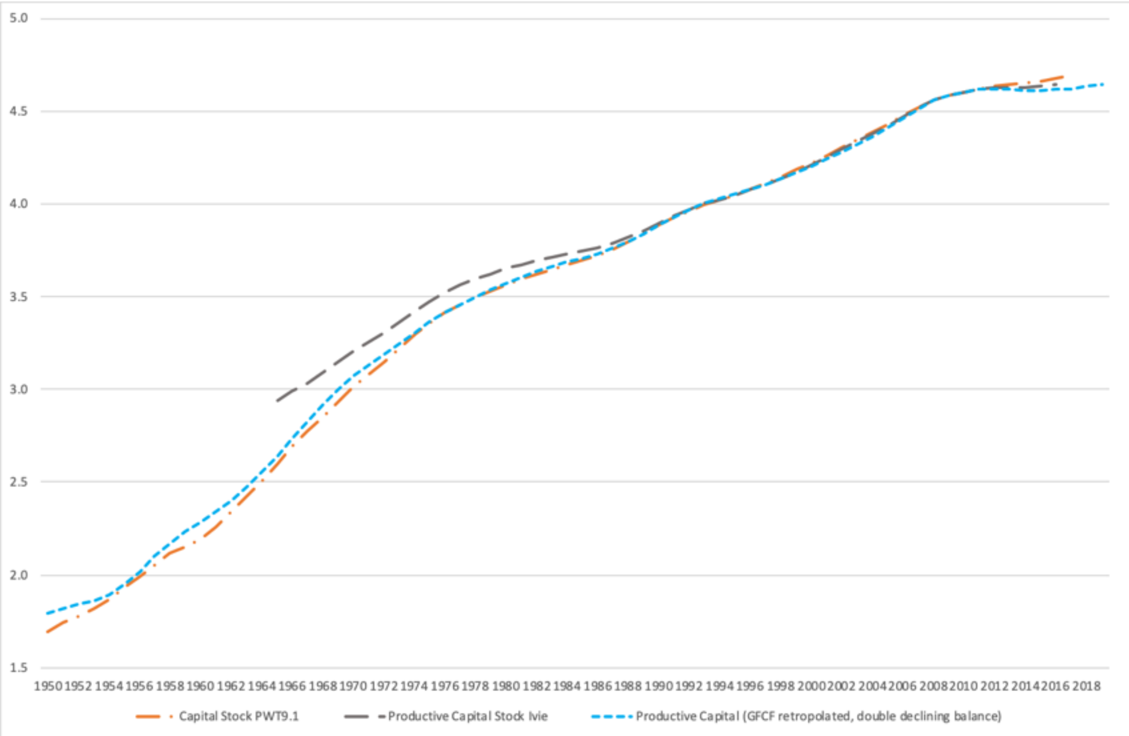

Figure 4b. Productive Capital Stock derived with GFCF retropolated series and double declining balance geometric depreciation, 1950-2019. Comparison with PWT9.1 and Ivie Estimates (2010=100) (logs)

III. Capital Services

We can now proceed to compute the capital input, that is, the flow of capital services into production. To do so, a volume index of capital services is derived as a weighted average of productive stock indices by type of asset in which each asset's share in total user cost of capital (that is, the current value of capital services) are the weights. This procedure implies that, for each asset, its flow of capital services is proportional to its productive stock, although the rate of variation of capital services differs across assets (Jorgenson and Griliches, 1967).

Thus, we need to compute the unit user cost of capital for each asset, that is, the price of capital services per unit of productive stock, and represents the marginal returns an asset generates during one period of production (OECD, 2009). Once obtained, the unit use cost, F_0^t, is multiplied by the asset's productive capital stock, $K^{k,t}$, to derive the value of its capital services, $U^{k,t}$. Adding up all assets' values we get the total value of capital services, U^t.

Different rates of return have been used to compute the unit user cost in empirical studies. The *ex-post* endogenous rate of return is the realised rate of return and, in principle, preferable. For example, The Penn World Tables 9.1 (Feenstra et al., 2015, updated) and Conference Board (2020) use it. An *ex-post endogenous* rate of return equals the value of capital services to capital compensation in national income (that is, the gross operating surplus plus the capital share in gross mixed income), which is consistent with an economy of perfect competition and constant returns to scale (OECD, 2009).[15] The use of an *ex-post endogenous* rate of return requires, however, a complete coverage of all assets and a distinction between market and government sectors. Otherwise, the rate of return will be biased.[16] Unfortunately, our data do not meet such stringent requirements.

The alternative is, then, to compute an ex-ante rate of return, that is, the one expected by the investor.[17] In an ex-ante approach, the rate of return for investment on a given asset should not be higher than in an alternative investments of comparable risk. The OECD Manual (OECD, 2009) recommends working with real rates of return

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[15] Thus, the endogenous, ex-post rate of return for every period is computed by equating capital compensation G^t <u>plus</u> capital related taxes on production T_K^t to the total user costs of capital U^t

$G^t + T_K^t = U^t = \Sigma_{k=1}^N P_0^{k,tB} (1+\rho^t) [r^{t*} + \delta^k(1+i^{k,t*}) – i^{k;t*}]K^{k,t}$ (7)

From which the ex-post endogenous real rate of return can be derived,

$r^{t*} = \{(G^t + T_K^t) (1+\rho^t) - \Sigma_{k=1}^N P_0^{k,tB} [\delta_0^k(1+i^{k,t*}) – i^{k;t*}]K^{k,t}\}/\{ \Sigma_{k=1}^N P_0^{k,tB} K^{k,t}\}$ (8)

Then, the ex-post user cost per unit of capital services for a particular type of asset is obtained as

$F_0^t = P_0^{k,tB} (1+\rho^t) [r^{t*} + \delta_0^k(1+i^{k,t*}) – i^{k,t*}]$ (9)

where G^t Non-labour income consists of gross operating surplus and the part of mixed income that can be attributed to capital

T_K^t taxes on production

$P_0^{k,tB}$ is the purchase price of a new asset at the beginning (^{B}) of year t

ρ^t is the rate of change of the consumer price index at the beginning of period t

r^{t*} is the real rate of return that applies at the beginning of period t

δ^k is the rate of depreciation for a new asset k

$i^{k,t*}$ is the ex-post, real rate of asset price inflation for asset k during period t

$K^{k,t}$ is the productive capital stock of asset k during period t

[16] Upwards biased if coverage is incomplete, since capital income will be compared to an under-valued capital stock, and downwards biased if no clear distinction is made between market and government sectors since, probably, only market capital income will be compared to the value of the total capital stock.

[17] Nonetheless, capital services have also been derived using an ex-post endogenous rate of return in order to provide a contrast to the ex-ante exogenous estimates. See Appendix C.

and real changes in asset prices as they are independent from inflation and less volatile, and, in particular, suggests a 4% real rate of return, which is close to Spain's historical rate, and adopted in Ivie's estimates (Pérez et al., 2019).[18] In fact, assuming a fixed real rate of return on investment matches one of Kaldor's (1957) stylised facts, namely, the rate of return on investment is roughly constant over long periods of time. It can be objected, though, that when an ex-ante exogenous rate of return is chosen the resulting value of capital services may not match capital compensation in national income.

The ex-ante unit user cost, or capital service price, F_0^t, can be defined as

$$F_0^t = P_0^{k,tB} (1+\rho_{(tB)}) [r_a^* + \delta_0(1+i_{(tB)}^*)- i_{(tB)}^*] \qquad (10)$$

The ex-ante user cost of an asset,

$$U^{k,t} = F_0^t K^{k,t} \qquad (11)$$

And the total user cost of capital,

$$U^t = \Sigma_{k=1} U^{k,t.} \qquad (12)$$

being $P_0^{k,tB}$ the purchase price of a new asset at the beginning (^{B}) of year t,

$\rho_{(tB)}$ the rate of change of the price index (GDP deflator) at the beginning (^{B}) of year t,

r_a^* the real rate of return (the nominal rate corrected for inflation), 4%, in this case,

$i_{(tB)}^*$ the real anticipated change in asset prices at beginning (^{B}) of year t,

δ_0 the rate of depreciation of a new asset,

$K^{k,t}$ the productive capital stock of asset k during period t

Furthermore, a simplified ex-ante exogenous rate of return can be derived by setting the anticipated real holding gains term i^{*t} equal to zero. Although this approach has the advantage that does not require to estimate anticipated real holding gains, it is only a reasonable alternative if asset price changes do not deviate significantly from changes in the GDP deflator. The resulting user cost, then, becomes,

$$SF_0^t = P_0^{k,tB} (1+\rho_{(tB)}) [r_a^* + \delta_0] \qquad (13)$$

Lastly, a Törnqvist index of aggregate capital services is computed as,

$$\ln(KS^{k,t}/KS^{k,t-1}) = \Sigma\bar{v}^{k,t} \ln(K^{k,t}/K^{k,t-1}) \qquad (14)$$

[18] Actually, in ivie's estimates 4% real rate of return is chosen for the market sector and 3.5% rate for the non-market sector. The average real rate of return of bank deposits in Spain since 1850 is 4.5% (computed from underlying data in Prados de la Escosura and Rosés (2010), updated to 2019.

where $K^{k,t}$ is the productive capital stock of asset k and $\bar{\upsilon}^{k,t} = \frac{1}{2} (\upsilon^{k,t-1} + \upsilon^{k,t})$ the two adjacent year average share of each asset in total user cost of capital, being $\upsilon^{k,t} = U^{k,t}/U$. Then, the volume index of capital services (VICS) is obtained as the exponential.

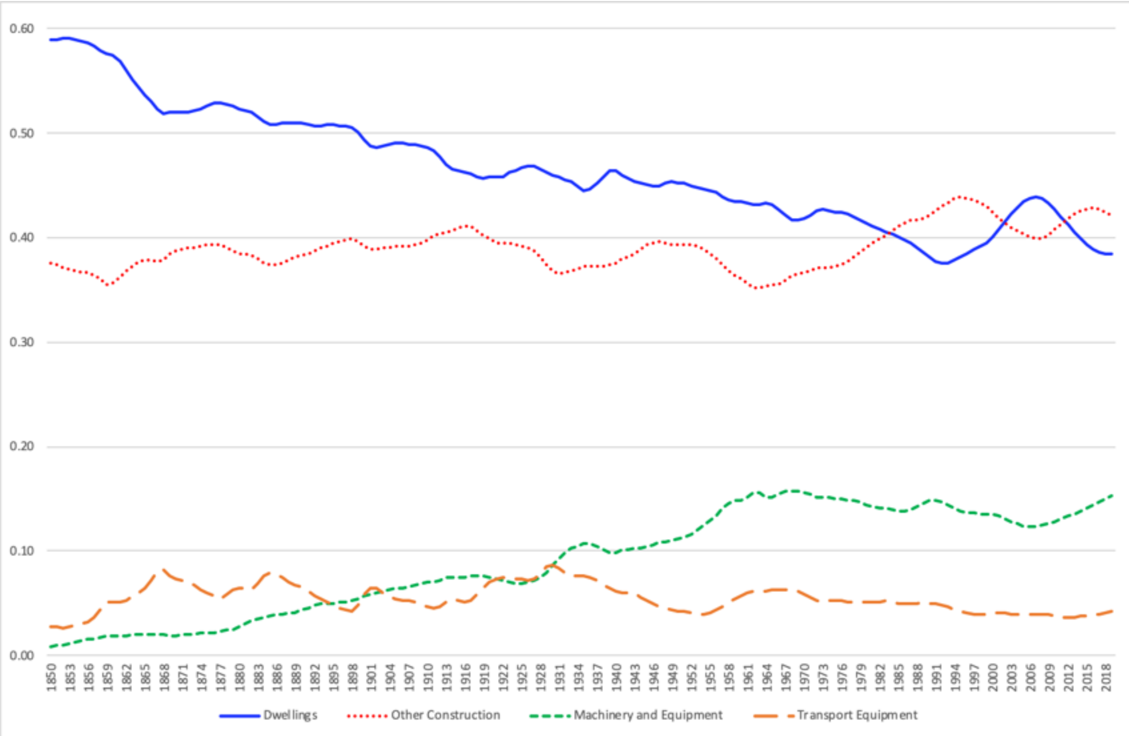

Figure 5. Net Capital Stock Composition (current prices) (%)

It is worth noting the different weighting of the capital stock (the share of assets in its total current value) and the index of capital services (the share of assets in total returns to capital). Figure 5 shows the composition of the net capital stock, dominated by structures (dwellings and other construction) that in spite of the long-term fall in the share of dwellings until the early 1990s and the rise of machinery and equipment up to the early 1960s, still contribute four-fifths of the net capital stock value in 2019. A different and more volatile picture results from the composition of capital returns as assets with lower average service lives (and, hence, higher depreciation rates) have higher marginal returns (Figure 6). Thus, machinery and equipment matches the share of other construction since mid-20th century and the share of dwellings declines more than in the net capital stock.[19]

[19] Similar trends, although less marked, and machinery and equipment never matches other construction, are observed when the ex-post endogenous rate of return is used (Figure A1).

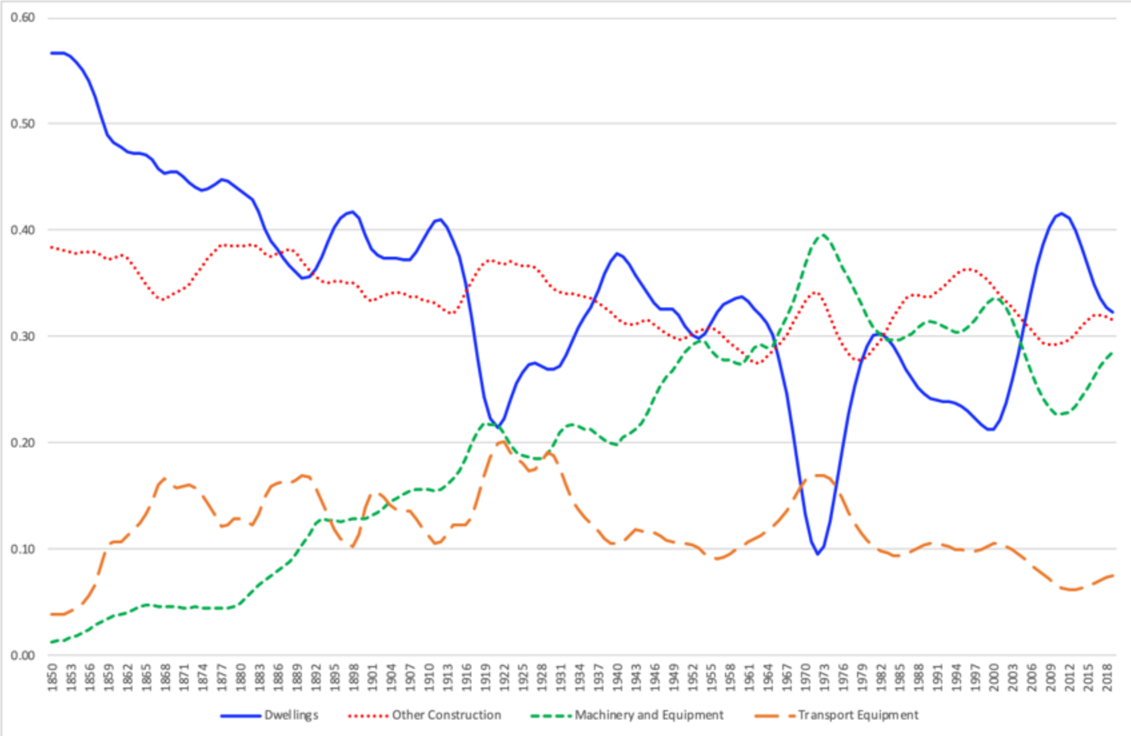

Figure 6. Capital Services' Composition (ex-ante exogenous rate of return) (current prices) (%)

But how different is the composition of capital services when they are obtained with the simplified ex-ante exogenous rate of return, as favoured in Ivie's estimates (Pérez et al., 2019)? Similar but less volatile trends appear even though machinery and equipment's remains below other construction's share (Figure A2), but the validity of the simplified approach depends on the stability of relative GFCF prices.

Figure 7 offers the evolution of the price of each type of asset relative to the GDP deflator and shows how they fluctuate.[20] For example, the relative price of both machinery and transport equipment experienced a decline between the late 1850s and 1880s, that coincided with the railways construction and the early stage of industrialisation, and a sustained fall from the 1950s, steeper until the late 1970s. Embodied technological change in helps explain these assets' trends. Thus, assuming that assets' prices mimic the general price index is unrealistic and alters the weighting of the volume index of capital services.

[20] Similar results are obtained using the private consumption deflator.

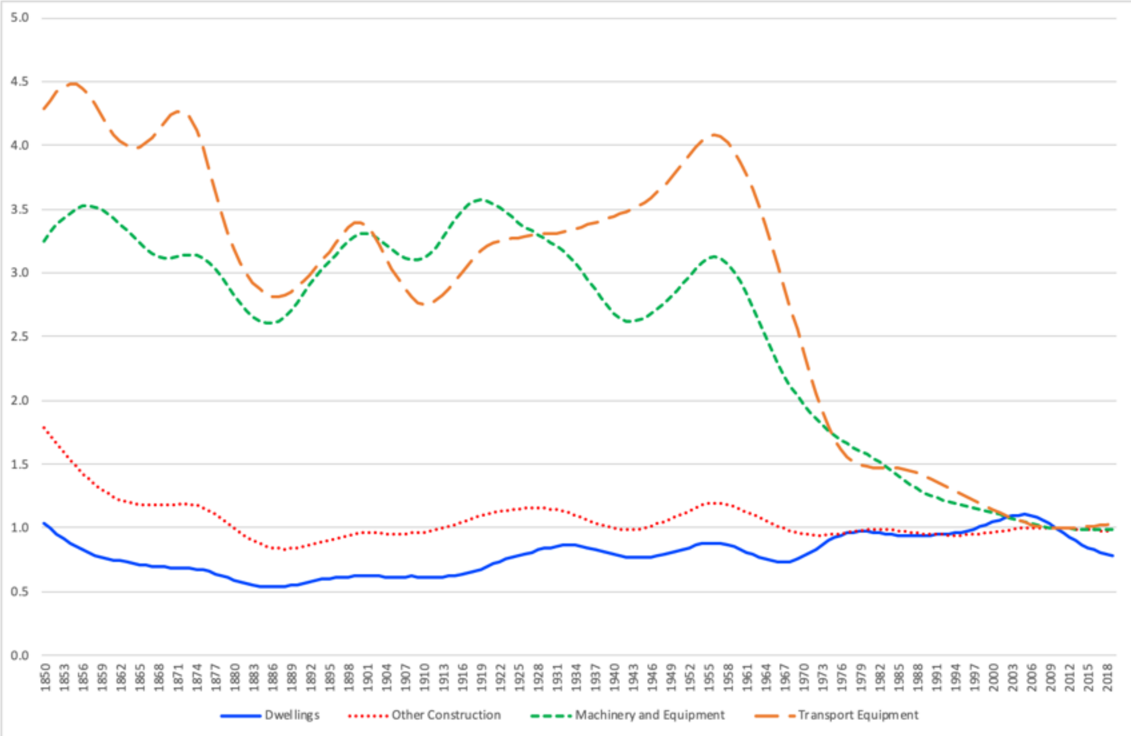

Figure 7. GFCF Prices Relative to the GDP Deflator (2010=1) (Hodrick-Prescott smoothed)

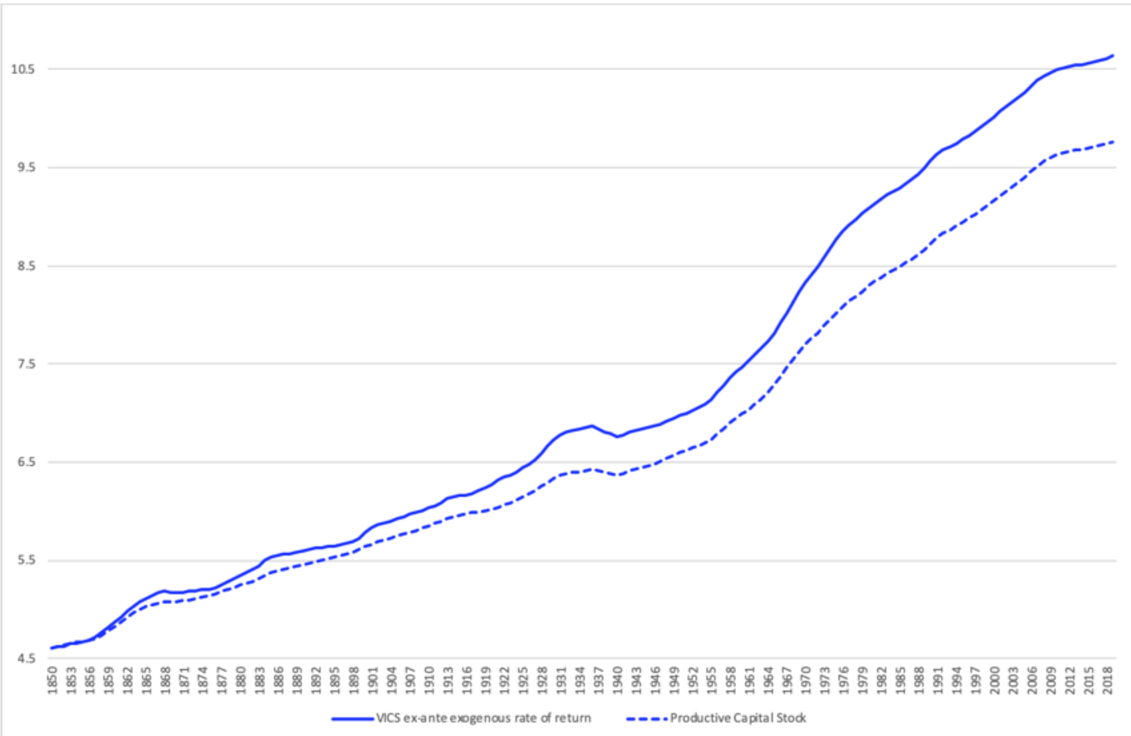

Figure 8. Volume Index of Capital Services (ex-ante exogenous rate of return) and Productive Capital Stock, (1850=100) (natural logs)

The different weighting of the net capital stock and capital services also reflects in the evolution of productive capital stock and the volume index of capital services since VICS grows faster than PKS as more dynamic assets are usually those of shorter average service life but higher returns. Figure 8 confirms their divergent evolution that has widened since the 1970s.[21]

An index of capital "quality" that measures the capital input's composition effect can be derived as the ratio between the volume index of capital services and that of productive capital stock,

$$KQ^{k,t} = KS^{k,t} / K^{k,t} \qquad (15)$$

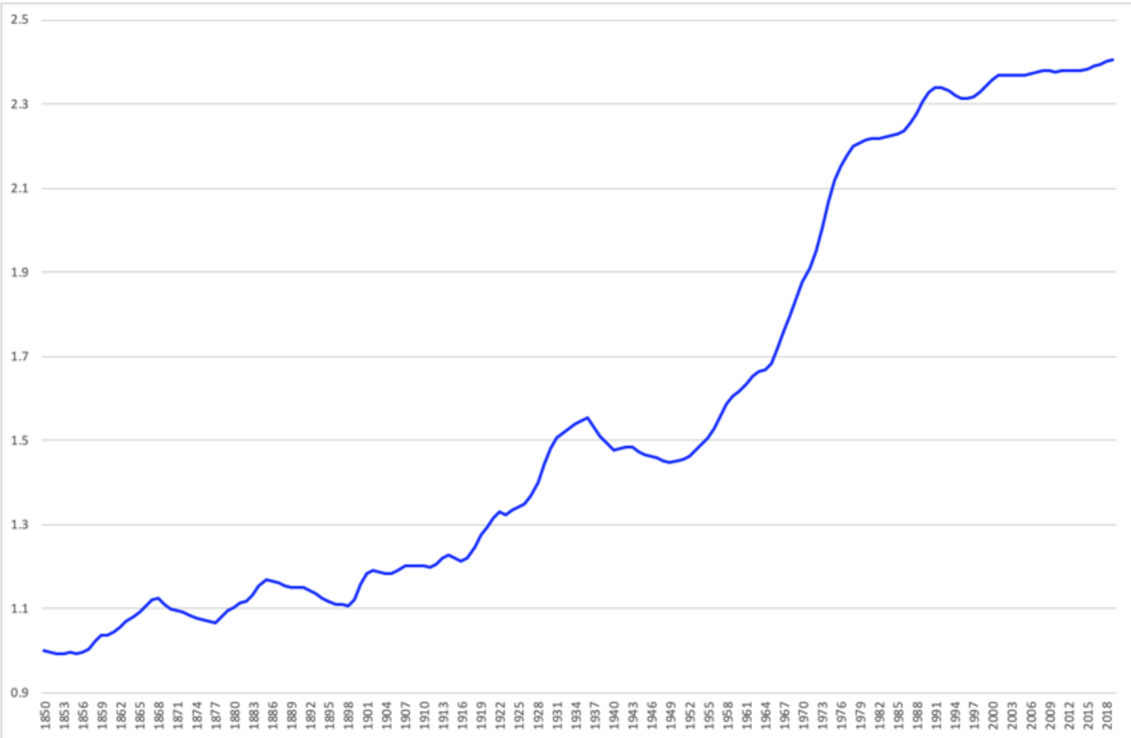

Figure 9. Capital Quality (ex-ante exogenous rate of return) (1850=1)
Note: Capital Quality = Ratio of Volume Index of Capital Services to Productive Capital Stock

Figure 9 shows a long run increase in the "quality" of capital, punctuated by reversals, in which a contraction during the Civil War (1936-39) and its autarkic aftermath (1939-53) and a fast increase between the mid-1950s and the late 1970s, followed by deceleration, stand out. A rise in the index signals a shift towards capital goods with higher unit user costs and, hence, higher marginal productivity.[22]

[21] The gap is narrower gap when VICS is obtained with an ex-post endogenous, rather than an ex-ante exogenous rate of return. This finding is consistent with the presumed underestimate of capital services derived with an ex-post endogenous rate of return when information on capital assets is incomplete as it is our case (Figure A3).

[22] Although the evolution of "quality" of capital using alternatively ex-ante exogenous and ex-post endogenous rates of return share the same tendencies, the level of capital "quality" is lower for the

It is worth stressing that the VICS derived with the full and simplified ex-ante exogenous rate of return are practically identical until 1970 when the 'simplified' VICS lags gradually behind the "full" VICS (Figure A4). Thus, the choice of a 'simplified' VICS underestimates the improvement in capital quality since the late 1960s (Figure A6b).

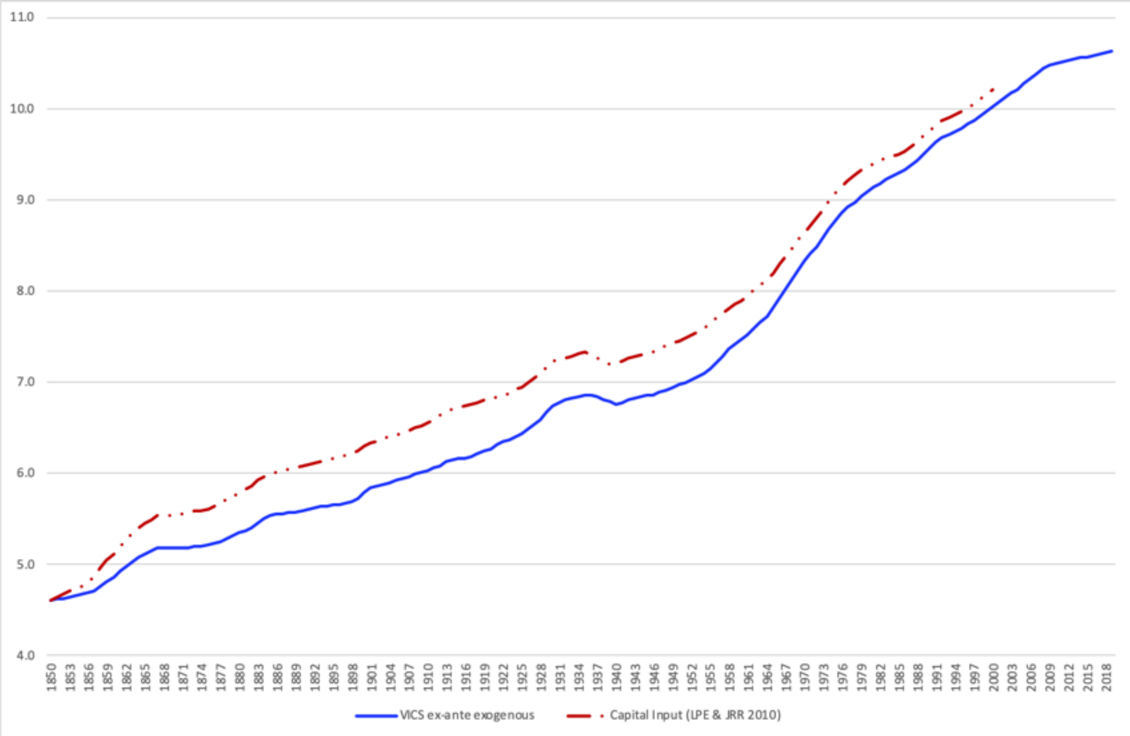

Figure 10. Volume Index of Capital Services*: Comparison with Prados de la Escosura and Rosés (2010) (1850=100) (natural logs)   *ex-ante exogenous rate of return

A comparison between the new volume index of capital services and earlier estimates is pertinent. In the first place, let us compare the new results with Prados de la Escosura and Rosés (2010) estimates, under similar assumptions (namely, Hulten and Wykoff's declining balance depreciation rates and GFCF series spliced through interpolation). A common pattern is found but the new VICS presents lower levels, although tend to converge in the late 20th century (Figure 10). Such a difference may derive from the lower (and fixed) average service lives used here, while Prados de la Escosura and Rosés employed higher (and variable) average service lives, which, by increasing the gross stock and reducing depreciation, result in a larger net capital stock.

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latter as could be anticipated due to the possible underestimate of capital services when they are computed with incomplete information (Figure A6a).

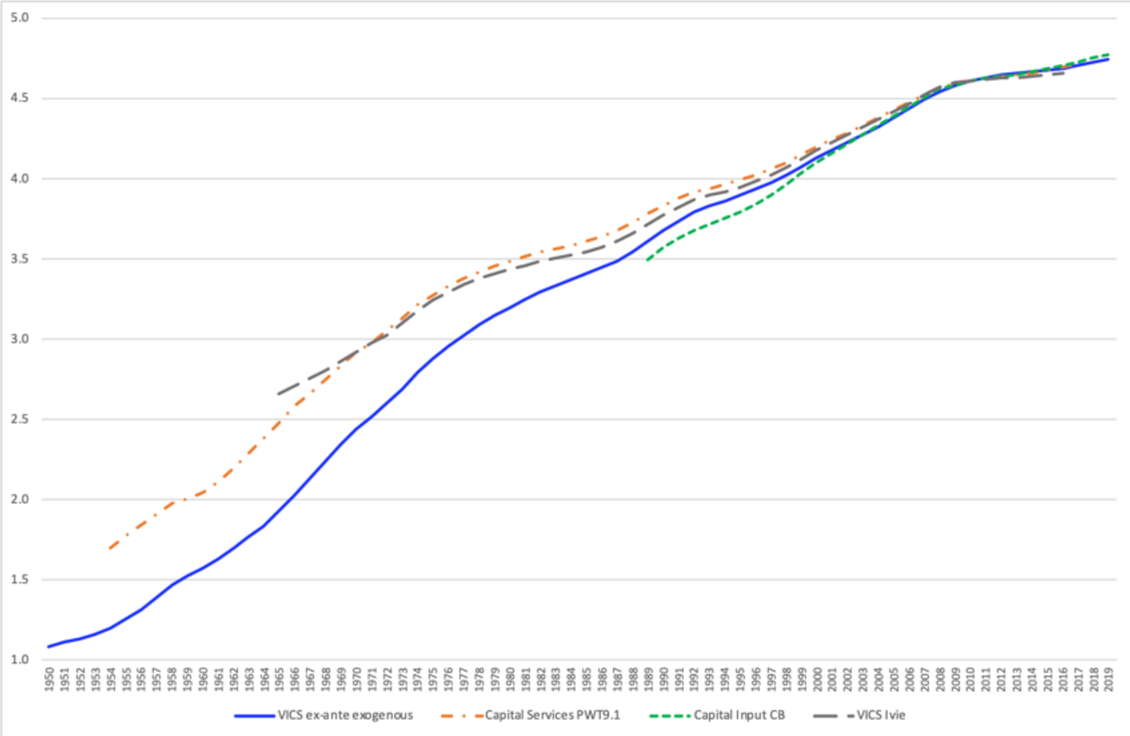

Figure 11a. Volume Index of Capital Services: Comparison with PWT9.1, CB, and Ivie Estimates, 1950-2019 (2010=100) (natural logs)

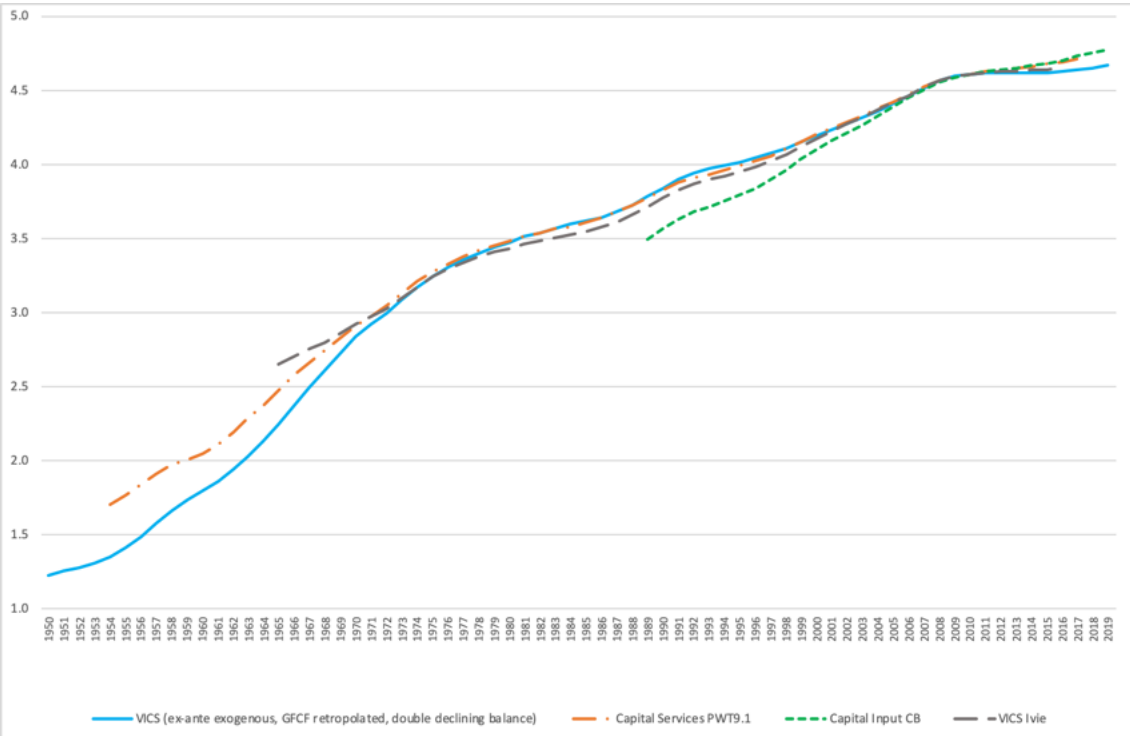

Figure 11b. VICS, 1950-2019. Alternative estimates derived with GFCF retropolated series and double declining balance Comparison with PWT9.1, CB, and Ivie Estimates (1850=100) (natural logs)

Another contrast is carried out with VICS derived by PWT9.1 and Ivie (Pérez et al., 2019) to which Conference Board (2020) estimates since 1990 have been added. Slower growth result from PWT9.1 and Ivie series, but slightly faster from the Conference Board series (Figure 11a).[23] The main explanation of the different pace of growth is that both PWT9.1 and Ivie estimates are based on pre-1995 GFCF series spliced through retropolation, unlike the new VICS that draw on GCFC interpolated series. Figure 11b confirms that when VICS are derived using retropolated GFCF series and double declining balance geometric depreciation, the gap with PWT9.1 and Ivie narrows down sharply, especially from the late 1970s onwards. Moreover, as PWT9.1 estimates are derived with an ex-post endogenous rates of return, the differential narrows further down when the new VICS are computed with this rate of return (Figure A8). The comparison in terms of capital quality, that is, the ratio between capital services and productive capital indices, reveals that quality gains are much larger in the new estimates and Ivie's than in the PWT9.1 ones (Figure 12).[24]

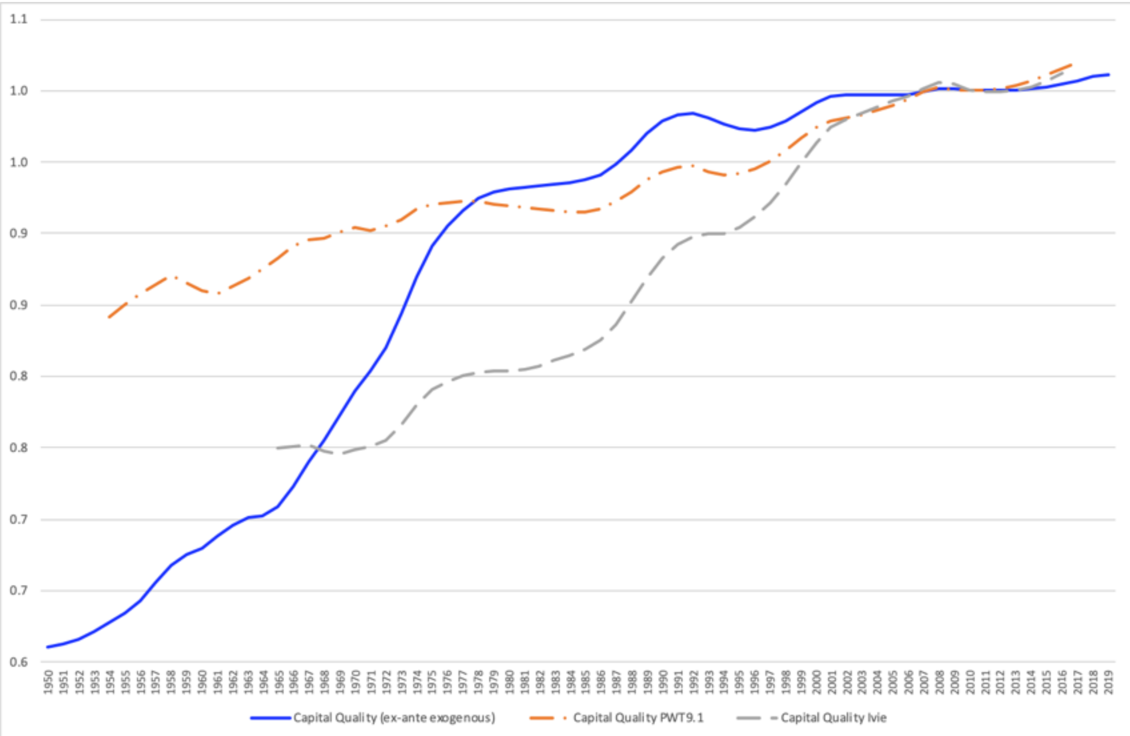

Figure 12. Capital Quality: Comparison with PWT9.1 and Ivie Estimates, 1950-2019 (2010=1)

[23] See Figure A7 for a comparison that included the new estimates derived with both ex-ante exogenous and ex-post endogenous rate of return.
[24] Figure A9 adds up the new estimates of capital quality derived with ex-post endogenous rate of return that exhibits milder gains than when obtained with the ex-ante exogenous rate of return..

Table 2. Capital input* Growth, 1850-2019 (annual average logarithmic rates %)
*ex-ante exogenous rate of return

	Productive Capital Stock	Capital Quality	Capital Input
1850-2019	3.0	0.5	3.6
1850-1872	2.2	0.4	2.6
1873-1892	1.9	0.2	2.2
1893-1913	2.1	0.3	2.4
1914-1919	1.2	0.7	2.0
1920-1929	3.0	1.3	4.2
1930-1935	2.0	1.1	3.2
1936-1939	-0.8	-0.9	-1.7
1940-1945	1.4	-0.3	1.1
1946-1953	2.5	0.1	2.6
1954-1958	4.6	1.4	6.1
1959-1975	6.6	1.7	8.3
1976-1985	4.7	0.5	5.2
1986-2007	4.6	0.3	4.9
2008-2013	2.7	0.0	2.7
2014-2019	1.4	0.2	1.6

What are the observed trends in capital input? Capital services grew at 3.6% during the last 170 years but its pace was uneven. It is possible to distinguish a period of steady growth, slightly above 2% per year, up to 1920, in which the compositional change of capital (capital quality) represented a minor proportion (Table 2). In the 1920 the growth rate doubled, with more than one-third contributed by capital quality. The slowdown of the early 1930s did not revert to the pre-1920 growth, thanks to its compositional change. After shrinking during the Civil War and recovering mildly in World War II years, capital input growth went back to its pre-1920 growth trend until the mid-1950s when began an acceleration that lasted for half a century and was cut short by the onset of the Global Financial Crisis (2008). During Spain's delayed and short Golden Age (1959-75) capital input growth was nearly four-fold that of the pre-1920 era, with capital quality contributing at least one-fifth of it. The oil shocks that coincided with the decade of 'transition to democracy' (1976-85) represented a substantial slowdown in absolute and per capita GDP but not in terms of capital input that, with hardly any quality improvement, kept growing at 5% yearly during the 'transition' decade and after Spain's accession to the European Union. The

Great Recession (2008-13) nearly halved the post-1975 rate of capital services growth and, since 2014, capital input has been growing at the slowest pace since World War II.

Table 3. Capital Deepening* Growth, 1850-2019 (annual average logarithmic rate %)
*ex-ante exogenous rate of return

	Productive Capital Stock/hour	Capital Input/hour
1850-2019	2.6	3.1
1850-1872	1.6	2.0
1873-1892	1.9	2.1
1893-1913	1.5	1.8
1914-1919	0.8	1.6
1920-1929	2.3	3.6
1930-1935	0.4	1.6
1936-1939	-0.1	-1.1
1940-1945	0.7	0.4
1946-1953	1.2	1.3
1954-1958	3.9	5.3
1959-1975	6.4	8.1
1976-1985	7.8	8.3
1986-2007	2.2	2.5
2008-2013	5.7	5.7
2014-2019	-0.8	-0.6

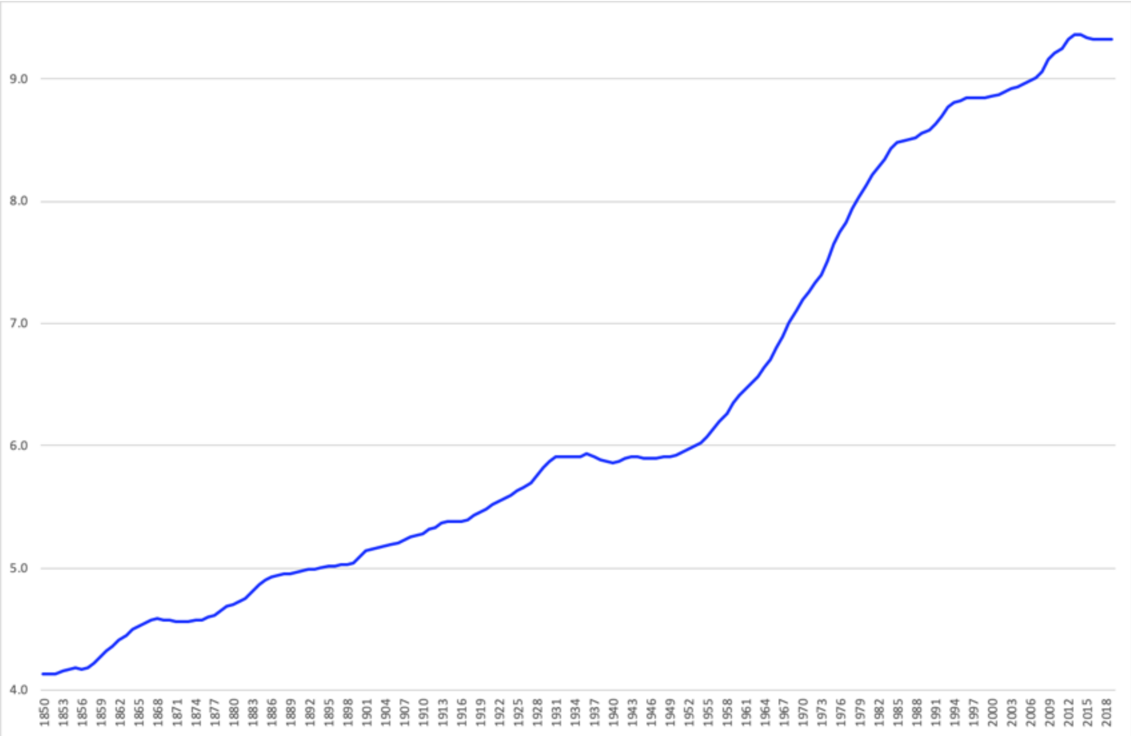

Figure 13. Capital Deepening* (2010=100) (natural logs of x100 level)
Note: * Volume Index of Capital Services (ex-ante exogenous rate of return) per Hour Worked.

If we look now at the volume of capital services per hour worked, that is, capital intensity or deepening, it grew steady up to 1930 and after nearly stagnating for two decades, it expanded at an accelerated pace between the early-mid 1950s and mid-1980s (Table 3 and Figure 13). Capital deepening slowed down thereafter, particularly between the mid-1990s and 2007 and, after a spurt during the Great Recession, has declined mildly in recent years. A comparison with alternative capital deepening figures shows that the new estimates grew faster than those resulting PWT9.1 and slightly slower than Conference Board's since 1989 (Figure 14).

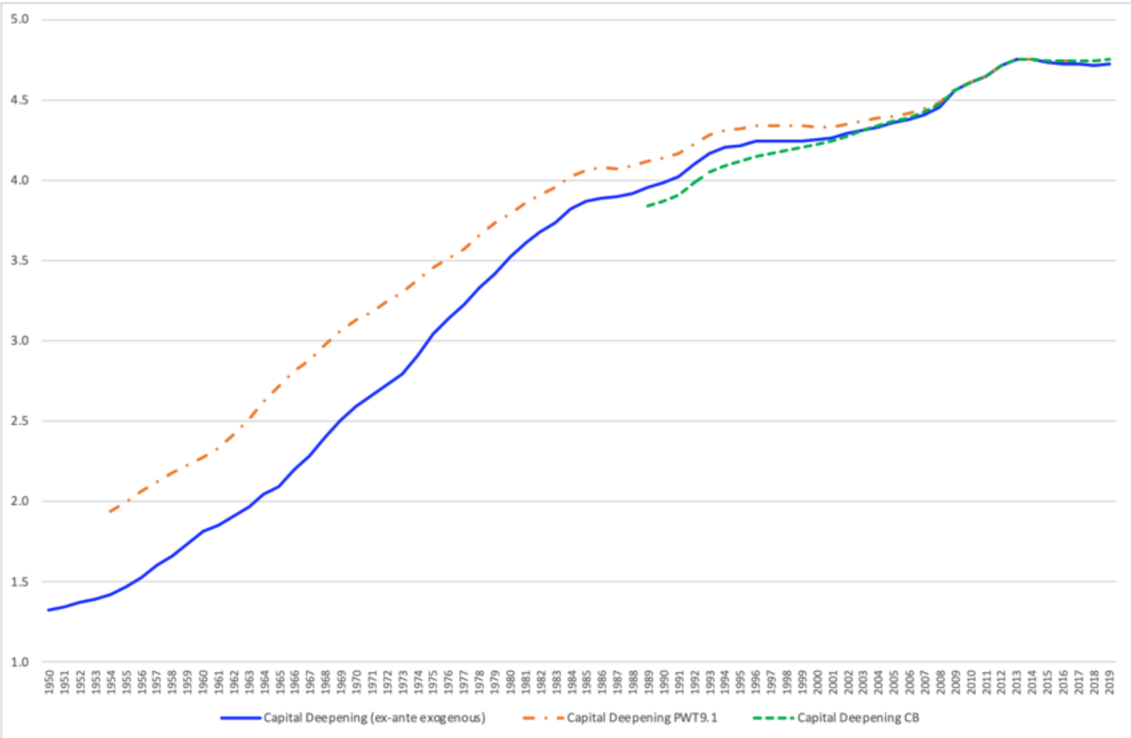

Figure 14. Capital Deepening*, 1950-2019: Comparison with PWT9.1 and Ivie (2010=100) (natural logs)
* Volume Index of Capital Services (ex-ante exogenous rate of return) per Hour Worked.

It is worth highlighting the inverse association between capital deepening and employment growth in post-Franco's Spain (Figure 15). Employment destruction during the decade of 'transition to democracy' (1976-85) and the Great Recession (2008-13) contribute to explain capital deepening in those years; conversely, from the accession to the EU to the onset of the Global Financial Crisis (1986-2007), and in the post-2014 recovery, employment creation underlies the deceleration and contraction in capital deepening. Thus, capital deepening slowdown since 1986 suggests that expanding sectors have not attracted much investment-specific technological progress.

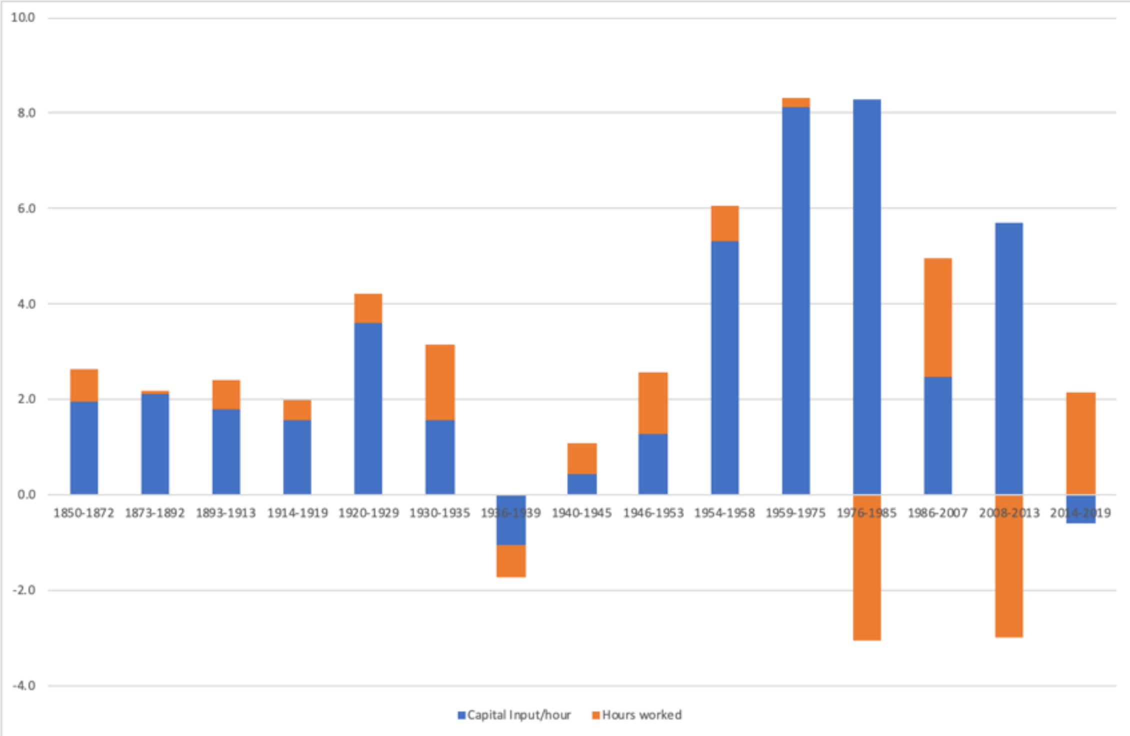

Figure 15. Volume Index of Capital Services* (ex-ante exogenous rate of return): Growth Breakdown (%)
Note: * VICS = VICS/hour x Hours worked

IV. Capital-Output Ratio and Capital Consumption

Capital has a dual nature as a storage of wealth and provider of capital services to production (OECD, 2009). So far the focus has been on capital services. Let us now look at the evolution of wealth or net capital stock.

Piketty's (2014) claim of a fluctuating capital-output ratio going back to the 18th century has challenged one of Kaldor's (1957) stylised facts. namely, the stability of the capital-output ratio. Such claim is, nonetheless, hardly news for economic historians who have long been sceptical about empirical regularities. Prados de la Escosura and Rosés (2010) challenged the long-run stability of the capital-output ratio, and Gallardo-Albarrán and inklaar (2020) have rejected it for more than 30 countries over the last hundred years.

The evolution of Net Capital Stock ratio to GDP, expressed at current prices, shows that after declining until the early 1880s, a sustained increase took place, with the capital-output ratio rising 4-fold between 1886 and 2013 (Figure 16). A first phase of expansion reached up to the early 1930s, in which the ratio more than doubled, peaking during the Civil War (1936-39) for economic activity severely contracted. Relative stability from the late 1940s to 1960, with the ratio ranging between 2.0 and

2.5, was followed by a dramatic fall until the mid-1960s, at a time of fast economic growth, and a subsequent recovery that heralded a strong and sustained increase in the capital-output ratio, punctuated by reversals in the late 1980s and, again, in the late 2010s.

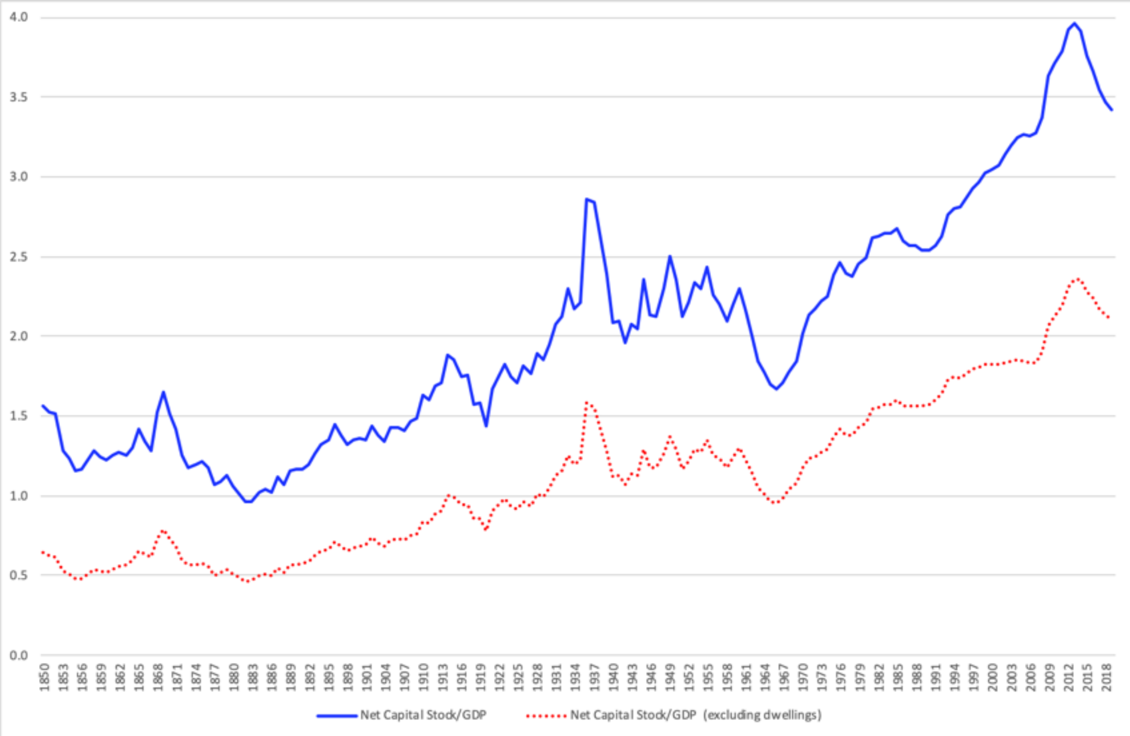

Figure 16. Net Capital Stock/GDP Ratio (current prices): With and Without Dwellings

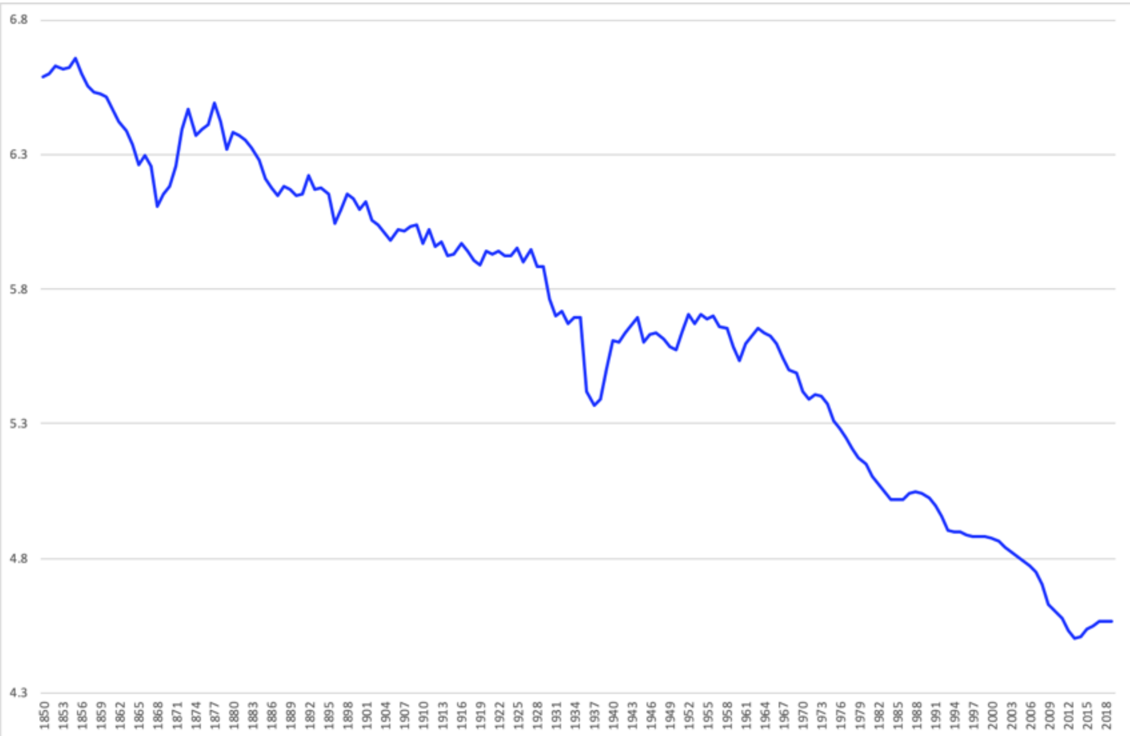

Figure 17. Capital Productivity (ex-ante exogenous rate of return) (2010=100) (natural logs)
Note: Capital Productivity: Ratio of Real GDP to Volume Index of Capital Services

The sustained rise of the capital-output ratio and capital deepening led to the decline of capital productivity (that is, real GDP per VICS) over the long run (Figure 17).

From the late 1990s low interest rates and the scarcity of urban land fuelled a boom in the price of dwellings -as the increase in the relative price of dwellings until the mid-2000s confirms (Figure 7)- that contributed to the rise of the capital-output ratio. That is why the capital-output ratio excluding dwellings is also presented. The same trends, but with less intensity, are confirmed.

The evolution of the capital-output ratio in Spain matches the experience a large sample of countries during the last century in which the capital output ratio doubled (Gallardo-Albarrán and Inklaar, 2020), although the increase seems to have been more intense in the Spanish case, unlike the UK's where the capital-output ratio stopped its expansion and declined during the last two decades of the past century (Oulton and Wallis, 2016). By 2013, the capital (wealth)-output ratio at current prices reached a value of 4, when it was just 2 in 1970, in line with Piketty and Zucman (2014) findings for western European countries. However, this represents practically half the ratio of personal wealth to national income estimated for Spain, although it also doubled during the same time span (Artola Blanco et al., 2018). A necessary caveat is that private wealth estimates add financial assets to the net capital (wealth) stock (that is, non-financial assets), while exclude financial liabilities.

The consumption of fixed capital, expressed as a proportion of GDP, follows the pattern of the capital-output ratio, jumping from 3 to nearly 15% between the late 1880s and 2013 (Figure 18). However, when the ratio of capital consumption to net capital stock -that is, the depreciation rate- is considered, it expanded up to the mid-1930s and, again, since 1950, peaking in the late 1960s, and, then, declined steadily until the mid-2000s, to rebound later. What explains this behaviour? As the composition of capital stock changes towards more productive but higher depreciation assets, one would expect a rise in the depreciation rate. However, new capital goods are more productive as they embodied new vintage technology, so a decline in its relative prices would accompany its expansion (Figure 7) and helps explain the fall in the rate of depreciation between 1970 and 2007.[25]

[25] It is worth stressing that the described patterns for the capital-output ratio and the consumption of fixed capital are confirmed for alternative estimates derived using different average service lives and

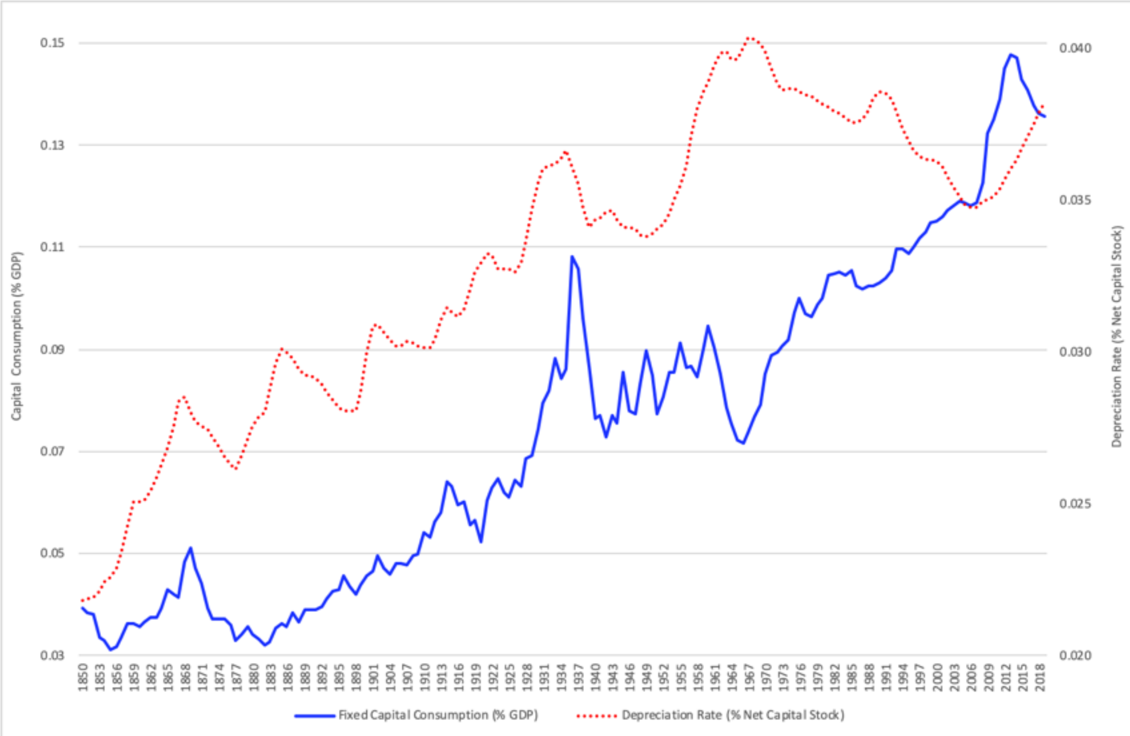

Figure 18. Consumption of Fixed Capital (% GDP) and Depreciation Rate (CFC as % Net Capital Stock), (current prices).

VI. Conclusions

The on-going debate on the rising trend in the capital-output ratio and the productivity slowdown requires long run, consistent, and integrated series of output and production factors. This paper presents new estimates of net capital (wealth) stock and capital services for Spain during the last 170 years that allow us to address welfare and growth issues.

The new net capital stock estimates are not off the mark when compared to official national statistical series for the early 21st century and their differences for the last half a century with the Penn World Tables 9.1 and Ivie's figures largely result from methodological differences.

Capital services expanded over time accelerating in the 1920s and between the mid-1950s and 2007, with capital 'quality' contributing until 1975. Capital deepening increased in the long-run, especially from 1955 to 1985, slowing down after Spain's

depreciation rates. Longer lives, by reducing depreciation, increase the level of net capital stock (Figure A11), and the use of the double declining balance implies higher depreciation rates which increases capital consumption and, hence, reduces the level of net capital stock (Figure A12), while increases the ratio of the consumption of fixed capital ratio to GDP and net capital stock, respectively (Figure A13).

accession to the European Union, as expanding economic sectors attracted less investment-specific technological progress.

The net capital (wealth) stock-GDP ratio rose over time, contradicting Kaldor's (1957) stylised fact while confirming Piketty and Zucman (2014) results. Although the consumption of fixed capital (% GDP) shadowed the capital-output ratio, the rate of depreciation fell from 1970 to the onset of the Global Financial Crisis as new capital goods' relative prices declined due to embodied technological change.

The inverse association between capital deepening and employment growth in post-Franco's Spain mimics the behaviour of labour productivity, which raises when employment falls and declines when employment expands (Prados de la Escosura, 2017). How much did capital deepening contribute to raising labour productivity over the long run? Providing an answer is the matter for a new investigation.

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Appendix A. A Note on Splicing GFCF Series in Spain's National Accounts

Available national accounts' series are provided for different and usually short periods on the basis of different benchmark or reference years and different methodologies. In order to present a single homogeneous series, splicing is required. There is no consensus on how to do it. The most frequent splicing procedure has been retropolation in which the value provided by the latest benchmark estimate is projected backward with the rate of variation for previous benchmark series so the earlier series is re-scaled to match the new benchmark level. The practical advantage is that it preserves the rate of variation of the earlier benchmark series. On the downside, however, retropolation tends to overexaggerate past levels since new rounds of national accounts introduce new definitions and classifications and new sources and estimation procedures that usually translate into higher levels for the new benchmark series at the year in which the new and the old benchmark series overlap.

The interpolation method, instead, accepts the levels computed directly for each benchmark-year as the best possible estimates -as they are computed with 'complete' information on quantities and prices-, and distributes the gap between the 'new 'and 'old' benchmark series in the overlapping year at a constant rate over the time span in between the old and new benchmark years. By respecting the levels for the different benchmark years, the interpolation method alters the rate of variation, unlike the retropolation method. The consequence is that earlier levels are usually lower in the interpolated series than in the retropolated series.

In other words, the retropolation method presumes the error lies in the level of the 'old' series, but not in its rate of variation. The interpolation method challenges this assumption and deems the cumulative result of the emergence of new goods and services, not considered in the old benchmark series, the source of error.

The interpolation method appears provides a superior alternative, supported by the fact that recent rounds of national accounts have chosen it. In the case of Spain, for 1995-2019, national accounts provide spliced estimates in which, once adjustments are made for methodological changes, the different benchmark series are interpolated (Prados de la Escosura (2016, 2017). Thus, the dilemma about the splicing method refers only to the pre-1995 period (with the exception of 198-86 in which national accounts were also interpolated).[26]

More specifically, since the 2000 benchmark (CNE00) the *interpolation* method was used after adjusting upwards the old benchmark series for methodological changes. Thus, the gap between, say, CNE15 and CNE10 in the year 2015, was decomposed into methodological and statistical plus other differences. Firstly, CNE10 series for 2010-2014 were adjusted upwards for methodological discrepancies with CNE15. Then, the *residual* gap, due to statistical and other differences, was distributed at a constant rate throughout the in-between benchmarks years, 2011-2014.[27] A detailed discussion of the splicing of Spanish national accounts and the available alternatives is provided in Prados de la Escosura (2017, Ch. 9) https://link.springer.com/chapter/10.1007/978-3-319-58042-5_9

[26] A break in the linkage of GDP series through retropolation was introduced in CNE86, when national accounts were spliced using the interpolation approach and the GDP differential between CEN86 and CEN80 in 1985 was distributed at a constant rate over the years 1981-1984.

[27] The Spanish Statistical Institute notes, for example, "The [remaining] differences between both estimates [say, CNE00 and CNE95 in the year 2000] are due to the statistical changes, and given that information is not available regarding how and at what time they have been generated, it is assumed that this has occurred progressively over time, from the beginning of the previous base" (INE, 2007: 5).

Appendix B. Statistical Series

Table A1
Net Capital Stock and Consumption of Fixed Capital, 1850-2019 (million current Euro)

	Dwellings	Other Construction	Machinery and Equipment*	Transport Equipment	Total	Consumption of Fixed Capital
1850	24	15	0	1	40	0.9
1851	23	15	0	1	40	0.9
1852	24	15	0	1	40	0.9
1853	24	15	0	1	40	0.9
1854	23	15	1	1	40	0.9
1855	23	14	1	1	39	0.9
1856	23	14	1	1	39	0.9
1857	23	14	1	1	40	0.9
1858	23	15	1	2	41	1.0
1859	24	15	1	2	42	1.1
1860	25	16	1	2	44	1.1
1861	26	17	1	2	46	1.2
1862	27	18	1	3	48	1.2
1863	27	19	1	3	50	1.3
1864	28	19	1	3	51	1.4
1865	28	20	1	3	53	1.4
1866	28	20	1	4	53	1.5
1867	28	20	1	4	54	1.5
1868	28	21	1	4	55	1.6
1869	28	21	1	4	54	1.5
1870	28	21	1	4	54	1.5
1871	28	21	1	4	55	1.5
1872	29	21	1	4	55	1.5
1873	29	22	1	4	56	1.5
1874	29	22	1	4	56	1.5
1875	30	22	1	3	56	1.5
1876	30	22	1	3	56	1.5
1877	30	22	1	3	57	1.5
1878	30	22	1	3	57	1.5
1879	30	22	1	4	57	1.6
1880	30	22	2	4	58	1.6
1881	30	22	2	4	58	1.6
1882	30	22	2	4	58	1.6
1883	30	22	2	4	59	1.7
1884	31	23	2	5	60	1.8
1885	31	23	2	5	60	1.8
1886	31	23	2	5	60	1.8
1887	31	23	2	5	60	1.8
1888	31	23	2	4	60	1.8
1889	31	23	2	4	61	1.8
1890	31	24	3	4	62	1.8

1891	32	24	3	4	63	1.8
1892	33	25	3	4	64	1.9
1893	33	26	3	4	66	1.9
1894	34	27	3	3	68	1.9
1895	35	27	3	3	70	2.0
1896	36	28	4	3	72	2.0
1897	37	29	4	3	74	2.1
1898	38	30	4	3	76	2.1
1899	40	31	4	4	79	2.3
1900	41	33	5	5	84	2.5
1901	43	34	5	6	88	2.7
1902	44	35	5	6	90	2.8
1903	45	36	6	6	92	2.8
1904	46	37	6	5	95	2.9
1905	48	38	6	5	97	2.9
1906	49	39	6	5	99	3.0
1907	50	40	7	5	102	3.1
1908	51	41	7	5	105	3.2
1909	53	43	8	5	109	3.3
1910	56	45	8	5	114	3.5
1911	59	49	9	6	121	3.7
1912	62	53	9	6	130	4.0
1913	67	57	11	7	142	4.4
1914	72	63	12	8	155	4.9
1915	78	69	13	9	169	5.3
1916	85	76	14	9	184	5.7
1917	92	82	15	10	200	6.3
1918	100	89	17	13	218	7.0
1919	108	95	18	15	236	7.7
1920	116	101	19	18	253	8.3
1921	124	107	20	20	272	9.0
1922	132	114	21	22	288	9.6
1923	140	119	21	22	302	9.9
1924	147	124	22	23	316	10.3
1925	153	129	23	24	329	10.7
1926	160	133	24	24	341	11.1
1927	166	137	25	26	355	11.7
1928	173	142	28	29	371	12.5
1929	181	146	31	33	392	13.6
1930	190	152	35	36	414	14.7
1931	197	157	40	36	431	15.5
1932	202	162	44	35	442	16.0
1933	207	168	47	35	457	16.5
1934	214	176	50	36	476	17.3
1935	223	186	53	38	500	18.3
1936	234	195	56	39	524	18.9
1937	246	203	57	39	545	19.4

1938	262	213	58	38	571	19.8
1939	280	225	59	38	603	20.6
1940	302	245	64	40	651	22.3
1941	333	275	73	43	723	24.9
1942	373	312	83	49	818	28.3
1943	422	358	95	56	932	32.3
1944	480	413	109	59	1062	36.5
1945	546	477	126	63	1212	41.3
1946	624	549	147	69	1390	47.4
1947	722	636	174	76	1608	54.7
1948	848	741	204	84	1877	63.6
1949	993	863	240	95	2190	74.0
1950	1150	999	284	107	2540	86.1
1951	1320	1149	332	121	2923	99.4
1952	1502	1313	388	136	3340	114.3
1953	1702	1492	459	152	3806	131.5
1954	1935	1687	544	173	4339	151.8
1955	2207	1908	640	204	4959	175.9
1956	2522	2159	762	246	5689	205.6
1957	2854	2425	914	302	6495	240.9
1958	3184	2690	1069	370	7313	278.0
1959	3511	2941	1196	440	8087	311.7
1960	3813	3167	1304	505	8789	341.7
1961	4119	3388	1443	570	9519	375.2
1962	4469	3646	1605	631	10351	412.5
1963	4887	3987	1757	695	11325	451.8
1964	5410	4425	1899	775	12508	495.7
1965	6045	4971	2114	876	14006	554.8
1966	6790	5653	2464	995	15901	636.5
1967	7687	6548	2878	1143	18255	736.1
1968	8855	7708	3336	1321	21220	854.8
1969	10435	9153	3930	1525	25043	1005.0
1970	12504	10972	4678	1761	29915	1193.1
1971	15167	13263	5539	1999	35968	1414.4
1972	18633	16234	6650	2308	43824	1700.9
1973	23214	20190	8211	2812	54428	2102.5
1974	29192	25457	10329	3569	68547	2649.7
1975	36639	32159	12960	4544	86302	3337.5
1976	45568	40282	16051	5608	107510	4144.6
1977	56134	50148	19756	6862	132901	5110.3
1978	68355	62021	24112	8416	162905	6258.2
1979	82080	75870	28831	10157	196939	7538.6
1980	97214	91854	33987	12143	235198	8969.1
1981	113806	109594	39729	14317	277446	10552.2
1982	131759	128657	45746	16715	322877	12244.9
1983	150500	149320	52133	19254	371208	14045.8
1984	169582	170889	58674	21460	420605	15851.9

1985	188909	193318	65418	23608	471253	17698.4
1986	209032	217497	72947	26045	525521	19722.4
1987	230829	243660	81960	28983	585431	22048.7
1988	255144	272472	93152	32650	653417	24812.9
1989	282188	305770	106521	36888	731368	28042.0
1990	312084	344605	120978	41214	818882	31579.0
1991	344517	388124	135114	45154	912909	35180.1
1992	378386	433336	148211	48500	1008433	38652.1
1993	413583	477214	158809	50754	1100360	41695.7
1994	450866	520929	167912	52464	1192171	44530.1
1995	492333	567145	178732	54655	1292865	47741.9
1996	539027	614504	191916	57218	1402666	51378.3
1997	590196	662730	206881	60553	1520360	55400.2
1998	646917	714821	224138	65307	1651184	60027.9
1999	711743	772893	243779	71574	1799989	65370.6
2000	789340	835443	265250	79390	1969422	71404.9
2001	879501	901806	287198	87463	2155969	77804.6
2002	977864	974087	308170	94431	2354553	84223.4
2003	1084202	1051549	329273	101213	2566237	90876.9
2004	1196849	1133442	351225	108870	2790385	97929.3
2005	1313187	1220117	374914	117704	3025923	105487.8
2006	1430988	1311749	401684	127757	3272178	113682.9
2007	1542452	1404752	432236	138633	3518074	122348.9
2008	1632320	1492554	464172	148079	3737125	130559.6
2009	1684091	1565374	488423	150829	3888718	136169.6
2010	1700370	1620623	506585	149469	3977046	139645.4
2011	1693083	1662165	524286	149211	4028744	142520.4
2012	1669379	1689997	538478	149142	4046996	144442.6
2013	1637954	1707152	549051	149465	4043622	145625.4
2014	1610472	1719360	558619	151150	4039600	146796.2
2015	1592908	1731685	570797	154824	4050214	148656.6
2016	1585571	1744493	586661	159018	4075742	151174.0
2017	1590518	1757582	605134	164363	4117597	154323.3
2018	1607210	1774012	625736	171347	4178305	158167.5
2019	1632386	1792942	648118	178795	4252241	162460.2

* includes biological resources and "other" that, after 1995, incorporates intellectual property

Table A2
Net Capital Stock/GDP Ratio, 1850-2019

	Net Capital Stock /GDP	Net Capital Stock/GDP (excluding dwellings)
1850	1.6	0.6
1851	1.5	0.6
1852	1.5	0.6
1853	1.3	0.5
1854	1.2	0.5
1855	1.2	0.5
1856	1.2	0.5
1857	1.2	0.5
1858	1.3	0.5
1859	1.2	0.5
1860	1.2	0.5
1861	1.3	0.5
1862	1.3	0.6
1863	1.3	0.6
1864	1.3	0.6
1865	1.4	0.7
1866	1.3	0.6
1867	1.3	0.6
1868	1.5	0.7
1869	1.6	0.8
1870	1.5	0.7
1871	1.4	0.7
1872	1.2	0.6
1873	1.2	0.6
1874	1.2	0.6
1875	1.2	0.6
1876	1.2	0.6
1877	1.1	0.5
1878	1.1	0.5
1879	1.1	0.5
1880	1.1	0.5
1881	1.0	0.5
1882	1.0	0.5
1883	1.0	0.5
1884	1.0	0.5
1885	1.0	0.5
1886	1.0	0.5
1887	1.1	0.5
1888	1.1	0.5
1889	1.2	0.6
1890	1.2	0.6

1891	1.2	0.6
1892	1.2	0.6
1893	1.3	0.6
1894	1.3	0.7
1895	1.3	0.7
1896	1.4	0.7
1897	1.4	0.7
1898	1.3	0.7
1899	1.4	0.7
1900	1.4	0.7
1901	1.4	0.7
1902	1.4	0.7
1903	1.4	0.7
1904	1.3	0.7
1905	1.4	0.7
1906	1.4	0.7
1907	1.4	0.7
1908	1.5	0.8
1909	1.5	0.8
1910	1.6	0.8
1911	1.6	0.8
1912	1.7	0.9
1913	1.7	0.9
1914	1.9	1.0
1915	1.9	1.0
1916	1.8	0.9
1917	1.8	0.9
1918	1.6	0.9
1919	1.6	0.9
1920	1.4	0.8
1921	1.7	0.9
1922	1.7	0.9
1923	1.8	1.0
1924	1.7	0.9
1925	1.7	0.9
1926	1.8	1.0
1927	1.8	0.9
1928	1.9	1.0
1929	1.9	1.0
1930	2.0	1.1
1931	2.1	1.1
1932	2.1	1.2
1933	2.3	1.3
1934	2.2	1.2

1935	2.2	1.2
1936	2.9	1.6
1937	2.8	1.6
1938	2.6	1.4
1939	2.4	1.3
1940	2.1	1.1
1941	2.1	1.1
1942	2.0	1.1
1943	2.1	1.1
1944	2.1	1.1
1945	2.4	1.3
1946	2.1	1.2
1947	2.1	1.2
1948	2.3	1.3
1949	2.5	1.4
1950	2.4	1.3
1951	2.1	1.2
1952	2.2	1.2
1953	2.3	1.3
1954	2.3	1.3
1955	2.4	1.3
1956	2.3	1.3
1957	2.2	1.2
1958	2.1	1.2
1959	2.2	1.2
1960	2.3	1.3
1961	2.2	1.2
1962	2.0	1.1
1963	1.8	1.0
1964	1.8	1.0
1965	1.7	1.0
1966	1.7	1.0
1967	1.7	1.0
1968	1.8	1.0
1969	1.8	1.1
1970	2.0	1.2
1971	2.1	1.2
1972	2.2	1.2
1973	2.2	1.3
1974	2.2	1.3
1975	2.4	1.4
1976	2.5	1.4
1977	2.4	1.4
1978	2.4	1.4

1979	2.5	1.4
1980	2.5	1.5
1981	2.6	1.5
1982	2.6	1.6
1983	2.6	1.6
1984	2.6	1.6
1985	2.7	1.6
1986	2.6	1.6
1987	2.6	1.6
1988	2.6	1.6
1989	2.5	1.6
1990	2.5	1.6
1991	2.6	1.6
1992	2.6	1.6
1993	2.8	1.7
1994	2.8	1.7
1995	2.8	1.7
1996	2.9	1.8
1997	2.9	1.8
1998	3.0	1.8
1999	3.0	1.8
2000	3.0	1.8
2001	3.1	1.8
2002	3.1	1.8
2003	3.2	1.8
2004	3.2	1.9
2005	3.3	1.8
2006	3.3	1.8
2007	3.3	1.8
2008	3.4	1.9
2009	3.6	2.1
2010	3.7	2.1
2011	3.8	2.2
2012	3.9	2.3
2013	4.0	2.4
2014	3.9	2.4
2015	3.8	2.3
2016	3.7	2.2
2017	3.5	2.2
2018	3.5	2.1
2019	3.4	2.1

Table A3
Productive Capital Stock (million 2010 Euro)

	Dwellings	Other Construction	Machinery and Equipment	Transport Equipment	Total
1850	20013	6995	97	222	27327
1851	20293	7042	100	211	27646
1852	20680	7114	105	202	28101
1853	21067	7213	111	204	28596
1854	21354	7304	120	210	28988
1855	21549	7371	128	207	29255
1856	21757	7459	134	220	29570
1857	22129	7624	142	249	30145
1858	22745	7871	154	312	31082
1859	23654	8187	168	380	32389
1860	24822	8717	178	400	34118
1861	25835	9416	187	420	35857
1862	26672	10101	200	464	37437
1863	27574	10754	217	514	39059
1864	28375	11305	233	564	40477
1865	28958	11681	245	622	41506
1866	29372	11928	252	698	42249
1867	29760	12148	253	788	42949
1868	30049	12327	253	800	43429
1869	30191	12440	250	737	43619
1870	30340	12513	250	701	43803
1871	30613	12598	254	683	44148
1872	31003	12734	263	671	44671
1873	31429	12874	274	648	45224
1874	31848	13011	280	632	45771
1875	32350	13199	287	614	46449
1876	32987	13469	298	604	47357
1877	33757	13819	314	607	48497
1878	34513	14151	331	683	49679
1879	35114	14434	352	770	50670
1880	35683	14781	387	816	51668
1881	36309	15198	434	843	52785
1882	37052	15684	486	849	54072
1883	37983	16262	538	949	55733
1884	38942	16862	585	1098	57487
1885	39694	17372	620	1174	58861
1886	40225	17818	641	1167	59851
1887	40662	18294	654	1141	60751
1888	41062	18810	660	1086	61617
1889	41488	19285	677	1049	62498
1890	42036	19776	718	1038	63567

1891	42648	20324	765	1004	64742
1892	43304	20866	812	947	65928
1893	44014	21376	840	896	67125
1894	44743	21813	851	851	68258
1895	45478	22236	870	808	69392
1896	46182	22646	893	775	70497
1897	46873	22997	923	753	71546
1898	47611	23356	953	740	72660
1899	48537	23795	995	844	74171
1900	49887	24438	1078	1086	76490
1901	51242	25112	1166	1260	78780
1902	52263	25622	1227	1288	80401
1903	53314	26150	1287	1259	82011
1904	54580	26755	1355	1239	83928
1905	55736	27292	1413	1237	85678
1906	56578	27756	1471	1270	87074
1907	57512	28320	1544	1331	88707
1908	58657	28950	1619	1341	90568
1909	59888	29559	1688	1322	92457
1910	61176	30336	1747	1323	94582
1911	62578	31271	1798	1314	96963
1912	64050	32232	1859	1379	99521
1913	65509	33158	1953	1541	102161
1914	66895	33947	2012	1657	104511
1915	67978	34581	2003	1634	106196
1916	68714	35052	2022	1577	107364
1917	69165	35413	2076	1638	108293
1918	69425	35692	2147	1852	109115
1919	69705	36019	2205	2096	110025
1920	70417	36623	2235	2321	111597
1921	71606	37610	2329	2540	114084
1922	72987	38861	2399	2690	116936
1923	74664	40133	2446	2702	119945
1924	76604	41386	2556	2827	123373
1925	78743	42835	2708	2943	127229
1926	81095	44499	2892	3006	131491
1927	83622	46220	3120	3229	136191
1928	86449	47986	3449	3618	141503
1929	89705	50007	3925	4152	147789
1930	93183	52293	4562	4486	154524
1931	95156	54279	5178	4513	159126
1932	95520	55713	5634	4338	161205
1933	95719	57158	5984	4186	163047
1934	95828	58698	6267	4166	164959
1935	95901	60128	6530	4165	166724

1936	95837	61300	6770	4041	167947
1937	95447	60419	6554	3722	166141
1938	94893	59386	6287	3334	163901
1939	94348	58163	6033	3021	161564
1940	93858	57153	5859	2830	159700
1941	94541	58249	6104	2729	161623
1942	96390	59732	6333	2789	165244
1943	98398	61458	6521	2835	169211
1944	100183	63260	6653	2691	172787
1945	101505	64694	6803	2539	175540
1946	102891	65802	7037	2461	178191
1947	105352	67160	7309	2389	182209
1948	109643	68962	7599	2333	188537
1949	113978	70833	7906	2333	195051
1950	117374	72580	8282	2349	200585
1951	120139	74165	8629	2369	205303
1952	122371	75671	9014	2387	209442
1953	124722	77193	9574	2402	213890
1954	128345	78942	10250	2469	220007
1955	133758	81466	11004	2660	228888
1956	141124	84957	12067	2968	241115
1957	149357	88895	13494	3397	255142
1958	157660	92895	14940	3926	269422
1959	166288	96572	16008	4462	283330
1960	174151	99659	16913	4934	295657
1961	182231	102675	18297	5405	308609
1962	191972	106726	20034	5859	324590
1963	203855	112962	21687	6344	344847
1964	218750	121443	23235	6994	370422
1965	235679	132056	25630	7845	401208
1966	252721	144757	29470	8853	435801
1967	269073	160445	33673	10087	473277
1968	285849	178676	37757	11524	513806
1969	303694	197783	42404	13061	556942
1970	320522	217267	47346	14672	599807
1971	335254	236344	51686	16015	639299
1972	349241	255865	56277	17541	678925
1973	364954	277261	62133	19992	724339
1974	383200	301196	69119	23400	776916
1975	402102	325679	76184	27124	831089
1976	420509	348335	82692	30146	881682
1977	439444	370823	89336	32923	932526
1978	459017	394077	96140	35856	985091
1979	478676	417318	102031	38359	1036384
1980	498648	441434	107592	40697	1088370

1981	519647	465076	113516	42718	1140957
1982	541210	487527	119152	44621	1192510
1983	561164	510825	125060	46292	1243341
1984	578286	533265	130955	46858	1289364
1985	592747	555375	137106	47285	1332513
1986	606529	579803	144663	48358	1379354
1987	622197	606609	154710	50391	1433908
1988	641618	636753	168120	53635	1500125
1989	664791	673659	184419	57703	1580571
1990	691530	718503	201404	61801	1673238
1991	720753	768613	216680	65278	1771324
1992	749864	817775	229267	67931	1864836
1993	778360	860674	237250	69163	1945447
1994	807137	899980	242622	69811	2019550
1995	838926	940169	250240	71222	2100559
1996	874071	978403	260887	73182	2186542
1997	909900	1013695	273602	76142	2273339
1998	946985	1049966	288934	80824	2366710
1999	988152	1089391	306842	87246	2471632
2000	1039135	1129327	326521	95359	2590343
2001	1099209	1169172	346310	103556	2718247
2002	1163592	1212195	364546	110244	2850577
2003	1234031	1258128	382652	116556	2991366
2004	1311454	1307130	401523	123727	3143834
2005	1396718	1361048	422227	132087	3312079
2006	1491788	1421653	446316	141665	3501422
2007	1593055	1486637	474582	152016	3706290
2008	1688602	1550428	504459	160698	3904187
2009	1762887	1603851	526293	162120	4055151
2010	1816516	1644413	542067	159234	4162231
2011	1857604	1675670	557930	157629	4248833
2012	1887424	1696845	570610	156278	4311157
2013	1908335	1709833	579900	155338	4353406
2014	1927972	1719018	588330	155747	4391068
2015	1950983	1728230	599468	158077	4436758
2016	1977936	1736839	614259	160770	4489804
2017	2013337	1744228	631487	164463	4553515
2018	2059477	1753715	650658	169635	4633485
2019	2115429	1765048	671466	175118	4727063

Table A4
Capital Input, Productive Capital Stock, and Capital Quality (2010=100)

		ex-ante exogenous rate of return	
	Productive Capital Stock	Capital Quality	Capital Input
1850	0.7	42.1	0.3
1851	0.7	42.0	0.3
1852	0.7	41.8	0.3
1853	0.7	41.8	0.3
1854	0.7	41.9	0.3
1855	0.7	41.9	0.3
1856	0.7	42.0	0.3
1857	0.7	42.3	0.3
1858	0.7	43.0	0.3
1859	0.8	43.6	0.3
1860	0.8	43.7	0.4
1861	0.9	43.9	0.4
1862	0.9	44.5	0.4
1863	0.9	45.0	0.4
1864	1.0	45.5	0.4
1865	1.0	46.0	0.5
1866	1.0	46.6	0.5
1867	1.0	47.3	0.5
1868	1.0	47.3	0.5
1869	1.0	46.7	0.5
1870	1.1	46.3	0.5
1871	1.1	46.1	0.5
1872	1.1	45.9	0.5
1873	1.1	45.6	0.5
1874	1.1	45.4	0.5
1875	1.1	45.1	0.5
1876	1.1	45.0	0.5
1877	1.2	44.9	0.5
1878	1.2	45.5	0.5
1879	1.2	46.1	0.6
1880	1.2	46.5	0.6
1881	1.3	46.8	0.6
1882	1.3	47.0	0.6
1883	1.3	47.7	0.6
1884	1.4	48.7	0.7
1885	1.4	49.1	0.7
1886	1.4	49.1	0.7
1887	1.5	49.0	0.7
1888	1.5	48.6	0.7

1889	1.5	48.4	0.7
1890	1.5	48.5	0.7
1891	1.6	48.4	0.8
1892	1.6	48.1	0.8
1893	1.6	47.7	0.8
1894	1.6	47.3	0.8
1895	1.7	47.0	0.8
1896	1.7	46.8	0.8
1897	1.7	46.7	0.8
1898	1.7	46.6	0.8
1899	1.8	47.3	0.8
1900	1.8	48.8	0.9
1901	1.9	49.9	0.9
1902	1.9	50.1	1.0
1903	2.0	50.0	1.0
1904	2.0	49.9	1.0
1905	2.1	49.9	1.0
1906	2.1	50.1	1.0
1907	2.1	50.5	1.1
1908	2.2	50.6	1.1
1909	2.2	50.6	1.1
1910	2.3	50.6	1.1
1911	2.3	50.5	1.2
1912	2.4	50.7	1.2
1913	2.5	51.3	1.3
1914	2.5	51.6	1.3
1915	2.6	51.3	1.3
1916	2.6	51.0	1.3
1917	2.6	51.4	1.3
1918	2.6	52.5	1.4
1919	2.6	53.6	1.4
1920	2.7	54.4	1.5
1921	2.7	55.4	1.5
1922	2.8	55.9	1.6
1923	2.9	55.7	1.6
1924	3.0	56.1	1.7
1925	3.1	56.5	1.7
1926	3.2	56.8	1.8
1927	3.3	57.6	1.9
1928	3.4	59.0	2.0
1929	3.6	60.8	2.2
1930	3.7	62.4	2.3
1931	3.8	63.4	2.4
1932	3.9	63.9	2.5

1933	3.9	64.3	2.5
1934	4.0	64.7	2.6
1935	4.0	65.1	2.6
1936	4.0	65.3	2.6
1937	4.0	64.5	2.6
1938	3.9	63.6	2.5
1939	3.9	62.7	2.4
1940	3.8	62.2	2.4
1941	3.9	62.2	2.4
1942	4.0	62.4	2.5
1943	4.1	62.5	2.5
1944	4.2	62.0	2.6
1945	4.2	61.6	2.6
1946	4.3	61.6	2.6
1947	4.4	61.4	2.7
1948	4.5	61.1	2.8
1949	4.7	60.9	2.9
1950	4.8	61.1	2.9
1951	4.9	61.2	3.0
1952	5.0	61.6	3.1
1953	5.1	62.1	3.2
1954	5.3	62.8	3.3
1955	5.5	63.4	3.5
1956	5.8	64.3	3.7
1957	6.1	65.6	4.0
1958	6.5	66.8	4.3
1959	6.8	67.5	4.6
1960	7.1	68.0	4.8
1961	7.4	68.8	5.1
1962	7.8	69.6	5.4
1963	8.3	70.1	5.8
1964	8.9	70.2	6.2
1965	9.6	70.9	6.8
1966	10.5	72.3	7.6
1967	11.4	74.0	8.4
1968	12.3	75.5	9.3
1969	13.4	77.2	10.3
1970	14.4	79.0	11.4
1971	15.4	80.4	12.4
1972	16.3	82.0	13.4
1973	17.4	84.3	14.7
1974	18.7	86.9	16.2
1975	20.0	89.2	17.8
1976	21.2	90.6	19.2

1977	22.4	91.6	20.5
1978	23.7	92.5	21.9
1979	24.9	92.9	23.1
1980	26.1	93.1	24.3
1981	27.4	93.3	25.6
1982	28.7	93.4	26.7
1983	29.9	93.5	27.9
1984	31.0	93.6	29.0
1985	32.0	93.7	30.0
1986	33.1	94.1	31.2
1987	34.5	94.8	32.7
1988	36.0	95.8	34.5
1989	38.0	97.0	36.8
1990	40.2	97.9	39.3
1991	42.6	98.3	41.8
1992	44.8	98.4	44.1
1993	46.7	98.1	45.9
1994	48.5	97.6	47.4
1995	50.5	97.3	49.1
1996	52.5	97.3	51.1
1997	54.6	97.4	53.2
1998	56.9	97.9	55.7
1999	59.4	98.5	58.5
2000	62.2	99.2	61.7
2001	65.3	99.6	65.0
2002	68.5	99.7	68.3
2003	71.9	99.7	71.6
2004	75.5	99.7	75.3
2005	79.6	99.7	79.3
2006	84.1	99.8	83.9
2007	89.0	99.9	89.0
2008	93.8	100.1	93.9
2009	97.4	100.1	97.5
2010	100.0	100.0	100.0
2011	102.1	100.0	102.1
2012	103.6	100.0	103.6
2013	104.6	100.1	104.7
2014	105.5	100.1	105.7
2015	106.6	100.3	106.9
2016	107.9	100.5	108.4
2017	109.4	100.7	110.2
2018	111.3	101.0	112.4
2019	113.6	101.2	114.9

Table A5
Capital Deepening*, 1850-2019 (2010=100)
*** ex-ante exogenous rate of return**

1850	0.6
1851	0.6
1852	0.6
1853	0.6
1854	0.6
1855	0.7
1856	0.6
1857	0.7
1858	0.7
1859	0.7
1860	0.8
1861	0.8
1862	0.8
1863	0.9
1864	0.9
1865	0.9
1866	1.0
1867	1.0
1868	1.0
1869	1.0
1870	1.0
1871	1.0
1872	1.0
1873	1.0
1874	1.0
1875	1.0
1876	1.0
1877	1.0
1878	1.0
1879	1.1
1880	1.1
1881	1.1
1882	1.2
1883	1.2
1884	1.3
1885	1.3
1886	1.4
1887	1.4
1888	1.4
1889	1.4

1890	1.4
1891	1.5
1892	1.5
1893	1.5
1894	1.5
1895	1.5
1896	1.5
1897	1.5
1898	1.5
1899	1.5
1900	1.6
1901	1.7
1902	1.7
1903	1.7
1904	1.8
1905	1.8
1906	1.8
1907	1.9
1908	1.9
1909	1.9
1910	2.0
1911	2.0
1912	2.1
1913	2.1
1914	2.2
1915	2.2
1916	2.2
1917	2.2
1918	2.3
1919	2.3
1920	2.4
1921	2.5
1922	2.6
1923	2.6
1924	2.7
1925	2.8
1926	2.9
1927	3.0
1928	3.2
1929	3.4
1930	3.6
1931	3.7
1932	3.7
1933	3.7

1934	3.7
1935	3.7
1936	3.8
1937	3.7
1938	3.6
1939	3.5
1940	3.5
1941	3.6
1942	3.6
1943	3.7
1944	3.7
1945	3.6
1946	3.6
1947	3.6
1948	3.7
1949	3.7
1950	3.7
1951	3.8
1952	3.9
1953	4.0
1954	4.2
1955	4.3
1956	4.6
1957	4.9
1958	5.3
1959	5.7
1960	6.1
1961	6.4
1962	6.7
1963	7.1
1964	7.7
1965	8.1
1966	9.0
1967	9.8
1968	11.0
1969	12.3
1970	13.4
1971	14.2
1972	15.3
1973	16.4
1974	18.3
1975	20.9
1976	23.1
1977	25.1

1978	27.9
1979	30.6
1980	33.7
1981	36.9
1982	39.4
1983	41.9
1984	45.6
1985	47.9
1986	48.9
1987	49.1
1988	50.3
1989	52.1
1990	53.6
1991	56.0
1992	60.0
1993	64.3
1994	66.6
1995	67.8
1996	69.5
1997	69.7
1998	69.5
1999	69.6
2000	70.1
2001	71.2
2002	72.9
2003	74.5
2004	76.1
2005	77.7
2006	79.4
2007	82.2
2008	86.2
2009	95.3
2010	100.0
2011	104.4
2012	111.4
2013	115.8
2014	115.6
2015	113.5
2016	112.2
2017	111.9
2018	111.3
2019	112.1

Appendix C. Alternative Estimates: Figures

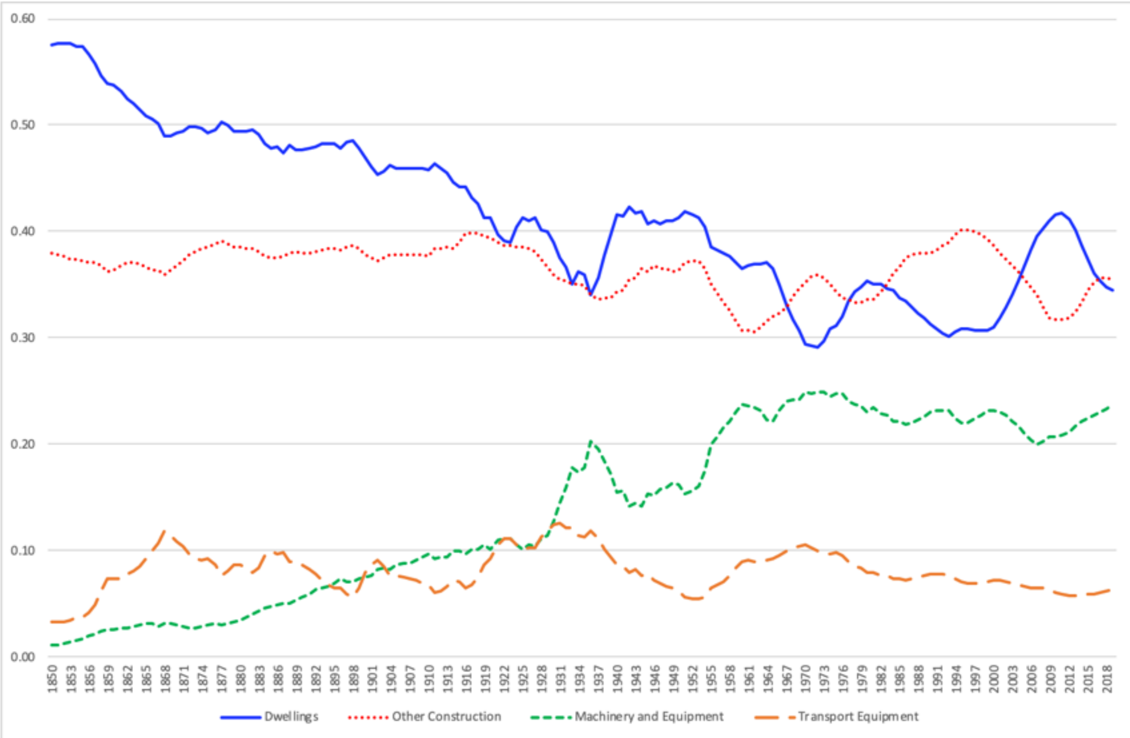

Figure A1. Capital Services' Composition (ex-post endogenous rate of return) (current prices) (%)

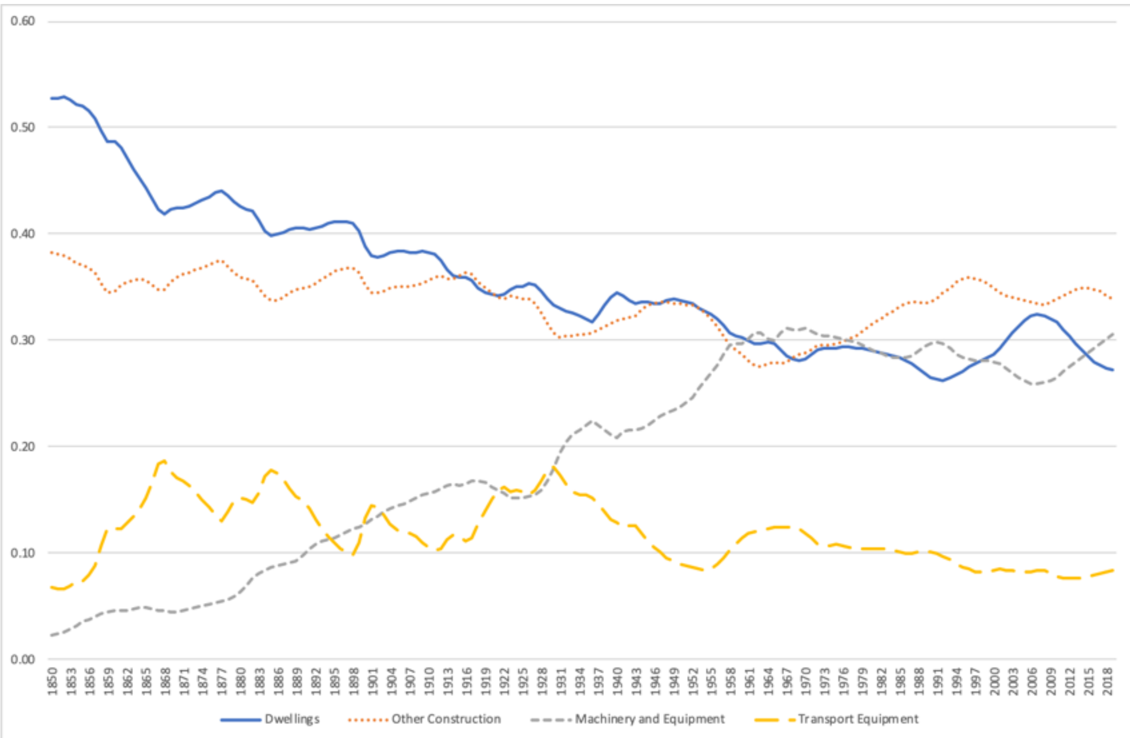

Figure A2. Capital Services' Composition (simplified ex-ante exogenous rate of return) (current prices) (%).

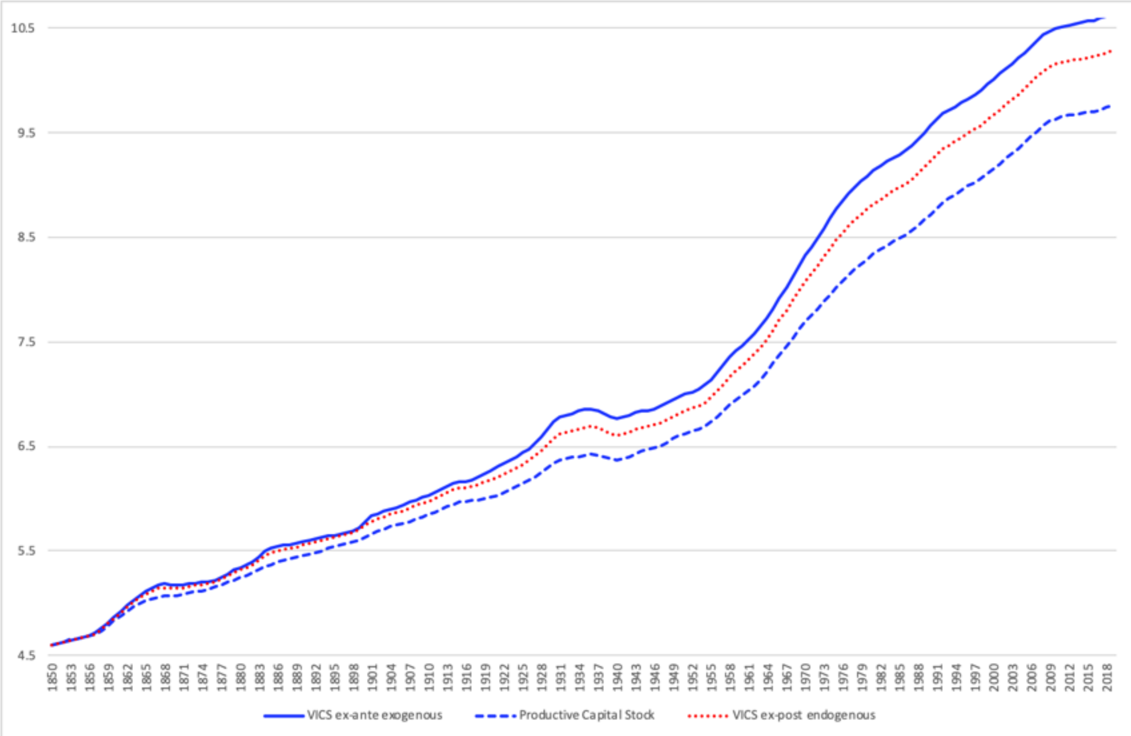

Figure A3. Volume Index of Capital Services (ex-ante exogenous and ex-post endogenous rate of return) and Productive Capital Stock (1850=100) (natural logs)

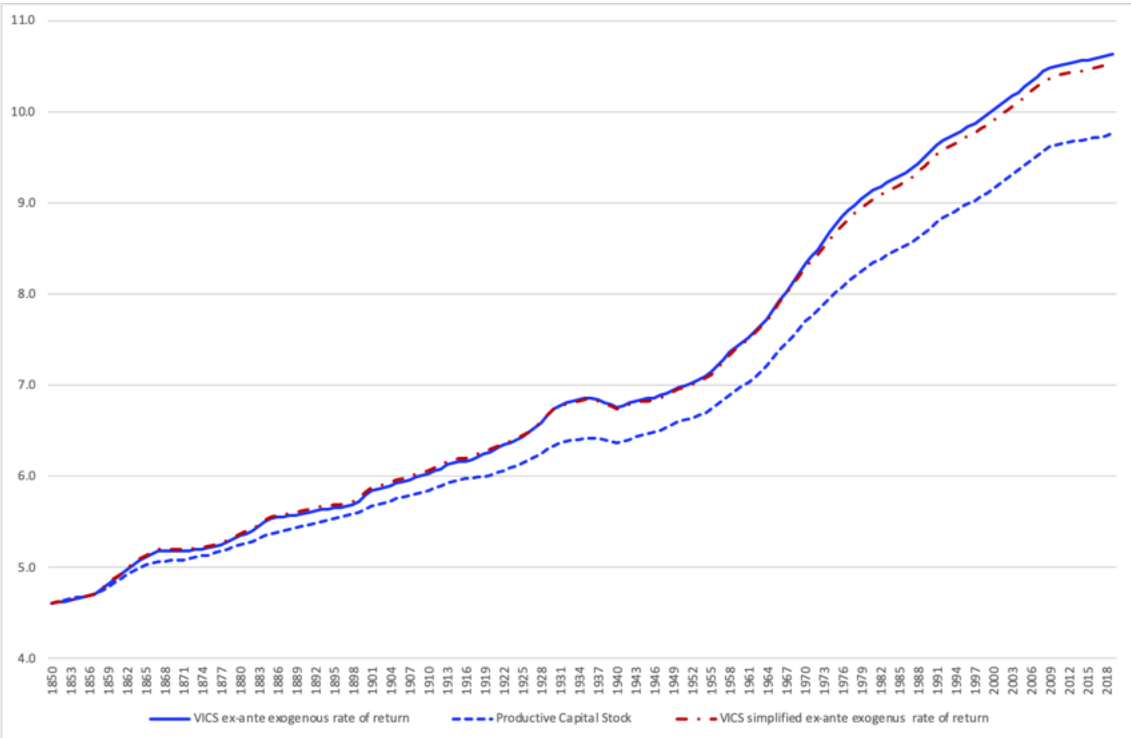

Figure A4. Volume Index of Capital Services (ex-ante exogenous and simplified ex-ante exogenous rate of return) and Productive Capital Stock (1850=100) (natural logs)

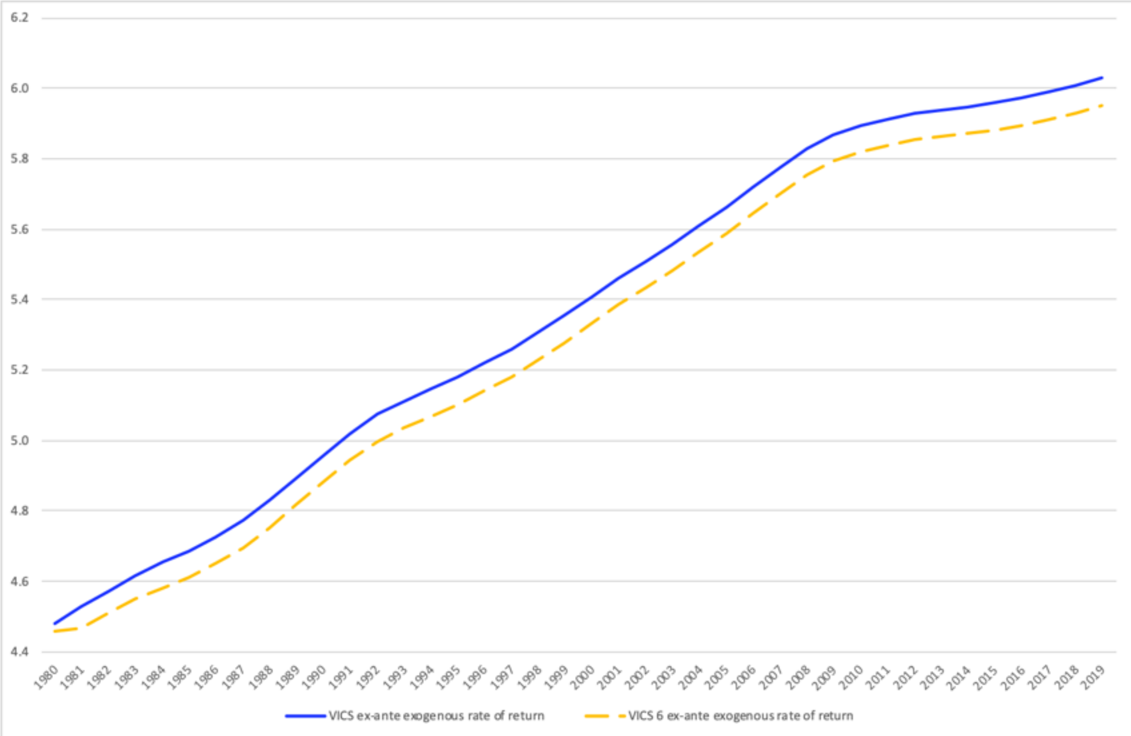

Figure A5. Volume Index of Capital Services* with 4 and 6 Assets, 1980-2019 (2010=100) (natural logs) * ex-ante exogenous endogenous rates of return

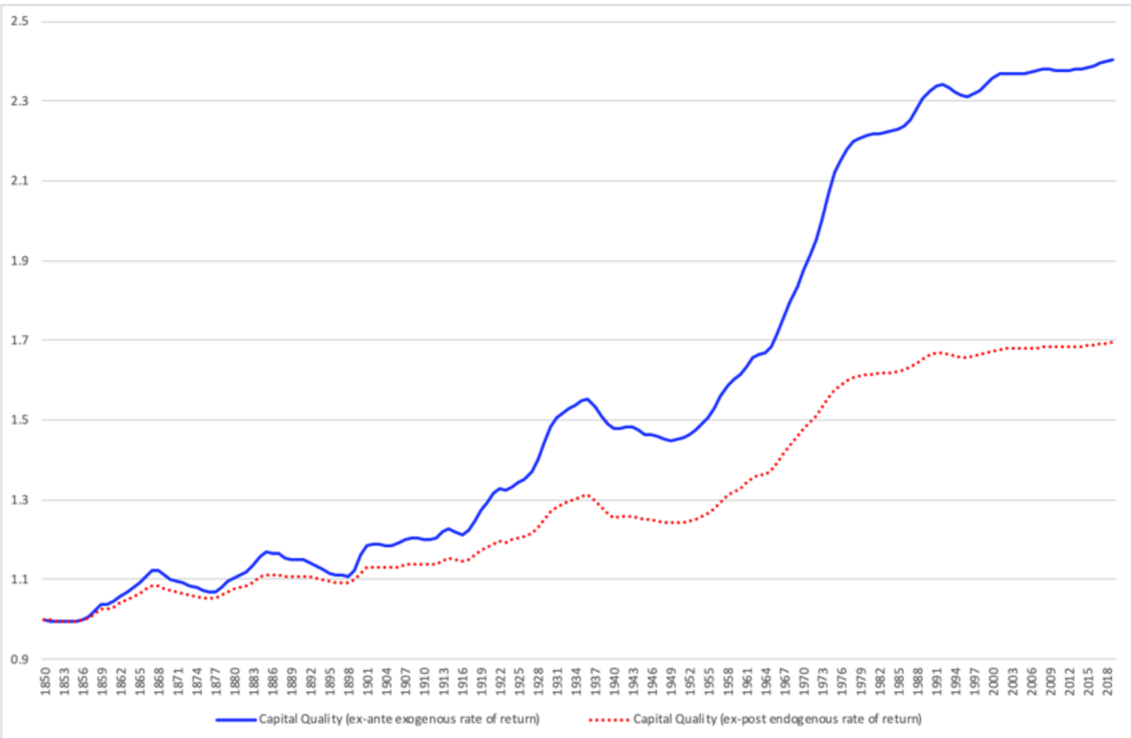

Figure A6a. Capital Quality (ex-ante exogenous and ex-post endogenous rate of return) (1850=1) Note: Capital Quality = Ratio of VICS to Productive Capital Stock

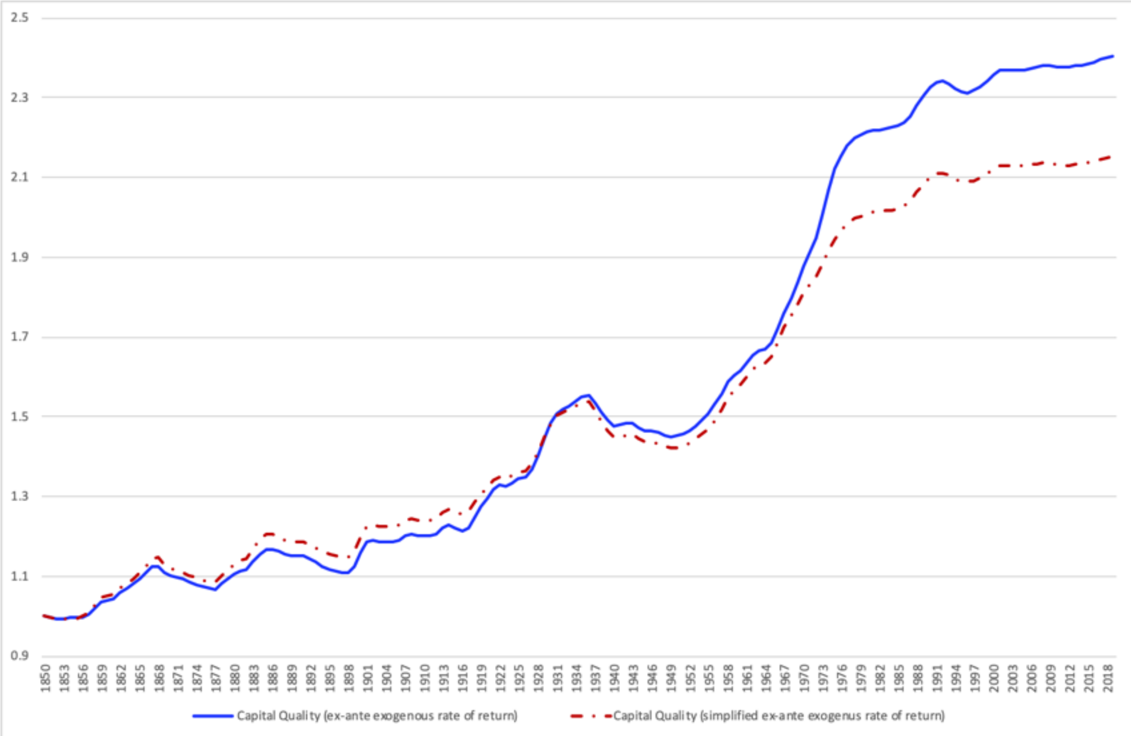

Figure A6b. Capital Quality (full and simplified ex-ante exogenous rate of return) (1850=1)
Note: Capital Quality = Ratio of VICS to Productive Capital Stock

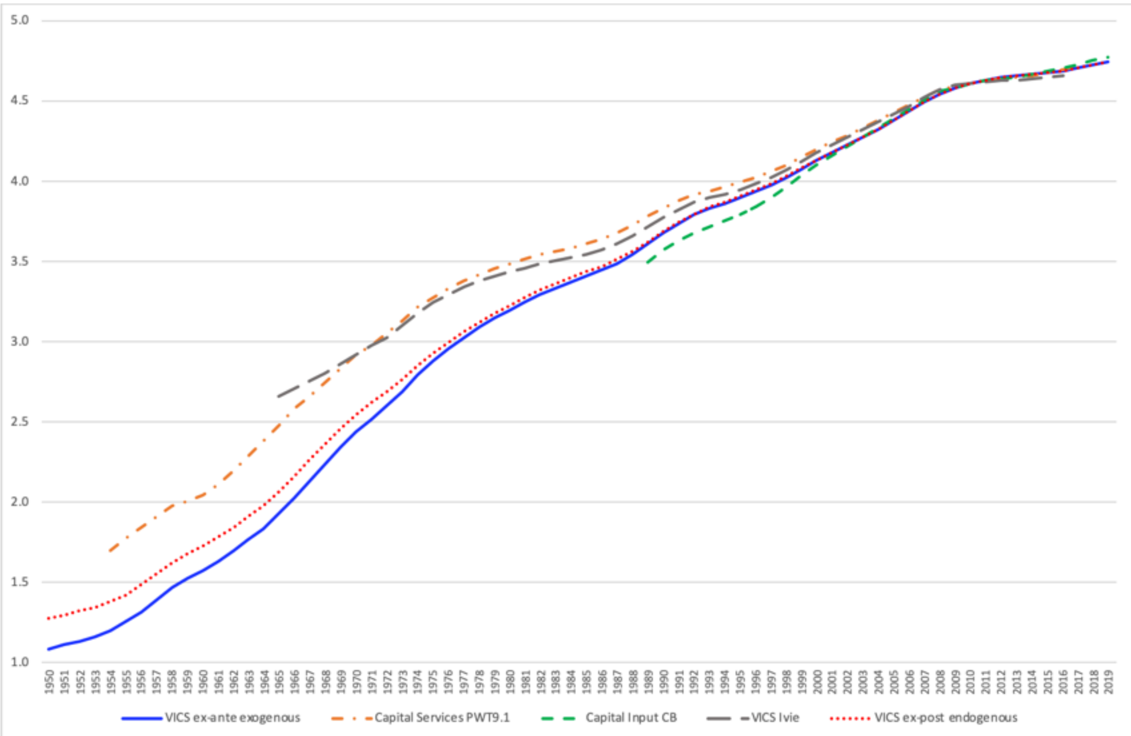

Figure A7. VICS*: Comparison with PWT9.1, CB, and Ivie Estimates, 1950-2019 (2010=100) (natural logs)* ex-ante exogenous and ex-post endogenous rates of return

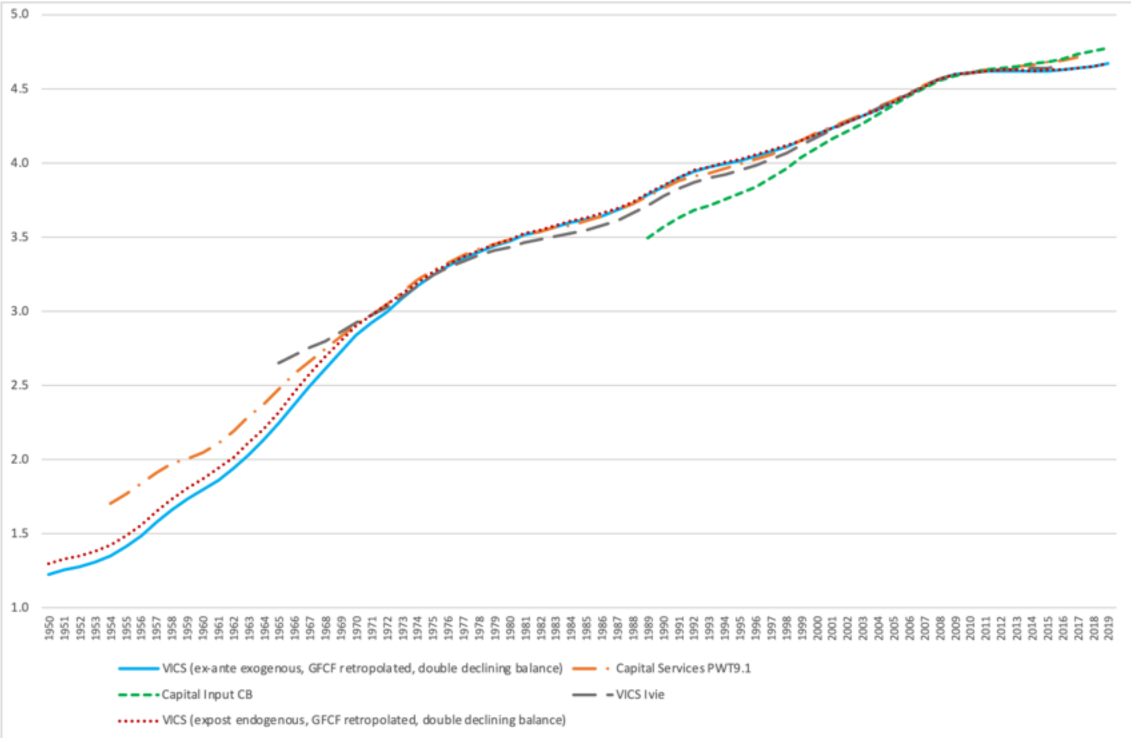

Figure A8. VICS, 1950-2019. Estimates with GFCF Retropolated series, double declining balance, ex-ante exogenous and ex-post endogenous rates of return: Comparisons with PWT9.1, CB, and Ivie (1850=100) (logs)

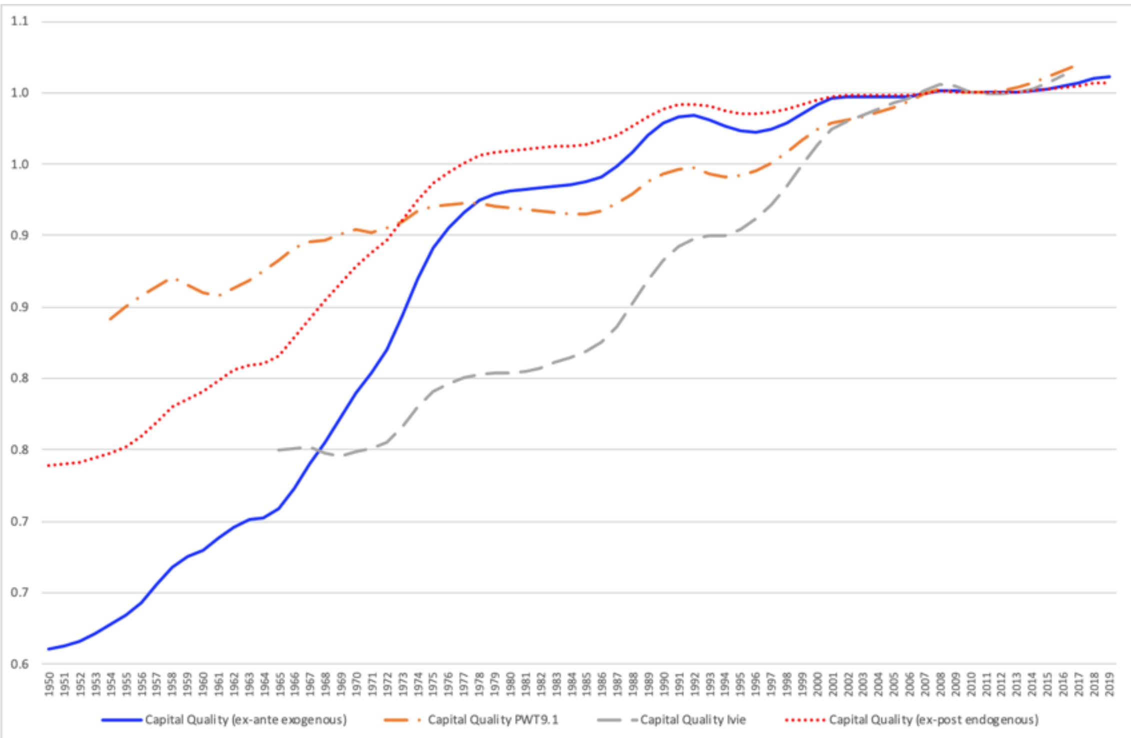

Figure A9. Capital Quality*: Comparison with PWT9.1 and Ivie Estimates, 1950-2019 (2010=1)
*New estimates derived with ex-ante exogenous and ex-post endogenous rates of return

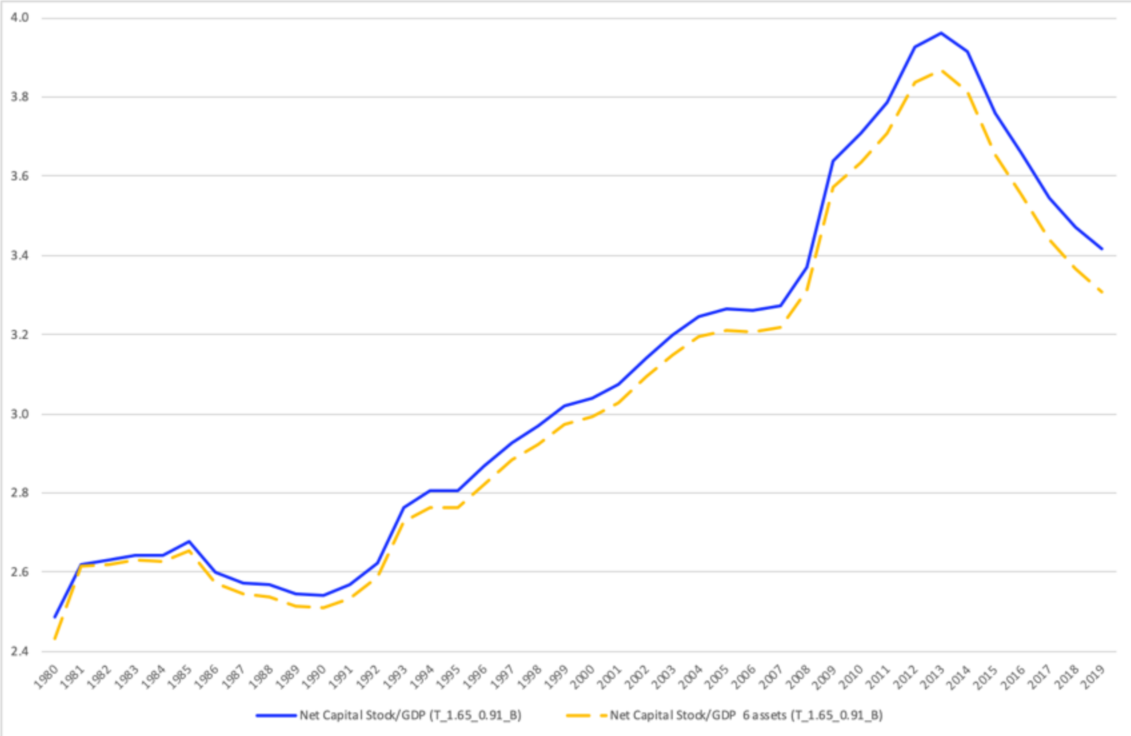

Figure A10. Net Capital Stock/GDP Ratio with 4 and 6 Assets, 1980-2019 (current prices)

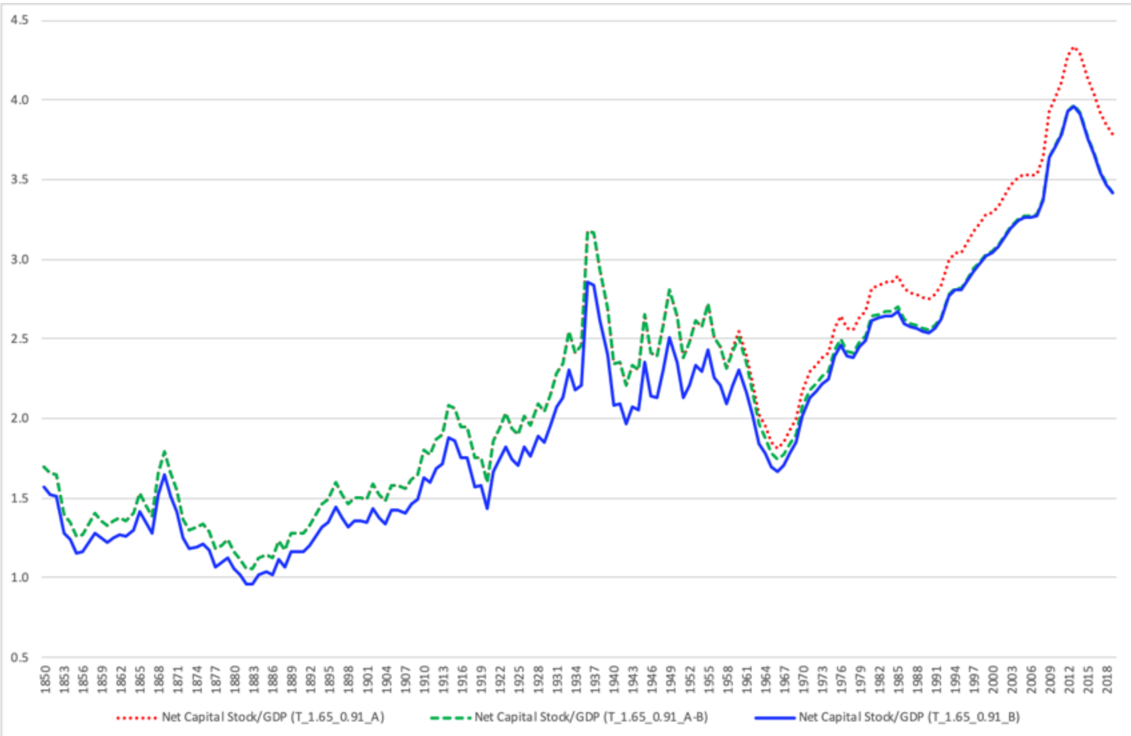

Figure A11. Net Capital Stock/GDP Ratio: Estimates with Alternative Average Service Lives (current prices)
Note: A, longer lives; B, shorter lives; A-B, A up to 1958 and B thereafter.

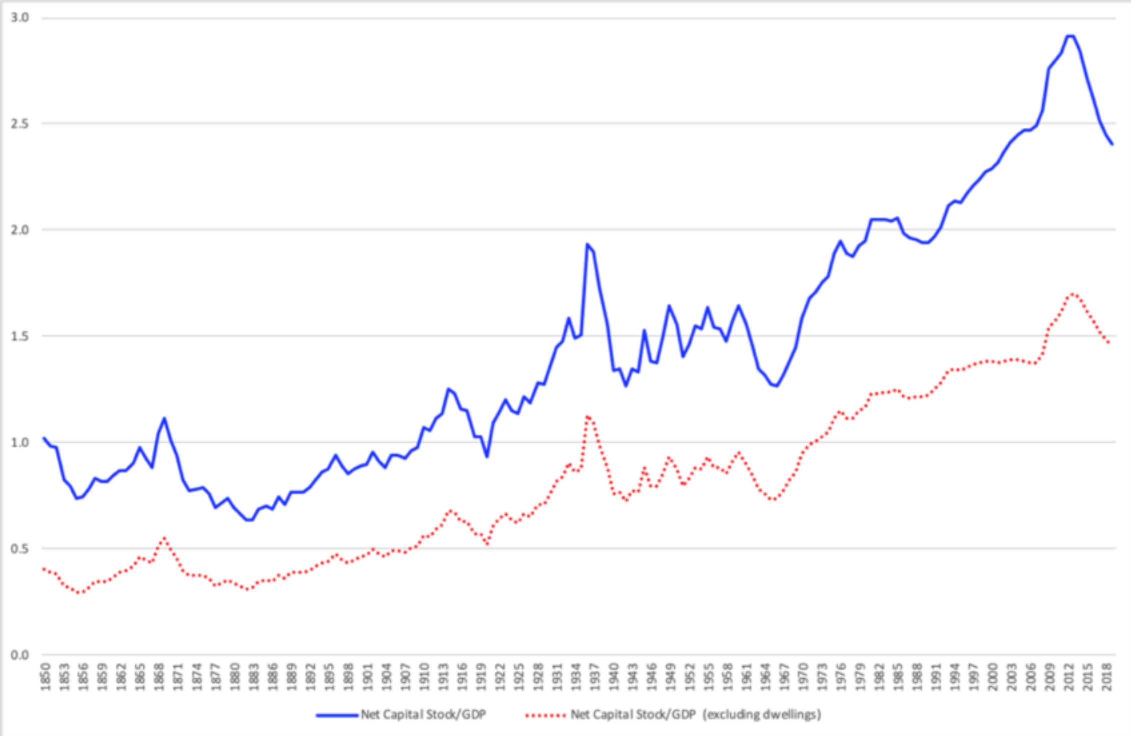

Figure A12. Double Declining Balance Net Capital Stock/GDP Ratio (current prices): With and Without Dwellings

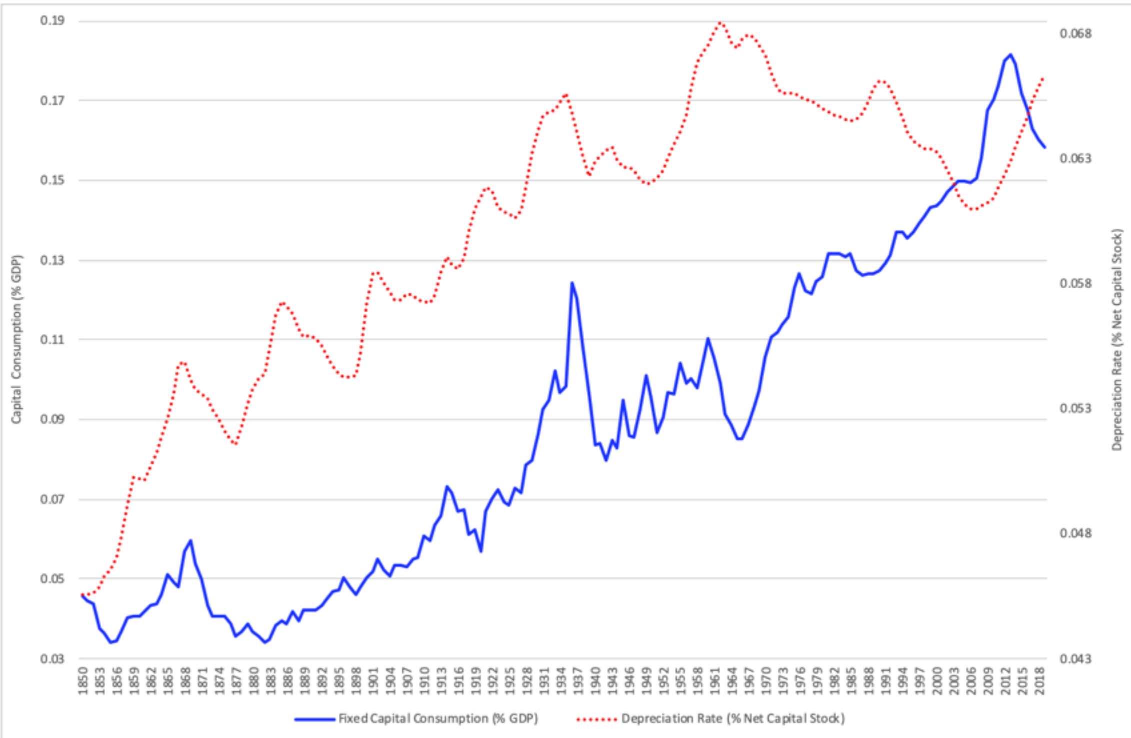

Figure A13. Double Declining Balance Consumption of Fixed Capital (% GDP) and Depreciation Rate (CFC as % Net Capital Stock), (current prices).