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# Is Inequality Increasing in r-g? The Dynamics of Capital's Income Share in the UK, 1210-2013

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# IS INEQUALITY INCREASING IN *r* - *g*? THE DYNAMICS OF CAPITAL'S INCOME SHARE IN THE UK, 1210-2013[1]

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**Abstract**. This paper provides the first very long term empirical examination of Piketty's (2014) controversial hypothesis that inequality is increasing in $r - g$, (*assets* - *real income*). Using unique annual data on asset returns for a balanced portfolio and several other variables for the UK over the period 1210-2013, the study examines whether the dynamics in capital's income share, $S^W$, are governed by ($r–g$). The analysis confirms that $r$ and $g$ are robust and significant determinants of factor shares and that they have been the major forces behind the large inequality waves over the past eight centuries.

**JEL Classification**: E1, E2, O4, N1, N30, P1
**Keywords**: Inequality and the ($r$-$g$)-gap; dynamics of inequality; inequality in the UK, 1210-2013

## 1. Introduction

Central to Piketty's (2014) *Capitalism in the 21st Century* is that the growth in wealth inequality is governed by the gap between the returns to wealth, $r$, and growth in economy-wide net national income, $g$. Piketty (2014) refers to $r > g$ as "the central contradiction of capitalist economics" (p. 398). Assuming that real asset returns remain fairly constant, Piketty (2014) predicts that the ($r$-$g$)-gap will widen over the rest of this century because of reduced population and per capita income growth – a prediction that has been met with a storm of resistance from the economics profession, mostly because the ($r$-$g$)-gap does not necessarily increase in response to a reduced $g$ in standard canonical Euler equations, and because, in standard growth models, the inequality $r > g$ ensures dynamic efficiency and is consistent with constant steady-state capital-income ratios (Abel *et al*., 1989).[2] Piketty's

[1] Comments and suggestions from Hal Hill, Takatoshi Ito, Stephen Broadberry, Chris Meissner, Antonio Minniti, Francesco Venturini, Solmaz Moslehi, Cyn-Young Park, Kyoji Fukao, Yukinoub Kitamura, Thomas Piketty, Andrew Rose, Holger Strulik, Harald Uhlig, Francesco Venturini, Yves Zenou, seminar participants at University of Western Australia, Queensland University of Technology, University of Southern Denmark, University of Melbourne, Australian Economic Society, Kiel Institute of World Economics, Paris School of Economics, Australian National University, University of Aix-Marseilles, Hitotsubashi University, University of Queensland, and participants at the Monash Macro/Finance Workshop, November 2016, the NBER Asian Seminar, July 2017, are also gratefully acknowledged. I am also grateful to the Australian Research Council for financial support (grants DP150100061 and DP170100339).
[2] Acemoglu and Robinson (2015), Krussel and Smith (2015), Mankiw (2015), and Ray (2015) are examples of critical assessments of Piketty (2014).

hypothesis that wealth inequality is increasing in the (*r*–*g*)-gap is closely related to what is sometimes referred to Piketty's 'third law', which says that inequality tends to diverge when $r > g$.[3]

Despite being central to the inequality debate, little empirical work has been undertaken to investigate the relationship between inequality and the (*r*-*g*)-gap, reflecting, to some extent, the absence of continuous long data on inequality and asset returns, not to mention the difficulties associated with construction of a composite measure of *r* that includes all asset classes. Relying mostly on recent data, Acemoglu and Robinson (2015) and Goes (2016) are two of the few attempts to test whether income inequality is increasing in the (*r*-*g*)-gap. Acemoglu and Robinson (2015) fail to find significant positive effects of the (*r*–*g*)-gap on top 1% income shares, and they conclude that inequality is driven by more important factors than the (*r*–*g*)-gap, such as institutions. Almost the same conclusion is reached by Goes (2016) who finds that capital's income share, as a proxy for inequality, is *negatively* related to the (*r*-*g*)-gap for more than 75% of his country sample.

This paper constructs an extensive *annual* macro dataset and examines whether capital's income share in the UK has been driven by the (*r*-*g*)-gap and, therefore, the extent to which the (*r*-*g*)-gap can be used as an analytical tool for inequality dynamics and inequality forecasting. More precisely, the paper examines the effects of *r* and *g* on capital's income share, $S^W$, for the UK over the past eight centuries, where *r* is measured as a weighted average of after-tax real returns on non-human wealth. Capital gains on non-reproducibles are included in capital's income share in most of the regressions, because these capital gains increase permanent income and, therefore, form a part of capital income. This concept is consistent with the Haig-Simons classical definition of income, which states that income is what we can consume while keeping our real wealth intact (see, for discussion, Roine and Waldenström, 2015).

The paper makes the following contributions to the literature. To enable tests of whether capital's income share is increasing in the (*r*-*g*)-gap, a unique annual historical dataset is constructed for the UK over the period 1210-2013 containing several variables including returns to assets, functional income distribution, contract intensive money, constraints on executive as well as several other variables. Asset returns are estimated as the average real returns to non-residential fixed capital, agricultural land, housing, government debt, net foreign assets, gold, silver, farm buildings, and livestock, weighted by the share of each asset in total wealth. In Sections 3.4 it is argued that $S^W$ is a sound proxy for income inequality and it encompasses key dimensions of inequality that are highly influential for inequality but that are not contained in conventional measures of inequality, such as

[3] Piketty (2014) does not use the term "third law of capitalist economics". Acemoglu and Robinson (2015) and Ray (2015) refer to $r > g$ as "Piketty's third law". Acemoglu and Robinson's definition of Piketty's Third Law is: "whenever $r >$ g; there will be a tendency for inequality to diverge" (2015, online Appendix p. 9).

capital gains, omission of income of the very rich and inflation-induced changes in relative wealth positions; sources that have been and will probably always be highly influential for income distribution as shown below.

The data cover several economic epochs in history, which not only enables assessment of whether the nexus between the (*r*-*g*)-gap and inequality applies to all modes of production, but also the extent to which the great historical waves in $S^W$ are related to the (*r*-*g*)-gap. The analysis covers the late medieval period when agriculture was the dominant mode of production, the First and the Second British Industrial Revolutions where manufacturing steadily took over as the leading sector of growth, and the third phase, starting around the time of the first oil price shock in 1973/74, in which information and communication technology services, ICT-services, have become the main growth promoting sector.

It is imperative to use ultra-long data in the analysis because $S^W$ moves at very low frequencies that even extend beyond a century, driven by slow-moving intergenerational wealth accumulation and low-frequency waves in asset prices. The finding that $S^W$ fluctuates at low frequencies around a constant level in the ultra-long run implies that estimates covering short periods are sensitive to the trajectory of $S^W$ in the particular estimation period, which, consequently, reduces the value of short-term analyses. Furthermore, long historical data enable one to gain insight into the dependency of income shares on the source of returns; e.g. whether the returns are predominantly derived from dividend yields, as during the industrial epoch, or real capital gains on land, as during the pre-industrial period as well as the post-industrial period in which urban land is the principal component of wealth accumulation. Econometrically, long data increase the efficiency of the parameter estimates and reduce their bias. Davidson and MacKinnon (2006), for example, show that instrument variable parameter estimates can be severely biased in small samples.

As another contribution, this paper tests whether $S^W$ can be explained by *r*, *g* and saving rates. Inflation, tariffs, and real food prices are used as instruments for *r*, *g* and saving rates to deal with endogeneity and measurement errors. Furthermore, several control variables, which are often stressed as important determinants of inequality, are included in the inequality regressions to ensure that the coefficients of *r* and *g* are not capturing the impact of omitted variables on inequality. These control variables are contract intensive money, constraints on executive, real prices of fixed capital, openness, old age dependency, skill premium, urban-rural wage gap, and taxes; variables that cater for globalization waves, institutional quality, demographics, inequality between wage earning groups, and labor-saving technological progress.

The empirical exercise gives three principal insights. First, three large waves in *r* and the (*r*-*g*)-gap are identified over the past eight centuries and graphical evidence suggests that these waves coincide with the waves in factor shares. The waves in the data are an outcome of political struggles between capitalists, the landed class and workers, and major shocks such as wars and epidemics; factors that result in inflations and deflations, fluctuations in tariff rates, and real food prices fluctuations. In the ultra-long run, however, $S^W$ converges towards a constant, as predicted by extant models of economic growth. Second, it is shown that a large fraction of *r* has been driven by real capital gains on non-reproducibles and that these have been a great source of the evolution of inequality, proxied by capital's income share including capital gains, since 1210. Third, it is shown that *r* and *g* are highly significant and robust determinants of $S^W$, and have the expected signs.

The rest of the paper is organized as follows. The nexus between the (*r*-*g*)-gap, inequality and economic theory and the main criticisms of Piketty's $r > g$-hypothesis are briefly discussed in Section 2, while data construction, data reliability, and graphical analyses are reviewed in Section 3. Regression results and robustness checks are presented in Sections 4 and 5, and Section 6 concludes.

## 2. The (*r*-*g*)-gap, inequality and growth

According to Piketty (2014, 2015a, 2015b) $r$ and $g$ play a vital role in the dynamics of inequality. While $r$ results in accumulation of wealth and capital income, $g$ dilutes them (Piketty, 2014; Brunnschweiler *et al.*, 2017). Furthermore, the inverted Pareto coefficient, which measures the thickness of the upper tail of the wealth distribution, is steeply increasing in (*r*-*g*) (e.g. Jones, 2015; see also Kesten, 1973, for a fully articulated model). However, Piketty's proposition that $r > g$ will lead to *increasing* inequality has been met with criticism. As stressed by Acemoglu and Robinson (2015) and Mankiw (2015), $r > g$ holds in steady state in standard growth models, and yet the capital-output ratio, *K*-*Y*, remains constant. As a central model in macroeconomics, for example, the dynastic model poses the following steady state relationship:

$$r = \gamma g^A + \rho, \qquad (1)$$

where $r$ is real asset returns; $g^A$ is productivity growth; $\gamma$ is the inverse intertemporal elasticity of substitution; and $\rho$ is the consumer's time preference. If, for example, $\gamma = 1$, then $r - g^A = \rho$ and it follows automatically that $r > g^A$ in steady state.

Furthermore, there has been some confusion in the literature as to whether the (*r*-*g*)-gap has growth or level effects on inequality. The criticism of Mankiw (2015), among others, relates to Piketty's (2014) statements that a sufficiently large (*r*-*g*)-gap has permanent growth effects on wealth inequality; partly reflecting the mixed signals given by Piketty.[4] As shown below and in the online Appendix, standard macro models predict a level-level relationship between the (*r*-*g*)-gap and $S^W$. Another concern is whether the impact on inequality is the same for changes in *r* and *g* and, therefore, whether the (*r*-*g*)-gap is the right metric to assess the forces that are guiding inequality. As shown in the empirical section, changes in *g* and *r* have quite different effects on inequality. To overcome these concerns the empirical analysis below includes *r* and *g* individually and allows *r* and *g* to have growth, as well as level, effects on inequality.

## 3. Data construction

Most of the discussion in this section centers on the principal variables: $S^W$, *g* and, particularly *r*, since, together with *g*, *r* is the focus variable in the analysis and the data for *r* in this paper offers a significant advance over the proxies for *r* used in the existing literature. Here, $S^W$ is used as a proxy for inequality as discussed in depth below (Section 3.4). Asset returns, *r*, are computed as a weighted average of real after-tax returns on non-human assets, where the weights are the share of each individual asset in the total portfolio. Following Piketty (2014), Piketty and Zucman (2014), and Waldenström (2017) total wealth, *W*, is defined as total non-human private wealth at market prices and, therefore, includes productive and non-productive wealth and real capital gains on non-reproducibles. The broad principles behind the data construction are presented in this section. Data sources, further details of data construction, data reliability, and the construction of control variables and instruments are discussed in depth in the online Appendix. In terms of data reliability it is argued in Section A4.1 that the quality of the data may not have deteriorated much as we go back in time because the narrow variety of products and the slow pace of innovative activity rendered measurement substantially simpler

[4] Piketty (2014), for example, suggests that the (*r*-*g*)-gap has permanent growth effects on inequality by the following statement: "If the difference $r - g$ surpasses a certain threshold, there is no equilibrium distribution: inequality of wealth will increase without limit, and the gap between the peak of the distribution and the average will grow indefinitely" (p. 258). Similarly, a higher saving rate will lead to permanently growing inequality: "If one saves more, because one's fortune is large enough to live well while consuming somewhat less of one's annual rent, then one's fortune will increase more rapidly than the economy, and inequality of wealth will tend to increase even if one contributes no income from labor" (p. 351). This reasoning gains support from Solow (2014) who states that: "This is Piketty's main point, and his new and powerful contribution to an old topic: as long as the rate of return exceeds the rate of growth, the income and wealth of the rich will grow faster than the typical income from work" (p. 1). However, in other places in his 2014 book and in later writings, Piketty suggests that the (*r*-*g*)-gap has level effects on inequality. For example, Piketty (2014) notes that "the distribution of wealth tends toward a long-run equilibrium and that the equilibrium level of inequality is an increasing function of the gap $r - g$" (p. 258). Furthermore, Piketty (2016) argues that the (*r*-*g*)-gap impacts on the level of inequality. For example, he remarks that "a central property of this large class of models is that for a given structure of shocks, the long-run magnitude of wealth inequality will tend to be magnified if *r*-*g* is higher" (p. 1).

*3.1 Asset returns*

Asset returns on a private portfolio are constructed annually as the weighted average of the real returns to government debt, fixed non-residential capital, agricultural land, dwellings, livestock, gold and silver, and net foreign assets, where the weights are their respective shares in total private wealth computed as a chain index:

$$r_t = \alpha_t^B r_t^B + \alpha_t^K r_t^K + \alpha_t^T r_t^T + \alpha_t^H r_t^H + \alpha_t^{G\&S} r_t^{G\&S} + \alpha_t^{LS} r_t^{LS} + \alpha_t^{FB} r_t^{FB} + \alpha_t^{NFA} r_t^{NFA}, \qquad (2)$$

where $\alpha^X$ = asset *X*'s share in total wealth and $r^X$ is asset *X*'s real expected after-tax returns; *B* = government debt/bonds; *K* is the real non-agricultural non-residential fixed capital; *T* = agricultural land (crop and pastoral land); *H* = dwellings (residential structures plus urban land); *G&S* = gold and silver; *LS* = livestock and working animals; *FB* = farm buildings; and *NFA* = net foreign assets.

The after-tax returns for each individual asset are computed as:

$$r_t^B = (1 - \tau_t^Y) r_t^{NB} - \pi_t^{CPI}, \qquad (3)$$

$$r_t^K = (1 - \tau_t^Y)\left(\frac{Div}{P^S}\right)_t + g_t^S - \pi_t^{CPI}, \qquad (4)$$

$$r_t^T = (1 - \tau_t^T)(1 - \tau_t^Y)\left(\frac{Rent^T}{P^T}\right)_t + g_t^T - \pi_t^{CPI}, \qquad (5)$$

$$r_t^H = [\,\theta_t(1 - \tau_t^H) + (1 - \theta_t)(1 - \tau_t^Y)]\left(\frac{Rent^H}{P^H}\right)_t + g_t^H - \pi_t^{CPI}, \qquad (6)$$

$$r_t^{G\&S} = g_t^{G\&S} - \pi_t^{CPI}, \qquad (7)$$

$$r_t^{FB} = (1 - \tau_t^Y) r_t^{RC} - \pi_t^{CPI}, \qquad (8)$$

$$r_t^{NFA} = (1 - \tau_t^Y)\left(\frac{Div^{NFA}}{NFA}\right)_t + g_t^S - \pi_t^{CPI}, \qquad (9)$$

$$r_t^{LS} = (1 - \tau_t^Y) r_t^{RC} + \pi_t^{LS} - \pi_t^{CPI}, \qquad (10)$$

where $\tau^Y$ = income tax rate; $r^{NB}$ = nominal bond rate on government debt; $\pi^{CPI}$ = consumer price inflation rate; *Div* = dividends per stock; $P^S$ = stock prices; $g^S$ = capital gains on stocks; $\tau^T$ = agricultural land taxes; $Rent^T$ = land rent per hectare; $P^T$ = price per hectare of agricultural land; $g^T$ = capital gains on agricultural land; $\tau^H$ = property taxes on dwellings; $\theta$ = share of dwelling wealth that is owner occupied; $Rent^H$ = unit housing rent; $P^H$ = unit dwelling prices; $g^H$ = capital gains on dwellings; $g^{G\&S}$ = capital gains on gold and silver; $r^{RC}$ = nominal rent charges; $Div^{NFA}$ = dividends on net foreign assets; *NFA* = value of net foreign assets; and $\pi^{LS}$ = livestock price inflation (weighted average of prices of cattle, horses, oxen, pigs and sheep).

In most cases returns to each individual asset are self-explanatory; however, the returns to foreign assets, bonds and fixed capital require some discussion. Returns to foreign assets are calculated as the sum of after-tax dividend yields on foreign assets plus capital gains on domestic stocks, where the dividend yield is estimated as the net income from abroad as a percentage of the net foreign asset position. Capital gains on domestic stocks are used for capital gains on foreign assets because the data on the growth in the net foreign asset position are not of a sufficiently good quality to be used; even the most recent data.[5]

Sold at least as early as the late 12th century, rent charges, which were the most important nominal debt instruments before the late 18th century (Clark, 1988), are also used to backdate nominal bond returns, $r^{NB}$, before 1775. Rent charges are perpetual fixed nominal obligations that give the owner of the rent charge the right to receive a specified payment each year in perpetuity. Since they were secured by land, houses and other property, they were considered to be safe debt instruments with low default probabilities, and they were not affected by medieval usury laws because they were regarded as a sale in advance of rent from property and not as a loan (Clark, 1988). Selling rent charges was a popular way of raising capital until the late 18th century (Clark, 1988). As argued by Clark (1988) rent charges are probably the closest one can come to the long historical cost of capital. Although interest rates on bonds and other credit instruments are repeatedly used as proxies for asset returns in the literature, they are particularly biased measures of returns on balanced portfolios before well into the 17th century (see, for an in-depth analysis of estimates of interest rates before the 18th century, online Appendix Section A4, and the discussion in Section 3.7).

The returns to non-residential non-agricultural fixed capital, $r^K$, are estimated as real after tax stock returns (see, Eq. (4)) because corporate earnings data are unavailable before 1900 and, more importantly, because stock returns adequately account for differential tax treatments of dividends and capital gains that are the result of additional fixed capital investment or share-buy-backs. Furthermore, in contrast to corporate earnings in national accounts, stock returns implicitly account for negative capital gains resulting from creative destruction in which new technologies replace older ones and, consequently, reduce the real value of the existing capital stock. The data on dividends and stock prices

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[5] I initially computed capital gains from net foreign assets using the following model:

$$g_t^F = g_t^{Fass} - \left(\frac{CA}{Fass}\right)_{t-1},$$

where $CA$ is current account on the balance of payments, and $g^{Fass}$ is the growth in the value of the net foreign asset position. While this approach is theoretically correct, the generated capital gains are implausibly high during the Napoleonic War and, particularly, after 1969. Using this method capital gains apparently exceeded 600% each year over the period 1974-1976, in spite of falling global asset prices, and the annual capital losses exceeded 22% each year over the ten years up to 2013; a period during which the global capital markets experienced large capital gains.

are available back to 1695 and real rent charges are used as proxies for returns to fixed capital before 1695.

The share of each asset in total wealth, $\alpha^X$, is based on the wealth estimates of Madsen (2016). The guiding principle behind the construction of the wealth data is that 1) non-residential non-agricultural fixed capital is valued by the volume of non-residential non-fixed capital stock multiplied by Tobin's $q$; 2) urban and agricultural land are valued at market prices and are estimated as the market value of the average unit of asset times its quantity; and 3) the value of farm structures, gold and silver and livestock are valued at acquisition costs.[6]

The advantage of the approach used here is that it is transparent, is based on annually changing weights (chain index), covers the main assets in a balanced portfolio, includes capital gains on each individual asset, and allows for movements of the relative prices of capital/wealth and consumption (see, on the last point, Caselli and Feyrer, 2007). An alternative method, which is used by Acemoglu and Robinson (2015) and Goes (2016), is to recover real returns from the equation $r^{SK} = S^W \cdot Y/W - \delta$, where $r^{SK}$ is real returns recovered from capital's income share and $\delta$ is the depreciation rate; however, this method requires data for wealth that are only sparsely available, mostly do *not* include important assets such as land, livestock, foreign assets, gold and silver, and requires weighted averages of depreciation rates that vary substantially for asset classes and over time as the production structure changes.[7] Problematic for this method is also that taxes cannot be adequately allowed for because they are specific to each asset and type of return (dividend yield versus capital gain) and that capital gains on non-reproducible assets are not included in $S^W$. Thus, $r^{SK}$ is likely to be a severely biased proxy for the real post-tax returns on a balanced portfolio.

The downside of the estimates undertaken here is that returns on individual assets may underestimate those of wealthy individuals (Piketty, 2014) and returns to subsoil wealth are unaccounted for. Data on the value of and the returns to mines are not available and even current methods do not provide wealth estimates for mines, but estimate subsoil wealth by discounting rents by a constant discount rate (see, for discussion, Caselli and Feyrer, 2007). Finally, although some of

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[6] An oft-used method to generate wealth before WWII is created from earnings records that are converted to wealth by multiplying by a fixed number; the so-called 'years of purchase' that is typically set to 20 for the main assets. In other words, this method assumes that earnings are perpetually discounted by a constant discount rate, regardless of whether earnings are atypical and discount rates change over time and, as such, is a very rough approximation (see, for a critical assessment, Madsen, 2016).

[7] Goes (2016) uses the post corporate-tax sovereign bond rate minus contemporary inflation. It is not clear, however, why the corporate tax rate as opposed to the direct tax rate, is used to compute the post-tax interest rate. In the robustness section he estimates returns as capital's share times the *Y-K* ratio from the Penn World Tables, where *K* is total fixed capital. There are several problems with his approach; most importantly: 1) $S^K$ includes labor income of the self-employed; 2) wealth in the denominator of the *Y-W* ratio is based on fixed capital; and 3) returns are measured as gross returns; i.e. is inclusive capital depreciation.

the data are interpolated on decennial frequencies, this should not affect the results since the estimates are undertaken in 10-year intervals.

### *3.2 Income*

The real and nominal GDP data are from Clark (2010) (real net national income) over the period 1210-1270; from Broadberry *et al*. (2015) over the period 1270-1820 and spliced to Bank of England's GDP data after 1820. The data constructed by Broadberry *et al*. (2015) constitutes the most thorough and probably the most credible reconstruction of long historical GDP data undertaken thus far.

### *3.3 Share of income going to capital*

Two measures of capital's income share are used in the regressions as measures of inequality; a conventional one and one in which capital gains on non-reproducibles are included:

$$S_t^W = 1 - \Psi_{1855} \frac{w_t^{UL}[\Phi_t^A wp_t^{UA} + (1-\Phi_t^A)(0.5+0.5wp_t^{SU})]Pop_t}{Y_t}, \tag{11}$$

and

$$S_t^{WCG} = S_t^W + [(g_t^T - \pi_t^{CPI})\alpha_t^T + (g_t^H - \pi_t^{CPI})\alpha_t^H]W_t/Y_t, \tag{12}$$

where $S^W$ = capital's income share of net national income *excluding* capital gains on non-reproducibles wealth (conventional case); $S^{WCG}$ = capital's income share *including* capital gains on non-reproducible wealth; *Pop* = population; $w^{UL}$ = *annual* wages of unskilled urban labor; $wp^{UA}$ = the ratio of *daily* wages of unskilled urban labor and agricultural labor; $wp^{SU}$ = the ratio of *daily* wages of skilled and unskilled urban labor; $\Phi^A$ = the employment share of agriculture in total employment; $W$ = total non-human wealth (agricultural land, dwellings, precious metals, consumer durables, livestock, fixed capital); $Y$ = nominal net national income; $g^H$ = capital gains on dwellings (underlying land plus structure); $\alpha_t^T(\alpha_t^H)$ = agricultural land (dwelling) share of total wealth; and $\Psi_{1855}$ = a conversion factor to realign the level of $S^W$ to capital's share derived from national accounts in 1855, when national account data become available.

Income shares, $S^W$, is based on Eq. (11) up to 1855, after which national account data are used as detailed in the online Appendix. Compensation to employees (second term in Eq. (11)) is computed as employment times annual average earnings per worker, where workers' average earnings are annual earnings of unskilled labor adjusted by the share of different types of labor and their hourly wages relative to that of unskilled labor, assuming that the ratio of hourly and annual wages of skilled and unskilled labor are the same (annual income is only available for unskilled urban labor). The wage data are constructed by Humphries and Weisdorf (2016) and offer a marked improvement over previous wage data because they allow for variations in the annual number of working days, which have changed substantially over time and reliable estimates of annual hours worked are not currently available (see, for discussion, Madsen and Murtin, 2017). The share of skilled urban labor in total urban employment is assumed to be 50%, as reflected by the term $w_t^{UL}(0.5 + 0.5wp_t^{SU})$, which gives half weight to the annual income of skilled as well as unskilled labor. After 1855 $S^W$ is estimated as one minus the share of compensation to employees in net national income, where labor earnings of the self-employed are imputed into compensation to employees (earnings from labor of the self-employed and working family members are counted as profits in national accounts). Nominal net national income is used in the denominator to ensure that $S^W$ is based on earnings after capital depreciation.

Capital gains on urban and agricultural land are included in the second measure of capital's share, $S^{WCG}$, because they add directly to wealth inequality and, indirectly to income inequality when the assets are sold, borrowed against, or passed on to the next generation in the form of gifts or bequests. While capital gains on non-reproducibles are not included in national account estimates of $S^W$, capital gains on fixed capital, in the form of capital gains on stocks, are implicitly contained in $S^W$ as corporate earnings in steady state since real stock prices only increase in the long run because of retained earnings, which are included in $S^W$ (for analysis, see Madsen, 2016).

Conventional income inequality measures will often give a misleading picture of capital gain induced movements in income and wealth inequalities. According to the permanent income hypothesis, wealth mirrors permanent income over peoples' lifespans, therefore, capital gains on non-reproducibles should be included in any measure of income dispersion. This result holds in dynastic models where consumption is spread over future generations as well as in economies with low social mobility and in which inheritance is a large fraction of income. As shown for France by Piketty (2014), inheritance is a large fraction of income and tends towards approximately 20% in the long run. Examining the period 1270-2010, Clark (2014) finds low social mobility in England over the period 1170-1800 with only a slight increase after 1800. The intergenerational correlation of underlying social status jumps from 0.83 before 1800 to 0.73 thereafter, suggesting that the stubbornly low social mobility that prevailed in mediaeval England has almost persisted to the present day. The low social mobility implies a persistent wealth distribution and that the relative income position of an individual will be echoed in the individual's relative wealth position, particularly when capital gains on non-reproducible assets are allowed for in the estimates of factor shares.

Capital gains have remained a large source of income (when the gain is realized) of top-income earners throughout the last century in the advanced countries. Based on data for Sweden, Roine and Waldenström (2012) find that the top 1% income share in total income was, on average, 40% higher over the period 1990-2008 when *realized* capital gains are counted as income. For the US over the period 1916-1998, Piketty and Saez (2003) find that 18% of the income of the top 1% share, on average, is attributed to capital gains. Furthermore, capital gains amplify the income inequality between employees, as, for example, high-income employees in the finance sector receive income from bonuses that are often linked to capital gains on real estate, while earnings of real estate agents are often more or less a fixed constant proportion to property values, and a high share of CEOs' remunerations are derived from share options. For the UK, the real capital gains share of total real asset returns has fluctuated between 15% and 30% over the period 1210-2013 and has been above 20% over the past two centuries if the real capital losses on government bonds are omitted from the estimates (see online Appendix for data sources).

*3.4 Capital's share as a measure of inequality and its mapping to the Gini*

This section asks the question of the quality of $S^W$ as a proxy for inequality. To gain insight into this issue consider the following decomposition of the Gini coefficient (see the online Appendix for derivation):

$$Gini = S^W(1-\kappa) + l^S l^U wp^{SU} + l^S l^A wp^{SA} + l^U l^A wp^{UA}, \quad (13)$$

where $\kappa$ = fraction of the capital-owning labor force; $l^S$ = fraction of the skilled labor in the total labor force; $l^U$ = fraction of the unskilled labor in the total force; $wp^{SU}$ = after-tax wage premium for skilled over unskilled labor and is defined as the ratio of skilled and unskilled workers' wages, $l^A$ = fraction of agricultural labor in the total force; and $wp^{SA}$ ($wp^{UA}$) = the after-tax wage premium of skilled (unskilled) labor over agricultural labor.

Consider first the pre-WWII period. The share of income going to capital, $S^W/S^{WCG}$, is likely to be a good indicator of personal income and wealth distribution well into the 20th century when there was a strong and clear divide between owners of land/fixed capital and workers. The working and landless classes were representative of almost the entire wage-earning population and this class derived little income from wealth (Prados de la Escosura, 2008). From the 18th century and, presumably earlier, up until WWI, approximately 90% of the English land was cultivated by tenants (Offer, 1991). Similarly, Kuznets (1955) finds that the middle class was very small in the pre-WWII period. Furthermore, Clark (2005) finds that the skill premium was relatively flat before WWII.[8] Thus, Eq. (13) in the pre-WWII period, approximately collapses to:

[8] The skill premium was relatively low and constant over the period 1210-1939, as indicated by the data constructed by Clark (2005). The wage ratio between skilled and unskilled building labor fluctuated closely around 1.6 over the period 1210-1869, except for the second half of the 13th century and most of the 14th century where the ratio fluctuated around 2. Since it is the variation in skill premium that has been minuscule relative to that of $S^W$, it implies that the main part of the

$$Gini \cong S^W + Constant. \quad (14)$$

Since the 'Constant' in this equation is captured by the constant term in the regressions below, $S^W$ is likely to mimic the Gini coefficient well before WWII.

For the post-WWII period, $l^A$ is miniscule. Thus Eq. (13) collapses to the following approximation:

$$Gini \cong S^W(1-\kappa) + l^S l^U wp^{SU}. \quad (15)$$

For simplicity, no distinction is made in the definitions of skilled and unskilled labor in Eqs. (14) and (15). However, their meanings have changed over time. In the pre-industrial era and well into the industrial era, skilled labor was customarily referred to as workers who had completed an apprenticeship (Clark, 2005). More recently, skilled labor is referred to as those with at least some college education, and one would probably put the benchmark at lower or higher secondary education in the transition between 1900 and 1950 for the UK. The WWII benchmark is used here for simplicity.

Defining skilled labor as those with some college education in Eq. (15), the share of skilled workers in the labor force, $l^S$, has increased from insignificance immediately after WWII to become significant after the 2000, as the highly educated students entered the labor market to replace the 60+ relatively low-educated workers exiting the labor force. Thus, more recently, factor shares may have weakened as indicators of inequality because the share of high income earners among employees has increased (Piketty, 2015a, 2015b). However, several recent studies suggest that the positive correlation between the personal and the functional income distribution has remained strong in the post-WWII period as high income earning employees have experienced large real capital gains on their assets and have large pension funds that are invested in assets (Roine and Waldenström, 2012). Furthermore, Gennaioli *et al*. (2014) show that financial income is a function of intermediated wealth, which, in conjunction with financial sector employees being a large fraction of high income earners, gives an indirect, but strong, link between employees' inequality and the $W$-$Y$ ratio and $S^W$. For the UK, Bell and Van Reenen (2014) find that bankers' bonuses account for two-thirds of the increase in the top 1% share over the period 1999-2008; thus confirming a strong link between profits and high-income employees.

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identifying variation in the Gini coefficient comes from variations in $S^W$ and not variations in the skill-premium between skilled and unskilled labor. Furthermore, Williamson (1991) estimates an overall Gini of 0.55 in 1891 (see his Table 2.5) while the Gini coefficient between industrial workers was only 0.18 in 1896 (see his Table 4.5), suggesting that most inequality is between groups and not within the working-class group.

Overall, the analysis above suggests that there is a high correlation between $S^W/S^{WCG}$ and $wp^{SU}$, implying that $S^W/S^{WCG}$ is likely to a good proxy for inequality. Empirically, the literature tends to find a strong positive relationship between inequality and the share of income going to capital (Giovannoni, 2010; Jacobson and Occhino, 2012; Adler and Schmid, 2013; Bengtsson and Waldenström (2017).

Weighting $S^W/S^{WCG}$ against other measures of inequality, it is not clear which is the best measure of inequality. On the downside, $S^W/S^{WCG}$ as a measure of inequality relative to other income inequality measures, does not fully capture the income dispersion between employees and those living predominantly of capital income. The upsides of using $S^W/S^{WCG}$ as measures of inequality are the following. First, $S^{WCG}$ captures capital gains on non-reproducibles, and this is a main source of permanent income in the pre- and the post-industrial society as discussed above. Second, inequality measures based on personal tax returns do not contain companies' retained earnings and nor do reinvested dividends in mutual funds (Bengtsson and Waldenström, 2017). Furthermore, taxable labor earnings typically do not include social security contributions (Bengtsson and Waldenström, 2017).

### *3.5 Graphical analysis*

#### *3.5.1 Returns to agricultural land*

After tax real returns to agricultural land, which are displayed in Figure 1, were influential on composite asset returns in the preindustrial era because agricultural land constituted more than half of total private wealth. The returns fluctuated around a mean of 3.5% during the preindustrial period 1210-1789, with a slightly higher level of 4.3% over the period 1560-1789. The increase in returns after 1560 came predominantly from increasing land productivity, enhanced by increasing crop rotation, technological innovations, improved drainage methods brought about by innovations, and the increasing spread of dissemination of information about the latest agricultural advances through agricultural technical manuals (Ang *et al*., 2013). Provided that per capita income was kept constant for the working class in a Malthusian regime, technological progress would automatically expand unit land rent. It is likely that land rents did not increase more than they did because tariff rates on imports were lowered from a high of approximately 50% to a plateau of approximately 25% over the period 1740-1800; thus, increasing the foreign competition.

Returns shift up in 1790 to a very high level and, although the spectacularly high level is temporary, the returns are, on average, 11.3% over almost two centuries up to 1973, when the UK joined the Common Market. The fundamental forces behind these extraordinarily high returns over the period 1790-1870 were large productivity advances in agriculture coupled with flat real wages that failed to keep up with the large productivity advances, presumably because of the strong population pressure and the Corn Laws over the period 1815-1846 that resulted in increasing real prices of agricultural products, which were already driven up to high levels during the Napoleonic wars. The real returns to land were, on average, no less than 17.5% over the period 1815-1846 during which the Corn Laws were in place.

**Figure 1. Agricultural Land Returns, 30-Y MA**

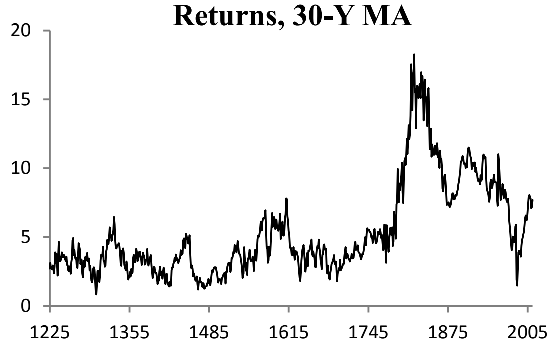
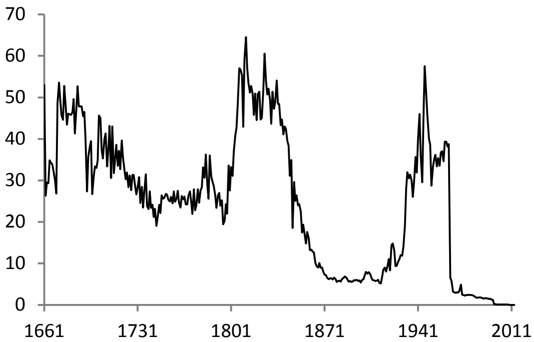



**Figure 2. Tariff Rate, %**




**Notes**. Land returns are after tax dividend yields on land plus real capital gains. The tariff rate is calculated as import duties divided by nominal imports of goods.

Remarkably, while capital gains are influential for high returns after WWII, dividend yields are explaining the lion's share of returns over the period 1790-1945. This raises the question of why increasing land rents were not capitalized in higher agricultural land prices during the same period to give room for a more normal dividend yield following the dividend discount model.[9] Reduced value attached to prestige and political influence from owning land and reduced earnings growth expectations are possible explanations for why the higher land rents were not capitalized in land prices.[10] A second puzzle is why returns to land were not driven noticeably down by the Black Death that resulted in a marked reduction in the population size that lasted up to 1450 (see Figure 4). A possible explanation is the prevalence of a high elasticity of substitution between land and labor. Clark (2016), for example, argues that farmers prevented a significant decline in returns by switching from

[9] An increase in land prices for a given land rent increases ex-post capital returns on impact. However, for a given expected real capital appreciation, ex ante returns will decline because the higher land prices have reduced dividend yields; the ratio between unit land rent and the unit price of land.

[10] Based on the dividend-discount model, the following expression can be derived for the land dividend yield:

$$\frac{Rent^T}{P^T} = [r^T - \mu - g^{Ear,T}]/[\,(1-\tau_t^T)(1-\tau_t^Y)]$$

where $\mu$ = annual value attached to prestige and political influence *relative* to earnings and $g^{Ear,T}$ is the growth in real-after tax land rent. If the prestige factor is assumed to be time invariant and constant per hectare of land, the dividend yield becomes $= [r^T - g^{Ear,T}]/[\,(1+\mu)(1-\tau_t^T)(1-\tau_t^Y)]$. Since declining land taxes were countered by increasing income taxes the denominator on the right-hand-side did not change much over the period. Reduced prestige from holding land, $\mu$, and declining earnings prospects are more likely to have kept the dividend-yield high during the period 1790-1945.

labor intensive arable cultivation to less labor intensive pasture.[11] This suggests an elasticity of substitution above one; however, note that in the ultra-long run the elasticity of substitution between capital, including land, converges to one because labor's share tends towards a constant, as shown below.

*3.5.2 Returns to corporate capital*

Real after-tax returns to non-residential capital fluctuate around an ultra-long average of 5.4% (Figure 3). The extraordinarily high return over the approximate period 1210-1340 (onset of the Black Death) was not unique to medieval UK but was widespread across Western Europe, and it appears that a high time-preference and imposition of usury laws and moral values discouraging lending were the underlying causes (see, e.g., Clark, 1988; Homer and Sylla, 2005). Since the onset of the Black Death in 1348, returns have fluctuated around a constant of 5%. Unlike returns to agricultural land, the trend returns are close to the long-run mean and the trend has not been affected by the British Industrial Revolution because technological revolutions do not increase asset returns – rather the contrary, because of creative destruction (see, e.g., Madsen and Davis, 2006). Like for land returns, the Black Death did not have noticeable effects on returns to fixed capital – perhaps because of a high elasticity of substitution between labor and fixed capital.

**Figure 3. Real After-Tax Stock Returns, 30-Y MA**

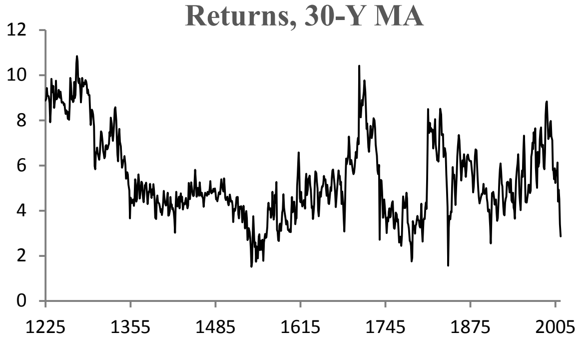
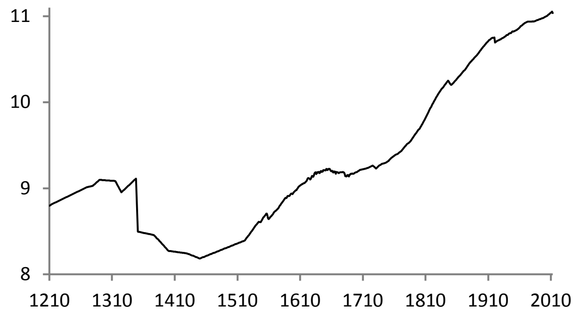



**Figure 4. Population, in Logs**




[11] Land cultivation was not only highly labor intensive during the harvest but also during the periods of plowing, weeding, fertilizing the soil, etc. In other words, labor and crop land were gross complements, while labor and pastoral land were gross substitutes, the Plague-induced labor shortage gave landowners an incentive to substitute animal production for corn production. This scenario is consistent with the time-profile of real wages: farmworkers' real wages increased by 100% over the period 1347-1350 and fell 33% over the period 1350-1352, yielding a net increase of approximately 33% (see online Data Appendix for sources). Using an alternative dataset to the one used here, Clark (2016) finds that the real wages of agricultural workers did not increase at the onset of the Black Death and immediately thereafter.

*3.5.3 Returns to government debt*

Real after tax returns to government debt fluctuated around 2% before 1939 and have since fluctuated around zero (Figure 5). The negative returns over the periods 1940-1958 and 1975-1988 were the results of inflationary shocks, which were probably mostly unanticipated, combined with marked increases in income tax rates after 1939. The three inflationary episodes, 1915-1920, 1940-1952 and 1973-1982 markedly reduced the real after-tax returns to bonds because the inflations were, to some extent, unexpected, and not all bond-holders understood the implications of inflation on bond returns. The effect of the low and negative returns to bonds on overall returns was compounded by the increasing weight of government bonds in the overall portfolio. The share of government debt in total wealth increased from 7% in 1913 to approximately 40% during WWI and fluctuated around this level up until the late 1950s, and didn't return to the pre-WWI level until 1977. Since the increasing inflation was only fractionally passed on to higher nominal interest rates, and the top-income tax rates increased to historical heights during WWII and remained high up to the early 1980s, the resulting negative post-tax real bond returns were major contributors to the low returns during this period (Roine *et al*., 2009; Piketty, 2014).

**Figure 5. Real After-Tax Returns on Government Debt**

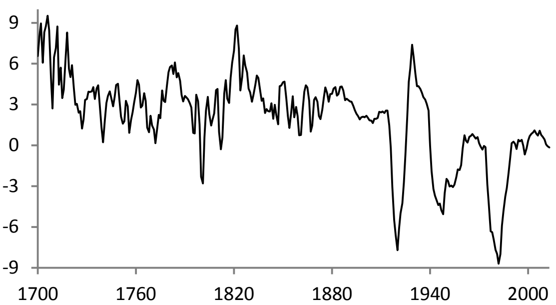
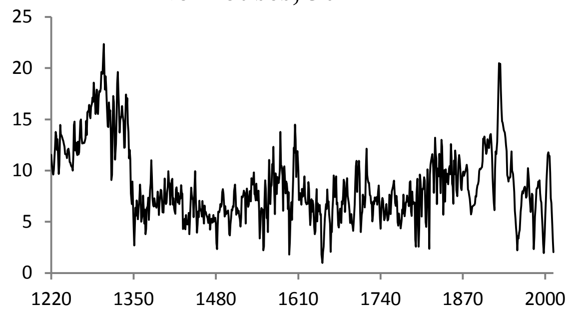



**Figure 6. Real After-Tax Returns to Houses, 30-Y MA**




*3.5.4 Returns to dwellings*

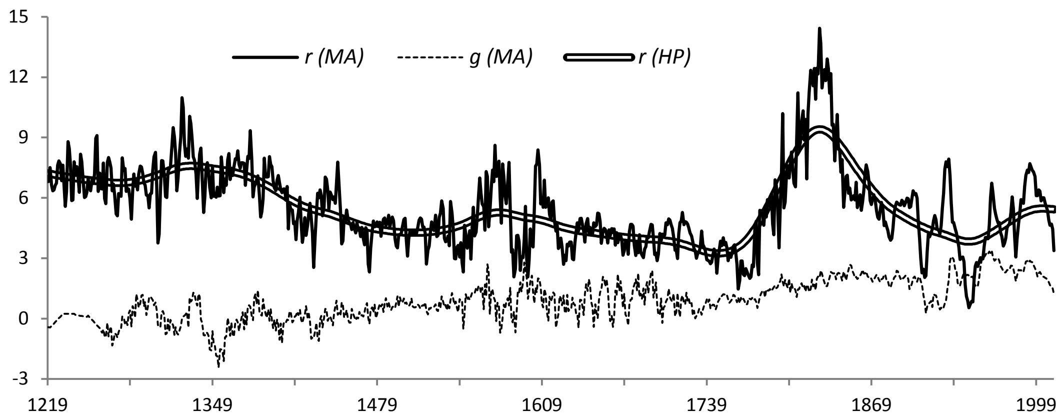
Real returns on dwellings, which are displayed in Figure 6, fluctuated around an average of 14.3% over the period 1210-1348, dropped to a mean of 7.6% over the remaining period 1349-2013. Real capital gains are, on average, 0.8%, suggesting that the high returns on dwellings is almost entirely driven by dividend yields, or rental income. Why did house returns fall so sharply at the onset of the Black Death when returns to agricultural land and fixed non-housing capital was hardly affected by the Black Death? High capital adjustment costs for dwellings in the downward direction is likely to have increased the excess supply of rental accommodation substantially and, through market forces reduced the rental income of the landlords. Returns never returned to their pre-1348 levels because the returns to assets in general were at much lower levels than their pre-1348 levels.

Turning to the real after-tax returns to houses, the high level is more difficult to explain. The consumption CAPM would explain the high level by a high correlation between real returns to dwellings and consumption growth as risk-averse investors prefer high returns during periods of low income in order to smooth out consumption over the life cycle – or over generations in the dynastic model. However, to explain the high excess returns on dwellings would probably require an unrealistically high degree of risk aversion/intertemporal elasticity of substitution. The high excess returns on dwellings over bonds gives rise to a housing premium puzzle that corresponds to the equity premium puzzle, but may be even harder to explain since the variance of real returns to dwellings is significantly lower than that of stocks.

### *3.5.5 Total asset returns*

First consider asset returns, $r$ (the evolution of $g$ is analyzed in the next subsection). Figure 7 identifies trends in $r$ at three different frequencies: 1) An ultra-long-run slow moving trend; 2) three long-term waves typically of 100-150 years; and 3) fluctuations below 100 years duration influenced by business-cycles, wars, crop failures and asset market run-ups. The trend in real asset returns is surprisingly constant in the ultra-long run, fluctuating around the sample average of 5.2%. This constancy is confirmed by regressing $r$ on a time-trend, which yields a coefficient of the time trend of -0.001(-0.44), where the figure in parenthesis is the $t$-value and $N = 804$.

**Figure 7. Asset Returns and Growth, %**




**Notes**. The double-tracked trend-line in $r$ is computed from the HP-filter with a smoothing factor of 100,000. The other lines are computed as 25-year centered moving averages of the actual data. Here $g$ is the annual growth in total real GDP and $r$ is the annual real after-tax returns to assets.

Three waves in $r$ can be identified during the approximate periods 1300-1400, 1560-1660, 1780-1870, and a half wave starting about 1960. The first wave was not unique to medieval UK but was widespread across Western Europe and it appears that usury laws and moral values discouraged lending and, consequently, generated an excess demand for loans. The decline in asset returns after 1400 is consistent with the timing of declining interest rates on long-term debt instruments in continental Europe (Homer and Sylla, 2005, Chs. 8 and 9) and the decline in house rent following the outbreak of the Black Death.

The second wave, and somewhat minor compared to the other two waves, in $r$ during the approximate period 1560-1660 was a result of high returns to fixed capital, partly brought about by the scientific and educational revolutions that increased the knowledge stock per worker and led to increasing returns to fixed capital (Madsen and Murtin, 2017). The landed class also enjoyed higher returns brought about by the three-fold increase in real food prices over the period 1570-1709 and significant technological progress in agriculture (Ang *et al*. 2013). Provided that per capita income was kept constant for the working class in a Malthusian regime, the technological progress would automatically increase the income of the wealthy and, therefore, inequality.

The third, and the most pronounced wave in $r$ occurred in the first half of the 19$^{th}$ century and was predominantly a result of extraordinarily high returns to agricultural land, housing, and fixed capital. The fundamental forces behind this increase were 1) large productivity advances in agriculture that increased the returns to land; 2) flat real wages that failed to keep up with the large productivity advances, presumably because of the strong population pressure; 3) ineffective unions and lack of political representation that made it difficult for workers to get a greater share of income; and, most importantly, 4) the Corn Laws over the period 1815-1846 that resulted in increasing already high real prices of agricultural products.

The Trade Union Act of 1871, which legalized trade unions, and the Great Agricultural Depression over the period 1873-1896 marked the end of the high asset returns enjoyed during most of the 19$^{th}$ century. WWI signaled a further blow to the high asset returns experienced during the 19$^{th}$ century and asset returns declined to an average low of 3.1% during the period 1915-1982; a return that even underperforms the average low of 3.4% that prevailed during the period 1350-1560. Falling real prices of agricultural produce, starting in the early 1920s and the often negative corporate profits during the Great Depression forced asset returns down during the 1930s

A final, but pressing, question is the extent to which $r$ has been driven by $g$, as predicted by intertemporal consumer-based models. Empirically, there is not a statistically significant positive relationship between $r$ and $g$ for Britain over the period 1222-2013 (see online Appendix for regression analysis). Looking at Figure 7, it is also difficult to pinpoint any positive association. Asset returns were well above their trend despite approximately zero growth rates up to the early 15th century, *r* and *g* moved in reverse directions during most of the 16th century, and the high growth period, 1920-1980 coincided with a low *r*. This finding could be a result of the blurred relationship between *r* and *g*, as implied by some growth models analyzed in Barro and Sala-i-Martin (1992), or that diminishing returns were avoided through high capital mobility and the fixed exchange rate system that prevailed in Britain over most of the period considered here. Malthusian population dynamics in the pre-industrial period could also have prevented diminishing returns to capital because population would respond endogenously to capital deepening (Peretto, 2015).

*3.5.6 The income growth path*

As seen from Figure 1, the trend growth rate was close to zero from 1210 until the mid-16th century because, apart for the marked negative population shock of 1348-1351 population growth rates were close to zero (Figure 4), and slow productivity growth rates that were driven predominantly by modest advances in technology and education (Madsen and Murtin, 2017). The growth rates picked up substantially during the later 16th century. The spread of the movable printer, which reduced book prices substantially during the 16th and the 17th centuries, was pivotal for the educational expansion in Britain and the dissemination of knowledge which, coupled with the scientific revolution in the 17th century and increasing innovative activity, lead to productivity advances not experienced earlier in recorded British history (Galor, 2005; Madsen *et al*., 2010; Madsen and Murtin, 2017).

The high population growth rates during the 16th and the 17th centuries additionally increased *g* directly; however, the total effect on *g* was reduced by the population growth drag introduced by land as a semi-fixed factor of production (Madsen *et al*., 2010). Assuming that the output elasticity of land was 0.5 and capital's income share was a third, the net effect of population growth on *g* was only 0.25%.

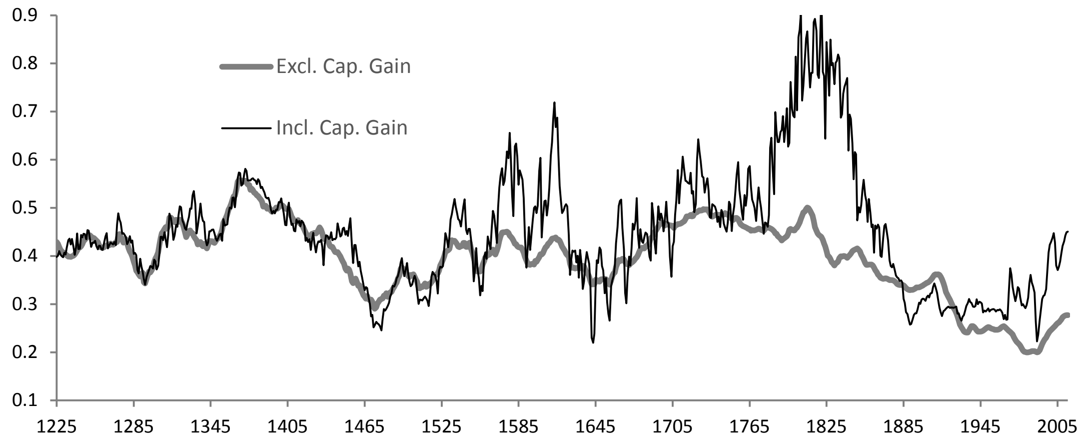
The productivity advances during the first phase of the British Industrial Revolution were associated with increasing population pressure (Figure 4) because the quantity effect remained strong relative to the quality effect in the fertility decision (Galor, 2005). The fertility transition, first occurred later during the British Industrial Revolution as parents substituted quality for quantity in response to increasing returns to education and increased opportunity costs of having children triggered by a reduced gender wage gap (Galor, 2005). The fertility transition coupled with slow productivity advances over the period 1910-1928, reduced *g* substantially. Subsequently, the educational and scientific advances over the period 1929-2007 resulted in strong productivity advances that kept *g* high despite low population growth rates (Madsen *et al*., 2010).

Finally, the largest growth wave over the entire timespan considered here occurs in the approximate period 1935-2000, and is heavily influenced by productivity advances driven predominantly by increasing R&D and human capital, and the fertility transition that was associated with increasing female labor force participation, reduced age dependency and enhanced saving (Madsen, 2010).

*3.5.7 The evolution in $S^W$ and $S^{WCG}$*

Capital's income shares, $S^W$ and $S^{WCG}$, are displayed in Figure 8. Factors shares oscillate around a constant ultra-long run trend at medium-term frequencies of 150-200 years. The long-run constancy in the $S^W$ and $S^{WCG}$, at least up to 1800, indicates that the elasticity of substitution between capital, broadly defined, and labor tends towards one in the ultra-long run, but periodically deviates from its long-run equilibrium of one through changing mark-ups, skill-biased technological progress and changing relative prices of reproducible capital (Karabarbounis and Neiman, 2014).[12] The periods 1300-1400/1450, 1550-1650, and 1790-1870 are associated the level of $S^{WCG}$ above its ultra-long trends and these periods tend to coincide with the waves in *r* and *g*.

**Figure 8. Capital's Income Share**




**Notes**. The data are 30-year centered moving averages. Capital's income shares, $S^W$ and $S^{WCG}$, are computed using Eqs. (11) and (12).

[12] Consider the Cobb-Douglas production function in which technological progress is always Hicks-neutral, $Y = AK^{\alpha}T^{\beta}L^{1-\alpha-\beta}$, where $T$ = land. Under perfect competition and profit maximization, the share of income going to capital is constant and determined by output elasticities:

$$S^W = \frac{rW}{Y} = \frac{r^K K + r^T T}{r^K K + r^T T + wL} = \alpha + \beta.$$

Starting from the first wave, the marked negative population growth rates over the period 1348-1380 (Figure 4) were likely influential for the sharp increase in capital's income shares over the period 1348-1380 as the shrinking population increased the concentration of wealth and earnings derived from wealth.[13] The technological advances during the second wave, 1550-1650, increased returns to fixed capital and land. Although we would expect capital deepening to reduce these excess returns on fixed capital relatively quickly, the adjustment process was slowed down considerably by the absence of well-developed credit markets. The third wave in capital's income shares was predominantly driven by large productivity advances in agriculture, the Corn Laws that upheld the high real corn prices achieved during the Napoleonic wars, and an expanding gap between real wages and the general productivity advances.

The marked decline in $S^{WCG}$ over the period from 1833 to 1910 is exceptional and deserves some discussion. Half of the decline is a gravitation towards the ultra-long-run trend and, as discussed above, capital's extraordinarily high share over the period 1800-1840 was predominantly a result of land rents driven up by a lucrative market for agricultural produce during the Anglo-French wars 1794-1815 (including the Napoleonic war) and kept artificially high by the Corn Laws. Land rents were deemed to fall as soon as the Corn Laws were repealed. Capital's income shares were pulled down by a sequence of events such as the repeal of the Corn Laws in 1846, and the Great Agricultural Depression over the period 1873-1896 (see, e.g., Fletcher, 1961) and the large population pressure in the 19th century furthered the reduction in the $W$-$Y$ ratio through wealth dilution effects.

The decline in $S^{W}$ after 1814 is less abrupt. It declines gradually throughout the period 1814-1990. Adverse shocks such as the agricultural crises in the 19th century, the inflationary spells in the 20th century that eroded the real value of nominal claims, high productivity growth rates, and increasing marginal tax rates and increased union strength, as indicated by increasing unionization up to its peak in 1979, have all contributed to the decline in $S^{W}$. The upward turn in $S^{W}$ from the 1990s and in $S^{WCG}$ from the 1980s has been associated with reduced growth relative to the previous decades, and the weakening of union strength, as signified by a fall in the union membership rate from its historical peak of 46% in 1979 to 22% in 2013. The ascending real prices of urban and agricultural land have also been influential for the increasing inequality.

[13] For the CES production function, $Y^R = \left[\alpha T^{(\sigma-1)/\sigma} + (1-\alpha) L^{(\sigma-1)/\sigma}\right]^{(\sigma-1)/\sigma}$, the rate of returns on non-residential and non-agricultural fixed capital is given by $r^T = \alpha (T/Y^R)^{-1/\sigma}$, where $\sigma$ = the elasticity of substitution between agricultural land and labor and $Y^R$ is real income and $T$ is agricultural land. Thus, capital's income share is given by $S^T = r^T * T/Y^R = \alpha (Y^R/T)^{(1-\sigma)/\sigma}$, where $S^T$ = the share of income going to agricultural land. If $\sigma > 1$, then a reduction in $L$ increases $S^T$.

## 4. Regression analysis

*4.1 Model specification*

The following two baseline regressions are used to test the (*r*-*g*)-hypothesis:

$$S_t^{WCG} = \alpha_0 + \alpha_1 S_{t-1}^{WCG} + \alpha_2 r_t + \alpha_3 g_t + X_t \xi' + \varepsilon_{1,t}, \tag{16}$$

$$S_t^{W} = \zeta_0 + \zeta_1 S_{t-1}^{W} + \zeta_2 r_t + \zeta_3 g_t + X_t \varsigma' + \varepsilon_{2,t}, \tag{17}$$

where, as stated above, $S^{WCG}$ = the share of income going to wealth including capital gains on non-reproducible wealth; $S^W$ = the share of income going to wealth; $r$ = the real post-tax return to wealth; $g$ = the growth in real net national income; $X$ = a vector of control variables; and $\varepsilon$ = a stochastic error term. The models are estimated over the period 1222-2013 in 10-year intervals to smooth out erratic movements in the data to reduce business-cycle influences on the estimates. The OLS and IV estimators are used to keep the exposition simple and transparent. More advanced techniques such as ARDL and VECM approaches could not be applied because the null hypotheses of unit roots were consistently rejected.

Lagged dependent variables are included in the models; 1) to capture the effects of omitted variables that are serially correlated; 2) to allow for slow adjustment towards long-run equilibrium; 3) to capture mean-reverting dynamics and persistent effects in the dependent variable that may be endogenous to inequality; 4) to reduce the bias of the coefficients of the focus variables, which is introduced by confounding variables that push $S^{WCG}$ and $S^W$ off their-steady-state trajectories, such as crises, epidemics, social unrest, war, *etc.*; 5) because it is not clear from the discussion in the literature whether $r$ and $g$ have temporary or permanent effects on $S^{WCG}$, (permanent growth effects of $r$ and $g$ follow from the limited case where $\zeta_1$ and $\alpha_1$ are one); and 6) bequests creates wealth persistence because a large fraction of wealth stems from inheritance (Piketty, 2011, and 2014, p. 268).

*4.2 Identification*

In the IV regressions, $r$, and $g$ are treated as endogenous because of potential feedback effects from the dependent variables and confounding factors. Real food price inflation, consumer price inflation, and macro tariff rates are used as instruments for $r$ and $g$. From the outset, however, it is important to stress that, although instruments are reasonably exogenous, the exclusion restrictions may not be fully satisfied for all instruments as discussed further below.[14]

[14] Educational attainment and mortality were also considered as instruments in an early draft of the paper following the predictions of the model of Becker and Mulligan (1997) in which the time preference is shown to be a negative function of educational attainment and life expectancy. Educational attainment (from Madsen and Murtin, 2017) was insignificant

High real food price inflation is likely to be associated with high *r* and low *g* through a combination of high earnings and low output growth in agriculture in the pre-industrial era and through capital gains on houses in the post-industrial era: The higher are real prices of food, the higher are the earnings in the agricultural sector, which in turn will tend to be capitalized in agricultural land prices. Farmland prices will influence urban land prices through ripple effects starting from urban land expansion at the fringes of cities (Madsen, 2009). Food prices are likely to be exogenous because they have, to a large extent, been determined by weather conditions, crop and livestock disease, population pressure, tariffs and world food prices (O'Rourke and Williamson, 2002); forces that are quite independent of the *W*-*Y* ratio.

Inflation is influential for real returns when inflation is unanticipated, as it lowers the real value of contractual nominal payments, such as housing rent, agricultural land rent, and interests on government bonds. Furthermore, Modigliani and Cohn (1979) argue that inflation reduces real returns to equity because; 1) growing inflation, *ceteris paribus*, reduces accounting earnings as it increases nominal interest payments on debt, however, investors fail to account for the fact that inflation erodes the real value of the firm's debt; and 2) investors tend to discount future earnings by nominal interest rates. Furthermore, the level and the change in inflation can be costly for owners of fixed-interest rate government debt; particularly during the approximate period 1940-1980 when marginal income tax rates were well above their long-run trend (Roine *et al*., 2009).

Macro tariff rates, calculated as the ratio of import duties to imports, are used as instruments for *r* and *g* because they have played a major role in the history of the political economy of rent seeking and, at the same time, they reduce income through various channels. Probably the best example of successful rent seeking through tariffs and trade barriers in British history is the marked increase in tariff rates following the introduction of the Corn Laws in 1815, as discussed above. The effects of the Corn Laws on tariff rates, first repealed in 1846, are highly visible in Figure 2. The macro tariff rates were a whopping 50% during this period, noting that macro tariff rates underestimate the effective tariff rates because of substitution away from products most affected by the tariffs. Similarly, capitalizing on the widening trade deficit after the wars between France and Britain in the period 1689-1713, protectionists engineered the imposition of high tariffs on a range of imports from France (Nye, 2007).

in all the first-stage model specifications covering the period 1270-2013 and, consequently, not included in the instrument set. Life expectancy, (also from Madsen and Murtin, 2017) has the expected negative sign and a *t*-value of about 3, depending on model specification, estimation period *etc.*; however, it was not included in the instrument set because of its low significance and because the data are first available from 1510.

Tariff rates are also a function of a complex political process related to increasing (e.g. Corn Laws), decreasing (tariffs during the Great Depression and WWII), or unaltered (e.g. entrance to the Common Market in 1973) wealth positions of the landed class. Thus, tariff rates are likely to be independent of land rent. Furthermore, the exclusion restriction is likely to be satisfied since tariffs impact the *W*-*Y* ratio through land rent because the tariff-induced changes to returns result in increasing wealth accumulation through saving and capital gains.

*4.3 Regression results*

The results of regressing Eqs. (16) and (17) are shown in Table 1. The coefficients of *r* and *g* are both highly significant and have the expected signs in the baseline regressions in the first two columns. These results remain intact in the non-overlapping 10-year interval regression in column (3). Comparing the $S^W$ and the $S^{WCG}$ estimates in columns (1) and (2), there are distinct differences. First, changes to *r* and *g* have much more persistent effects on factor shares in the $S^W$ estimates than the $S^{WCG}$ estimates, as signified by the coefficients of the lagged dependent variables of 0.84 in the $S^W$ regression and 0.41 in the $S^{WCG}$ regression, reflecting a low persistence of capital gains. Second, the statistical significance of *r* and *g* is higher in the $S^{WCG}$ regression than the $S^W$ regression, probably because a large fraction of the significance of *r* and *g* has been driven down by the highly significant coefficient of the lagged variable in the $S^W$ regression. It is well-known that lags of highly persistent dependent variables, such as $S^W$, remove a lot of the statistical significance of the other regressors even if they are relevant and their statistical significance increases substantially when the lag of $S^W$ is omitted (results are not shown).

**Table 1**. Parameter estimates of Eqs. (16) and (17).

| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
|---|---|---|---|---|---|---|---|---|
| Dep. Var. | $S_t^W$ | $S_t^{WCG}$ | $S_t^{WCG}$ | $S_t^W$ | $S_t^{WCG}$ | $S_t^{WCG}$ | $S_t^{WCG}$ | $S_t^{WCG}$ |
| | OLS | OLS | OLS/Ex OL | IV | IV | OLS | OLS | OLS |
| $S_{t-1}^W$/ $S_{t-1}^{WCG}$ | 0.84(19.1)*** | 0.41(9.60)*** | 0.36(3.79)*** | 0.52(10.3)*** | 0.20(6.28)*** | 0.13(3.04)*** | 0.35(7.28)*** | 0.37(6.59)*** |
| $r_t$ | 0.42(5.04)*** | 3.76(21.4)*** | 4.22(10.2)*** | 1.48(8.59)*** | 3.85(16.3)*** | 2.66(19.8)*** | 4.30(15.8)*** | 4.27(11.8)*** |
| $g_t$ | -1.41(3.15)*** | -2.97(8.12)*** | -3.26(3.44)*** | -6.80(8.90)*** | -8.66(15.2)*** | -0.74(2.05)** | -2.53(5.68)*** | -3.23(4.76)*** |
| $wp_t^{SU}$ | | | | | | | | |
| $wp_t^{UA}$ | | | | | | | | |
| $\chi^2(1)$ | 5.16*** | 4.33** | 1.09 | 57.6*** | 63.6*** | 25.5*** | 19.8*** | 3.24* |
| $R^2$ | 0.88 | 0.70 | 0.72 | NA | NA | 0.64 | 0.70 | 0.68 |
| # Obs | 792 | 792 | 79 | 792 | 792 | 379 | 414 | 314 |
| Est. Period | 1222-2013 | 1222-2013 | 1222-2013 | 1222-2013 | 1222-2013 | 1222-1600 | 1600-2013 | 1800-2013 |

**Notes**. The numbers in parentheses are absolute *t*-statistics based on serial correlation and heteroscedasticity consistent standard errors. Constant terms are included in the regressions but not reported. $S^W$ = capital's income share excluding capital gains on non-reproducibles; $S^{WCG}$ = capital's income share including capital gains on non-reproducibles. Constant terms are included in the regressions but not shown. Returns are measured in 10-year moving averages and the growth in real NNI, *g*, is measured in 10-year differences. The variables are measured in decimal points and growth, *g*, and returns, *r*, are annualized. OLS/Ex OL = ten-year *non*-overlapping observations. $\chi^2(1)$ = Wald test of the restriction $\zeta_2 = -\zeta_3$

(coefficients of $r$ and $g$), distributed as $\chi^2(1)$ under the null hypothesis that the restriction is satisfied. *: Significant at 10%; **: Significant at 5%; and ***: Significant at 1%.

Third, the absolute and the relative values of the coefficients of $r$ and $g$ are much closer in magnitude in the $S^{WCG}$ regression in column (2) than the $S^{W}$ regression in column (1). Although the restriction $\zeta_2 = -\zeta_3$ ($\chi^2(1)$ = 4.33) is rejected at conventional significance levels in the $S^{WCG}$ regression, it has to be noted that this rejection is partly driven by the extraordinarily high statistical significance of $r$ and $g$. In the regression in column (3) with non-overlapping data, for example, the restriction $\zeta_2 = -\zeta_3$ cannot be rejected at conventional significance levels even though the gap between $\hat{\zeta}_2$ and - $\hat{\zeta}_3$ is larger than that of its counterpart in column (2) with overlapping data.

The coefficients of $r$ and $g$ remain statistically and economically highly significant in the IV regressions in columns (4) and (5), indicating that the significance of $r$ and $g$ in the OLS regressions is not driven by feedback effects from $S^{W}$ or $S^{WCG}$ to $r$ and $g$. The long-run coefficients of $r$ and $g$ are, in absolute terms, significantly higher in the IV than the OLS regressions, suggesting the absence of positive feedback effects from the $W$-$Y$ ratio to $r$ and $g$ in the OLS estimates. For $r$ this means that factor shares that are driven by changes in the $W$-$Y$ ratio are not countered by potentially adverse responses in $r$, as is often stressed in criticisms of Piketty's first law (e.g., Ray, 2015).

The results of regressing the $S^{WCG}$ model over the periods 1222-1600, 1600-2013, and 1800-2013 are shown in columns (6)-(8). The regressions covering the period 1600-2013 (column (7)) give results that are close to the regression results covering the entire period (column (2)) in terms of statistical significance and magnitude of the long-run coefficients. The coefficients of $r$ and $g$ are also statistically highly significant in the pre-1600 period, however, the magnitude of the coefficient of $g$ is well below its post-1600 counterparts. This may be because of Malthusian feedback effects in which technological progress could increase inequality under a Malthusian regime because the real per capita income of the poor stays constant while the wealth and income of the landed class increases. Finally, the coefficients of the lagged dependent variable are substantially lower in pre-1600 regression than the post-1600 regression. This may reflect that the large swings in factor income shares were partly driven by large fluctuations in output prices and quantities combined with sticky nominal wages, as were characteristic for the predominantly agricultural society in the pre-1600 period; thus automatically reducing the persistence in factor shares.[15]

Common for the regressions in Table 1 is that the economic significance of the coefficients of $r$ and $g$ are generally high. Referring to the baseline regression in column (2) in Table 1, a one

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[15] Regressing consumer price inflation on its lagged value using annual data over the period 1222-1600, yields a coefficient of lagged inflation of 0.24(5.03), where the value in parenthesis is the *t*-statistic. For wage inflation of unskilled workers, the corresponding estimate is 0.64(17.0), indicating a much higher degree of wage than price stickiness.

percentage point increase in $r$ is associated with a 3.8% increase in capital's share, $S^{WCG}$, in the short run and 6.4% increase in the long run. To take an extreme event, the 5-percentage point reduction in the trend in $r$ that took place over the period 1830-1950 resulted in a long-run reduction in capital's share of almost 32%, suggesting that the declining $r$ was a massive force behind the reduced inequality over this period. A one percentage point increase in $g$ is associated with a 3.0% increase in capital's share, $S^{WCG}$, in the short run and 5.0% in the long run. The shift in the growth trend from approximately 0.7% before 1800 to 2.1% thereafter resulted in a 7% long-run reduction in $S^{WCG}$, suggesting that the historically larger shifts in $r$ have been a greater source of inequality fluctuations than $g$. A similar conclusion is reached when the effects of a one standard deviation change in $r$ and $g$ are considered. A one standard deviation increase in $r$ ($SD^r$ = 10.40) results in a 67.0% (10.4*3.8/(1-0.41)) increase in capital's share. The corresponding number is -29.3 (5.76*3.0/(1-0.41)) for a one standard deviation increase in $g$ ($SD^g$ = 5.76).

The finding that the coefficient of $r$ is significantly smaller than that of $g$ in absolute values suggests that the restriction $\zeta_2 = -\zeta_3$ in Piketty's analysis is too stringent and that the ($r$-2$g$)-gap is a more precise determinant of $S^{WCG}$; a result that is consistent with the results of the $W$-$Y$ regressions, as shown in the last two paragraphs of Section 4.3, and consistent with some theoretical models. As shown by De Nardi *et al*. (2015), for example, the restriction, $\zeta_2 = -\zeta_3$, may not be met for various reasons depending on the setup of the model describing inequality. De Nardi *et al*. (2015) show that $\zeta_2 < -\zeta_3$ because a lower rate of population growth is associated with a higher ratio of deaths to births and, consequently, a higher average bequest size. Since bequests are luxury goods, population growth will have a more significant impact on wealth concentration at the right tail of the wealth distribution than will an increase in $r$.

## 5 Extensions and further robustness checks

To gain more insight into the drivers and sources of wealth and income inequality the models in this section are modified in the following capacities: 1) skill premiums are included as additional regressors to control for wage dispersions between employees; 2) returns, $r$, are decomposed into dividend yields and real capital gains; and 3) the models are extended with variables that are likely to influence factor shares and, at the same time, might be correlated with the explanatory variables.

### *5.1 Including skill premiums*

The wage premium of skilled workers over unskilled workers, $wp^{SU}$, and that of unskilled workers over agricultural workers, $wp^{UA}$, are included in the regression in the first column in Table 2 to control for earnings inequality between employees, which will create a wedge between inequality across all income groups and factor shares, as shown in Section 3.3 and more formally in the online Appendix Section A1. Intuitively, if the mean preserving income gaps between the main income groups widens, *ceteris paribus*, capital's income share would remain unaffected even though overall income inequality has increased. Consequently, if these income gaps are omitted from the regressions, the coefficients of *r* and *g* would be biased to the extent that these income gaps are correlated with *r* and *g*. The estimation period terminates in 1869 because the skill-premium data used here are not available after 1869 and, more importantly, because earnings inequality between other wage earning groups becomes much more important for the inequality path after this period. The coefficient of $wp^{UA}$ is negative and highly significant as predicted by the models in the online Appendix. The negative coefficient of $wp^{UA}$ is consistent with the predictions of the model: A mean-preserving increase in $wp^{UA}$ induced by *r* or *g*, is associated with increasing inequality. However, since $S^{WCG}$ is unaffected by this increase, the $wp^{UA}$ term will capture the effects of *r* and *g* on inequality. Finally, the coefficients of *r* and *g* remain highly significant and have quite similar magnitudes to those of the baseline regressions in Table 1.

**Table 2**. Robustness checks and extensions (Eqs. (16) and (17)).

| | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| **Dep. Var.** | $S_t^{WCG}$ | $S_t^{WCG}$ | $S_t^{WCG}$ | $S_t^{WCG}$ | $S_t^{W}$ | $S_t^{WCG}$ |
| | | Div Y.-Cap. G | Incl. all contr. | Incl. sig. cr.. | Incl. sig. cr. | Incl. old age |
| $S_{t-1}^{WCG}/S_{t-1}^{W}$ | 0.14(4.15)*** | 0.45(11.0)*** | 0.11(2.85)*** | 0.13(3.67)*** | 0.70(18.9)*** | 0.29(5.61)*** |
| $r_t$ | 3.61(19.1)*** | | 3.25(24.3)*** | 3.31(24.8)*** | 0.25(4.90)*** | 3.81(14.6)*** |
| $g_t$ | -0.60(3.35)*** | -3.62(9.75)*** | -0.84(3.95)*** | -0.91(4.18)*** | -0.46(3.54)*** | -1.97(4.77)*** |
| $wp_t^{SU}$ | 0.01(0.77) | | | | | |
| $wp_t^{UA}$ | -0.11(7.48)*** | | | | | |
| $\ln s_t^{Y}$ | | | 0.21(2.40)** | 0.28(4.28)*** | | |
| $r_t^{CG}$ | | 5.40(22.4)*** | | | | |
| $r_t^{DY}$ | | 1.78(6.89)*** | | | | |
| $\ln(W/Y)_t^{GD.}$ | | | 0.01(0.94) | | | |
| $(M2\text{-}H0)/M2)_t$ | | | 0.10(2.19)** | 0.11(2.52)*** | 0.05(2.71)*** | |
| $Exec_t$ | | | 0.01(3.81)*** | 0.01(3.82)*** | | |
| $(IM/Y)_t$ | | | -1.30(8.10)*** | -1.33(8.61)*** | -0.27(5.75)*** | |
| $Tax_t$ | | | -0.19(4.26)*** | -0.18(3.97)*** | -0.10(5.63)*** | |
| $\sigma^2$ | | | 0.02(1.36) | | -0.03(4.41)*** | |
| $\text{Ln}(P^{INV}/P^{CPI})$ | | | -0.02(1.00) | | -0.01(1.93)* | |
| $Old\ Age_t$ | | | | | | 0.00(0.49) |
| $R^2$ | 0.74 | 0.75 | 0.78 | 0.77 | 0.90 | 0.90 |
| # Obs | 648 | 792 | 792 | 792 | 792 | 473 |
| Est. Period | 1222-1869 | 1222-2013 | 1222-2013 | 1222-2013 | 1222-2013 | 1541-2013 |

**Notes**. See notes to Table 1. The OLS estimator is used in all regressions. Dividend yield, $r^{DY}$, is weighted real returns on all wealth minus real capital gain on agricultural and urban land, $r^{CG}$; $wp^{SU}$ = wage premium of skilled workers over unskilled workers; $wp^{UA}$ = wage premium of unskilled labor over agricultural workers; $s^{Y}$ = the propensity to save out of net national income; $(W/Y)^{GD}$ = the government debt-income ratio; $(M2\text{-}H0)/M2)$ = contract-intensive money where $H0$ is coins and notes and $M2$ is broad money; *Exec* = constraints on executive; $(IM/Y)$ = import-income ratio; *Tax* = top-income tax; $P^{INV}$ = investment price deflator, $P^{CPI}$ = consumer prices; and $\sigma^2$ = the standard deviation of $S^{WCF}/S^{W}$, measured as the annual variation in the data within each 10-year interval. Column 1: The dependent variable is the ratio of non-residential fixed capital at market values and nominal NNI. Column 2: *r* is decomposed into dividend yield, $r^{DY}$, and real capital gain on non-reproducibles, $r^{CG}$. Column 3: All controls are included in the *W-Y* model. Column 4: Only the significant control variables (at 10%) from the regression in column (3) are included in the regression. Column 5: $S^{W}$ is the dependent variable and only the significant controls (at 10%) are included in the regression. Column 6: Old age dependency, *Old Age*, is included as a control and is measured as the fraction of the population above the age of 65 and the estimation period is limited by the unavailability of age distribution data before 1541.

### *5.2 Decomposing r into capital gains and dividend yields*

To gain deeper insight into the principal sources of wealth accumulation, asset returns are decomposed into dividend yields, $r^{DY}$, and real capital gains on agricultural and urban land, $r^{CG}$, in the regressions in column (2) in Table 2. Dividend yield is a real magnitude because implicit price deflators are included in the numerator (dividends) as well as the denominator (asset value) and, therefore, it does not need to be transformed to a real value by deducting consumer price inflation. Real capital gains on fixed assets (stocks) are not included in $r^{CG}$ because, in steady state, capital gains on stocks are driven by retained earnings and share buy-backs, otherwise Tobin's $q$ would be permanently, and at an increasing rate, diverted from its steady state equilibrium.

The coefficients of $r^{DY}$ and $r^{CG}$ are highly significant; however, the coefficients of $r^{CG}$ are three times as large as those of $r^{DY}$, showing that capital gains are much more important sources of wealth accumulation and inequality than dividend yields. These results imply that the marginal propensity to consume out of dividend yields exceeds that of capital gains, probably because 1) credit constraints prevent landholders from borrowing against capital gains on land; 2) capital gains are not expected to be permanent and, therefore, are not expected to increase permanent income; 3) landholders have imperfect knowledge of the real asset appreciation; and/or 4) habit persistence in consumption among landholders results in increasing saving in response to real capital gains on assets since dividend yields are more stable sources of capital income than capital gains.

The finding that capital gains on non-reproducibles are much more important sources of variations in wealth inequality than dividend yields suggests that, under modes of production in which non-reproducibles are a high share of total wealth, such as in the pre-industrial era (agricultural land) and the post-industrial era (urban property), capital gains on land are much more influential for the evolution in inequality than rental income in general. For measurement of wealth and income inequality, it implies that conventional measures of inequality insufficiently capture increases in inequality in periods of secular increases in land values; a conclusion also reached by Roine and Waldenström (2012) for Sweden. The aforementioned flat wealth inequality Gini coefficient since 2000 is a clear example of how standard wealth inequality measures fail to capture potentially large secular changes in inequality. Over the periods of sustained increasing inequality, such as the periods 1741-1871 and 1978-2013, real capital gains have been 40.0% higher than dividend yields, suggesting that the distortion in standard measures of inequality is even higher in periods of increasing inequality.

*5.3 Inclusion of control variables*

Government debt, institutional quality, import propensity, the variance of the dependent variable, the propensity to save out of income, old age dependency, relative prices of fixed non-residential capital, top income taxes, and institutional quality are included as controls in the regressions in Table 2, columns (3)-(6) because they may simultaneously affect the dependent variables, $r$ and $g$; thus, potentially leading to biased the coefficients of $r$ and $g$. These control variables have often been stressed as important for the inequality path in the inequality literature, as discussed below.

The government debt-income ratio, $(W/Y)^{GD}$, may have affected inequality because after-tax real returns on government debt were often rendered low or negative by unexpected inflation during, e.g., wars and, consequently, have driven average asset returns down during these periods. Although tax-payers may increase their saving in response to higher government debt to counter their future tax liabilities, this effect is captured by the saving terms $s^W$ or $s^Y$ in the regressions. The propensity to import, $Im/Y$, is likely to be negatively related to inequality before the second half of the 20th century because imports of agricultural products tended to reduce the prices on basic food and, conversely, reduce the income of the landed class. The variance of the $W$-$Y$ ratio, $\sigma^2$, is positively related to inequality following the predictions of standard portfolio models in which the required returns are positive functions of the riskiness of the asset. Following the life-cycle hypothesis, increasing old-age dependency may increase inequality as the aging population reduces its net asset position.

As argued by Karabarbounis and Neiman (2014), the relative prices of capital, $P^{INV}/P^{CPI}$, will affect factor shares through quantity and price effects, where $P^{INV}$ is the investment price deflator. In their influential paper they show that the marked decline in the real prices of investment goods since the early 1980s across the world has been responsible for approximately half of the decline in labor's income share. Under the assumption of an elasticity of substitution between capital and labor in excess of one, as validated by the regression analysis of Karabarbounis and Neiman (2014), a decline in real prices of capital leads to a substitution of capital for labor and, consequently, to an increasing share of income going to capital.

Top income tax rates are included as control variables following Piketty's (2014) argument that high income earners bargain harder for income shares when income tax rates are low because they have more to gain from incremental earnings. Based on calibrations of their model, Hubmer *et al*. (2016) show that the marked decrease in tax progressivity since the late 1970s has been by far the most powerful force for increasing wealth inequality in the US, because reduced tax progression spreads the distribution of after-tax resources available for consumption and saving and increases the returns to saving; thus leading to higher wealth accumulation. Empirically, Roine *et al*. (2009) find that higher top income tax rates significantly reduce income inequality. Tax rates are measured as the sum of income tax rates of the top 1% decile (statutory rates) and land tax rates because they jointly constitute taxation of high income earners. Land taxes were the dominant form of taxation on income in Britain before 1843 when income taxes were permanently introduced (low income tax rates were temporarily in place in the period 1798-1816), and land tax rates were gradually reduced and phased out after 1843 (see, for references, the online Appendix).

Institutions have often been stressed as essential determinants of inequality. As staunch advocates of the importance of institutions on economic development and inequality, Acemoglu and Robinson (2015) argue that changes in income shares are predominantly determined by institutions rather than $r$ and $g$. The Corn Laws, the restrictions on unions before the Trade Union Act in 1871, and the interest rate reducing consequences of the Glorious Revolution of 1688, as argued by North and Weingast (1989), are examples of institutional influences on asset returns. Constraints on the executive and contract intensive money are used as indicators of the quality of institutions.

Following the spirit of Polity IV, constraints on executive, *Exec*, is constructed as institutional constraints on the decision-making powers of governments, and it is operationalized by a seven-point scale, where the minimum value of 1 implies "executive authority" and the maximum value of 7 signifies "executive parity or subordination". Changes in the index over the period from 1210 up to 1832, when it reached the maximum value where it has stayed since, mostly reflect the changing power relationship between the Crown and the Parliament. Significant institutional changes constitute the Magna Carta of 1215, when everybody, including the king, became subject to the law, the Civil War of 1642-1649, when Parliamentary forces defeated Charles I, and the Glorious Revolution of 1688-1689, which gave Parliament supremacy over the King (see, North and Weingast, 1989, for discussion of the history of institutions in Britain).

Introduced by Clague *et al*. (1999), contract-intensive money, as another dimension of institutions, is proxied by ($M2$-$H0$)/$M2$, where $M2$ is broad money supply and $H0$ is the monetary base. Clague *et al*. (1999) argue that the higher the level of contract-intensive money, the better a government enforces contracts. In economies with excellent third-party contract enforcement, credit and monetary deposits will be the preferred store of money and medium of exchange over cash money, because they are safe, efficient, in most cases pay interest, and facilitate the tracking of credit history and, thereby better enable lenders to screen their borrowers. Conversely, if contracts are not enforced by the government, 1) the safety of money in financial institutions is not guaranteed; 2) repayment of loans cannot be taken for granted; and 3) lenders do not have the any security rights to mortgage assets if a borrower defaults (Clague *et al*., 1999). In these cases, cash will be the preferred medium of exchange over credit. Contract-intensive money affects the wealth accumulation process by simultaneously impacting $r$ and inequality through the same channels as constraints on executive, *Exec*.

*5.4 Results from the regressions with controls*

In the regressions in Table 2, columns (3)-(6) most of the coefficients of the controls are statistically significant determinants of $S^{WCG}$ and $S^{W}$. The coefficients of import propensity are negative and highly significant, suggesting that trade openness benefited labor income shares because, during the ptre-1870 period considered in the table, British imports traditionally competed with domestic agricultural production and, as argued above, it has long been in the interest of the landed class to keep profits up through restrictions on imports. The coefficients of real prices of capital, $P^{INV}/P^{CPI}$, are negative and slightly significant in the $S^{W}$-regression; a result that is consistent with the hypothesis of Karabarbounis and Neiman (2014). The coefficients of top income taxes are negative; thus, giving support to Piketty's (2014) postulate that high income earners have less incentive to bargain for higher income shares when taxes are high because of reduced expected gains from bargaining over income shares. The coefficients of $s^{Y}$ are highly significantly positive, which is consistent with Kuznets (1955) proposition that saving is a powerful source of inequality through asset accumulation. The old age dependency ratio, '*Old Age*', is insignificant (column (6)), suggesting that old age dependency has an ambiguous effect on inequality (note that, dictated by the availability of data on age distribution, the estimation period starts in 1541).

The institutional quality variables, contract-intensive money and constraints on executive, have signs contrary to the hypothesis of Acemoglu and Robinson (2015). The coefficients of contract-intensive money are significantly positive in all three cases and constraints on executive are significantly positive in the factor share regressions. This does not mean that institutional improvements, in general, adversely affect inequality, as validated by the results for import propensities and tariffs. What these results show is that institutional reforms need not be favorable to worker's income share. Some institutional reforms favor labor and some favor capital. For instance, although the institutions in Latin America have historically been more democratic than those in East Asia, for example, income distribution has been substantially more unequal in Latin America than East Asia (see, for data on these issues, Polity IV, and World Development Indicators). Similarly, as argued above, contract-intensive money may increase the investment opportunities of the wealthy high-income earners.

Finally, and most importantly, the coefficients of $r$ and $g$ in the factor shares regressions remain highly significant and close to those of the baseline regressions, indicating that the baseline results have not been driven by important omitted variables that simultaneously affect income shares and the focus variables, $r$ and $g$. Moreover, the high $R$-squares in the regressions indicate that the models explain a large share of the variation in $S^{WCG}$ and $S^{W}$. Finally, $r$ and $g$ are the key-drivers in the $S^{WCG}$

regressions. Comparing the $R$-squares in the baseline $S^W/S^{WCG}$ regressions in columns (1) and (2) in Table 1 with those of the regressions in columns (4) and (5) in Table 2, in which the baseline regression is extended with the significant control variables, the unadjusted $R$-squared improves by only 0.02/0.07 and the $R$-squared drops to 0.41/0.37 if $r$ and $g$ are excluded from the $S^W/S^{WCG}$ regressions (results are not shown); thus reinforcing the importance of $r$ and $g$ as the central determinants of the evolution of inequality.

## 6. Concluding remarks

The hypothesis that inequality is increasing in the ($r$–$g$)-gap is highly controversial and yet little, if any, empirical research has examined the validity of the hypothesis and the extent to which $r$ and $g$ are significant determinants of wealth and income inequality. Constructing annual data for Britain over the period 1210-2013, this paper is a first attempt to overcome this lacuna in the literature by examining the dynamics of capital's income shares, $S^W$ and $S^{WCG}$ (where $S^{WCG}$ includes capital gains on non-reproducibles), and their relationship to $r$ and $g$. It is shown that $r$ and $g$ have highly significant and quite persistent effects on factor shares, $S^W/S^{WCG}$. The results of the paper give three principal insights into the dynamics of inequality in the ultra-long run.

First, the regressions indicate that $r$ and $g$ have been important determinants of capital's income share over the past eight centuries. Although some controls, such as institutions, top income tax rates, openness, and savings are also significant determinants of $S^{WCG}$, $r$ and $g$ explain the lion's share of the variance in income share regressions. Second, the analysis showed a tendency for pre- and post-industrial eras to be more unequal than industrialized eras because of their potential for large capital gains on non-reproducibles, which are prone to aggravate wealth and income concentration. The income share elasticiticities of real capital gains are found to be significantly higher than those of dividend yields, suggesting that inequality dynamics are heavily dependent on the source of returns. Since real capital gains on assets in steady state are approximately limited to non-reproducibles, it follows that wealth accumulation is faster in economies in which agricultural and urban land are large components of wealth, as in the pre-industrial period and today, where the expansion of the service sector in the city areas has resulted in urban property being the largest component of personal wealth.

The tendency for income distribution to be more unequal in pre- and post-industrial regimes has two implications. First, it is the reverse of Kuznets' (1955) celebrated thesis that inequality starts up low in pre-industrial societies, rises during industrialization, and declines as the economy matures. Second, coupled with a likely reduction in growth in the rest of the 21$^{st}$ century, the implication of this finding is that inequality is likely to increase over the rest of the 21$^{st}$ century. The decline in growth is not only an implication of the declining fertility trend but also of the productivity growth deceleration with convergence to a stationary growth rate that follows from the S-shaped productivity growth path, as predicted by the Schumpeterian growth model of Peretto (2017).

Third, the estimates give *qualified* support for Piketty's ($r$-$g$)-hypothesis. While support is found for Piketty's thesis that $r$ and $g$ are the principal drivers of income inequality, the results suggest that Piketty's ($r$-$g$)-hypothesis needs to be extended to allow for saving propensities; that real capital gains on non-reproducibles have significantly stronger effects on inequality than dividend yield; and that $g$ impacts approximately twice as much on inequality as $r$, suggesting that an ($r$-2$g$)-gap (perhaps further decomposing $r$) is a better approximation than the ($r$-$g$)-gap.

The finding that $r$, $g$, and to some extent, saving are the principal determinants of factor shares, suggests that inequality is intrinsically a macroeconomic phenomenon and that Piketty's models, extended in various directions, could appropriately form the basis as a general macro model of inequality. Piketty (2014) has provided a framework that challenges the long-held view of inequality as being a microeconomic phenomenon, mostly explained by individual characteristics and often divorced from the macro economy. The general nature of Piketty's model takes it beyond the conventional macro models that seek to explain the inequality path over segmented periods by the real price of capital, biased technological progress, and institutions etc.

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