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Wealth inequality and credit markets: evidence from three industrialized countries

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Abstract Economic theory predicts that changes in the distribution of wealth in an economy affect real interest rates if capital markets are imperfect. We investigate this link for the US, the UK, and Sweden, using multivariate time series analysis that explicitly allows for feedback effects between wealth inequality and real interest rates. Our estimates yield that, over the course of the twentieth century, decreases in wealth inequality led to significant declines in real interest rates. Our results therefore point to the importance of capital market imperfections that arise from moral hazard. They put to question the empirical relevance of a negative interest rate effect of inequality that may arise in variants of these models with high inequality, heterogeneous agents or adverse selection.

Keywords Wealth distribution · Interest rates

JEL Classification E20 · E62

The views expressed herein are those of the authors and should not be attributed to the IMF, its Executive Board, or its management.

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1 Introduction

There is a considerable amount of theoretical research that analyzes the macroeconomic role of the wealth distribution. This research, beginning with the seminal contributions of Galor and Zeira (1993) and Banerjee and Newman (1993), focuses on the role of capital market imperfections. With imperfect capital markets, wealth is an important instrument that helps individuals to gain access to credit. Risky investment projects can be started more easily by individuals who can contribute their own funds. The wealth distribution should therefore affect aggregate credit supply and credit demand, hence playing a major role in shaping macroeconomic outcomes. In particular, theory predicts links between wealth inequality, interest rates and economic growth. While the relationship between inequality and economic growth has been studied thoroughly, very little is known about the impact of wealth inequality on real interest rates.

One view, put forward by Aghion and Bolton (1997) and Piketty (1997), is that inequality may foster more efficient wealth creation, which trickles down to the poor over time. With debt-equity ratios and capital costs determining the marginal return from effort, only richer agents can credibly commit to provide costly, but unobservable effort at higher interest rates. Poorer agents shirk, becoming subject to credit rationing. This is why higher inequality, implying a higher wealth level of the poorest entrepreneurs, increases equilibrium risk-free interest rates (Grüner and Schils 2007). This effect benefits all investors. But another, more pessimistic view is that, in an environment with heterogeneous abilities, wealth inequality may lead to a misallocation of firms to low ability rich entrepreneurs. The reason is that on the capital market, low ability rich entrepreneurs crowd out high ability poor entrepreneurs. Hence, less wealth inequality leads to the selection of better entrepreneurs who can pay higher returns to investors. Similar results obtain in more complex setting where both ability and effort are unobservable (Grüner 2003).

The purpose of our paper is to empirically investigate which of the two views is consistent with data from a number of industrialized countries: the US, the UK and Sweden. To capture wealth inequality, we capitalize on recently published data from Wolff (2002) on the net worth held by the top 1% of wealth holders (chosen because of the availability of consistent long run time series). Our econometric method follows a multivariate time series approach that has the key strength of allowing for possible feedback effects between wealth inequality, real interest rates, and output. As a baseline model, we consider a three-dimensional VAR process containing the variables real interest rate, wealth inequality and real per capita GDP. Dealing with these time series raises subtle issues concerning stationarity that we address by implementing a variety of unit root tests accounting for possible structural breaks and low power due to small sample size. Although these tests provide strong evidence for each variable individually containing a unit root, their linear combinations turn out to be stationary. This suggests that there may exist an equilibrium relationship between the original series on wealth distribution and real interest rates.

All in all, our results are consistent with the predictions from capital market models with moral hazard that more equality, when it is associated with a reduction in entrepreneurs' wealth, leads to a lower real interest rate. Our empirical results reject on the other hand negative real interest rate effects of inequality that play a role in Aghion and Bolton's trickel down growth model and models with heterogeneous ability. The VECM estimates yield a positive and highly significant cointegration relationship between real interest rates and our measure of wealth inequality in all three countries. The positive link between wealth inequality and real interest rates is economically meaningful, highly statistically significant and robust across sub-periods and control variables. When for instance studying the post World War II period (1948–1991), we find that a one standard deviation increase in wealth inequality is associated with an increase in real interest rates in the US by 0.48 standard deviations; in the UK by 0.32 standard deviations; and in Sweden by 0.60 standard deviations. We also find evidence that a similar relationship between wealth distribution and real interest rates exists for the period 1924–1948, thus including major shocks such as the Great Depression and World War II.

Most closely related to our work is a recent empirical literature that links measures of asset inequality to macroeconomic variables. Studying the role of land reform for economic growth, Besley and Burgess (2000) find that land redistribution reduces poverty and increases wages of the landless. In contrast, Deininger and Olinto (2000) obtain a negative relationship between an unequal asset distribution and growth. Our paper focuses on the relationship of wealth inequality and real interest rates and tackles three common technical problems. First, we do not rely on income inequality as our main measure for wealth inequality. Second, we apply an econometric methodology that allows for possible feedback effects between real interest rates and wealth inequality. Third, we isolate inequality's impact on the capital market by scrutinizing the mechanisms through which the distribution of wealth affects real interest rates. In contrast, hitherto empirical research on wealth inequality has mostly been cast in terms of its growth implications. After having refuted the Kuznets (1955) hypothesis of inequality first rising and then falling in the course of development (see Deininger and Squire 1998), less the link's direction of causality from inequality to measures of economic performance, but rather its sign and significance remain controversial issues (also see the surveys by Benabou 1996; Ferreira 1999; Perotti 1996). These results mainly differ because of the use of different data sets and econometric methodologies. Problematic are also the applied measures of income inequality (which turned out to be an inadequate proxy for wealth inequality)[1] and the identification of causal effects (also see Townsend and Ueda 2006, or Banerjee and Duflo 2005). Finally, when testing for the inequality-growth link, three channels of influence—partly supplementary, partly complementary in nature—interfere with each other: our capital market effect, political economy considerations[2] and social conflicts.[3]

The paper is structured as follows. Section 2 presents the theoretical background and Sect. 3 the data and the estimation method. Section 4 presents the main results. Section 5 concludes.

2 The theoretical arguments

To lay grounds, we first present the logic behind possible positive and negative interest rate effects of redistribution from capital market equilibrium models with asymmetric information. The analysis of this section draws upon Grüner and Schils (2007) static version of

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[1] This owes to wealth typically being much more dispersed than income. Yet, data availability is substantially better for income inequality (see Luxembourg Income Study, UNU-WIDER World Income Inequality Database; Atkinson and Piketty 2007; Piketty and Saez 2003 for the US; or Piketty 2003 for France). Ohlsson et al. (2008), instead, review the scarce data on wealth inequality for a limited number of countries and the problems pertaining to these series.

[2] According to Alesina and Rodrik (1994), Bertola (1993) or Persson and Tabellini (1994), a poorer median voter opts for higher tax rates which incur greater distortions.

[3] While e.g. Alesina and Perotti (1996) draw on reduced investment levels ensued by political instability, Rodrik (1999) blames the ability of political systems to efficiently respond to external shocks. Whereas Fajnzylber et al. (1998) build on the high opportunity costs caused by violence.

Aghion and Bolton (1997) and Piketty (1997) for the negative link based on moral hazard. A positive effect obtains in the same model when the economy is generously endowed with capital in the sense that, in equilibrium, agents with less than average wealth open a firm. The positive effect may also obtain in economies with little wealth when individuals are heterogeneous in their abilities.

2.1 Inequality increasing the rate of return

Consider an economy populated with a continuum of potential entrepreneurs of mass 1. Everyone is risk-neutral and endowed with initial wealth w_i. While the cumulative distribution of wealth is denoted $\Phi(w)$, average wealth is $\bar{w}$. Each agent may start an investment project which requires a fixed capital outlay $I > w$. An agent who does not start a project lends money to other agents. An entrepreneur with wealth $w_i < I$ needs credit $I - w_i$ from an investor. A project yields a positive return Y with probability p (resp. q) if the agent does (resp. does not) provide effort. With probability $1 - p$ (resp. $1 - q$) the project fails and returns zero. Effort costs B monetary units and is unobservable. The technology parameters Y, p, q and B are exogenously given.

Any credit contract must yield the market risk free return of R per unit lent by the investor. Under such a contract, an entrepreneur must pay $R(I - w)/p$ if he succeeds and nothing if he fails. This contract induces effort if shirking does not pay off, that is if

$$p\left[Y - R\left(I - w_i\right)/p\right] - B \geq q\left[Y - R\left(I - w_i\right)/p\right]. \tag{1}$$

Solving this incentive constraint for the wealth of an agent w gives

$$w_i \geq \omega\left(R\right) := I - \frac{p}{R}\left(Y - \frac{B}{p-q}\right), \tag{2}$$

reflecting that entrepreneurs only commit to provide effort if they are sufficiently wealthy. Otherwise, the lender anticipates that the borrower will shirk, making him offer a non-effort contract involving a repayment $R(I - w)/q$.

The initial distribution of wealth and the technology are exogenously given. The risk free return of R, the investment and effort decisions and the amount of money transferred to entrepreneurs via the capital market are all determined endogenously. The equilibrium rate paid by entrepreneurs is the risk free rate R, corrected for the risk of the project, i.e. R/p. The economy is closed.

A capital market equilibrium consists of (i) a risk free return of R, (ii) a set of entrepreneurs and a set of investors, (iii) equilibrium contracts for entrepreneurs, and (iv) effort choices which are consistent. Consistency requires that (i) entrepreneurs (investors) weakly prefer entrepreneurship (investing) at the given rate R, (ii) investors either weakly prefer investing at the given rate R, or, if rationed, they cannot offer better conditions to investors than the current entrepreneurs with the equilibrium contracts, (iii) the contracts maximize entrepreneurs' payoff subject to their own incentive compatibility and investors' participation constraints, (iv) effort choices are consistent with entrepreneurs' incentive compatibility constraint, and (v) capital demand and supply are equalized.[4]

The capital market equilibrium can easily be determined. If R satisfies

$$\Phi\left(\omega\left(R\right)\right) = 1 - \bar{w}/I, \tag{3}$$

[4] See Grüner and Schils (2007) for a complete formal description of an equilibrium.

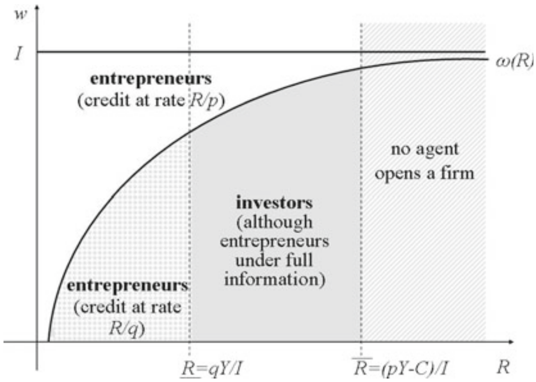

Fig. 1 Solution to the individual contracting problem given R and w

the wealth constraint holds exactly for a fraction $\bar{w}/I$ of individuals. Suppose now that the corresponding interest rate R also satisfies

$$\frac{qY}{I} =: \underline{R} < R \leq \bar{R} := \frac{pY - B}{I}. \tag{4}$$

In this case, R is the unique equilibrium interest rate. In the corresponding equilibrium, only agents with wealth above $\omega(R)$ become entrepreneurs, while all others find it more profitable to become investors (see Fig. 1).

When the poorest entrepreneur holds more than average wealth, i.e. $\omega(R) > \bar{w}$, a more equal society is associated with poorer entrepreneurs. In equilibrium, condition (2) must hold at a lower wealth level and hence also at a lower rate of return.[5] As entrepreneurs can only commit to provide effort if R is sufficiently low, equality may be linked negatively to the rate of return R.[6]

2.2 Inequality decreasing the rate of return

A negative interest rate effect of redistribution arises in the previous model if and only if the marginal (i.e. the poorest) entrepreneur holds more than the average wealth. If the marginal entrepreneur has less than the average wealth, more inequality—for example due to the accumulation of wealth by the very rich—leads to a lower equilibrium interest rate. This effect plays a major role in Aghion and Bolton (1997) dynamic analysis.

A negative effect of wealth inequality on the interest rate can also be derived from models with heterogeneous agents. Grüner (2003) has made this argument in a model with unobserved entrepreneurial abilities. In this model, redistribution of wealth may not only lead to the selection of better entrepreneurs and to a higher rate of return, but also to a Pareto-improvement. The reason is that after redistribution, former low-ability entrepreneurs receive a higher payoff from investing their reduced funds on the capital market at a higher equilibrium rate of return.

Grüner (2003) considers an economy with two wealth classes and two ability levels. A simple full information model with two classes and two ability levels can produce the same

5 Already Stiglitz and Weiss (1981) competitive equilibrium involves credit rationing if the "Walrasian return rate" is such that there is a lower R for which lenders' profit is higher.

6 Interpreting more inequality as more mass above the critical collateral threshold, this positive link also arises in capital market models that allow for investment sizes that vary with the market rate of return (see e.g. Piketty 1997).

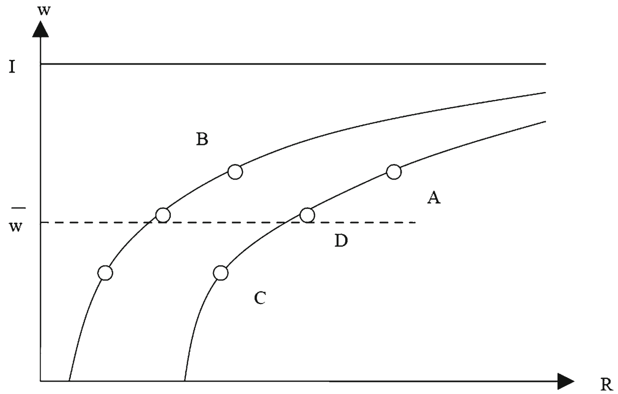

Fig. 2 Two equilibria with heterogeneous individuals

interest rate effect, but no Pareto dominance. Consider the same framework as before extended for the possibility of heterogeneity among agents. For simplicity, suppose that agents' ability, measured by the individual cost of providing effort B_i, is observable. In this case, the capital market equilibrium concept can still be applied. Wealth can now be used as a substitute for ability. This follows from solving the incentive constraint (1) for the rate of return R:

$$R \leq \rho(w_i, B_i) := \frac{p}{I - w_i}\left(Y - \frac{B_i}{p-q}\right). \quad (5)$$

According to this inequality, an agent can only commit to provide effort if the rate of return is not too large. As $d\rho/dB_i < 0$ and $d\rho/dw_i > 0$, a more able entrepreneur needs less wealth in order to obtain credit. An unequal wealth distribution may therefore allow low-ability rich loan applicants to crowd out poor loan applicants with higher ability. This triggers an equilibrium rate of return for investors that may be lower than with a more equal wealth distribution (when better entrepreneurs get financing for their projects).

To see why, think of an economy with two wealth classes $w_1 = \bar{w}+a$ and $w_2 = \bar{w}-a$ with $a > 0$ (see Fig. 2). Half of the population are in the upper class and a measures inequality. In both classes, ability levels may assume two values, B_l and B_h with corresponding shares υ_l and $\upsilon_h = 1 - \upsilon_l$. Further assume that low-ability rich individuals can commit to provide effort at a rate which is slightly higher than the rate for high-ability poor agents, i.e.

$$\rho(\bar{w} + a, B_l) = \rho(\bar{w} - a, B_h) + \varepsilon. \quad (6)$$

In Fig. 2, this is expressed by the fact that the low wealth level produces a maximum interest rate characterized by point C which is slightly lower than the one that corresponds to point B. When $\frac{I}{2} > \bar{w} > \frac{\upsilon_h}{2} I$, only rich agents (agents whose wealth is characterized by points A and B) become entrepreneurs and the equilibrium rate of return is $R = \rho(\bar{w}+a, p_l)$ (the rate of return which corresponds to point B). Now, consider a reduction in inequality to $\hat{a} < a$ such that

$$\rho(\bar{w} + \hat{a}, B_l) < \rho(\bar{w} - \hat{a}, B_h). \quad (7)$$

The increase of the poor agents' wealth has enabled the high-ability poor to get credit at interest rates, at which the low-ability rich would not be able to commit to provide effort. Consider now the case where $\upsilon_h I > \bar{w}$, i.e. the high ability agents would exhaust the economy's capital stock. In this case, in equilibrium, the wealth constraint is binding for high-ability poor agents

Table 1 Descriptive statistics

Variable	Mean	Min	Max	SD
Inequality_US	31.82	19.90	44.17	5.26
Inequality_UK	39.78	19.60	61.00	13.35
Inequality_Sweden	25.37	15.70	39.75	7.65
InterestRate_US	2.05	−10.83	15.40	4.18
InterestRate_UK	1.63	−20.58	23.82	6.40
InterestRate_Sweden	1.73	−10.85	8.37	3.63
GDP_US	12433.8	4777.0	23201.0	5491.6
GDP_UK	9203.6	4921.0	16430.0	3318.3
GDP Sweden	9402.8	3130.0	17695.0	4731.6

and the rate of return amounts to $R = \rho(\bar{w} - \hat{a}, B_h)$. Point D in Fig. 2 characterizes the new equilibrium interest rate after full redistribution ($\hat{a} = 0$). For sufficiently small values of ε, the new equilibrium rate of return is higher than $\rho(\bar{w} + a, B_l)$, since $d\rho/dw_i > 0$.

Intuitively, less inequality increases the wealth of the marginal poor entrepreneur who overtakes the rich low-ability entrepreneur in terms of the interest rate level at which he can provide effort.

Note that a positive interest rate effect is possible in this model but it need not necessarily occur. Whether or not the positive interest rate effect obtains depends on the joint distribution of wealth and talent in the economy.[7]

To summarize, the theoretical analysis predicts a positive interest rate effect of inequality in moral hazard economies in which only the rich invest in equilibrium. Economies in which the poor also invest and economies with heterogeneous agents may instead display negative interest rate effects.

3 Data

We now turn to our empirical analysis of the link between real interest rates and wealth inequality. We use the annual data summarized in Table 1 to study the relationship between wealth inequality and real interest rates for three OECD countries: the United States (1922–1992), the United Kingdom (1924–1991) and Sweden (1924–1992).

3.1 Descriptive statistics

Our main measure of *wealth inequality* is the percentage share of net worth held by the richest percentage of wealth holders.[8] The data are provided by Wolff (2002) at an annual frequency for US households from 1922 to 1992, for UK adults from 1924 to 1991 and for Swedish

[7] Other two class examples can be constructed where the interest rate effect of redistribution is not positive but smaller than in the case of a single ability level.

[8] Net worth is defined as the current value of all marketable or fungible assets minus the current value of debts. Also see e.g. Ohlsson et al. (2008) and Kopczuk and Saez (2004) for a discussion of issues pertaining to wealth inequality data (such as consistency, sources, measurement, patching).

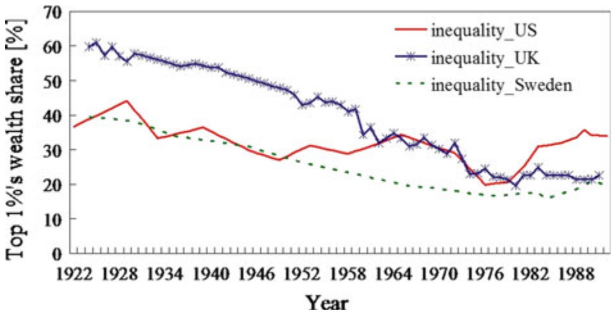

Fig. 3 Share of net worth held by top 1% of wealth holders (in %)

households from 1924 to 1992.[9] A key advantage of the data collected by Wolff (2002) for the purpose of our empirical analysis is that there are no missing observations in the time series of the wealth inequality data. Moreover, the wealth inequality data collected by Wolff are compiled from consistently benchmarked data sources. For the US, Wolff relies mainly on household surveys and estate tax records. For the UK, Wolff uses estimates of the wealth of the livings based on estate tax return data using mortality multipliers. And for Sweden, Wolff (2002) draws on actual wealth tax return data.

Figure 3 plots a time series graph of the evolution of our wealth inequality measure for the 1922–1992 period. The figure shows that the richest percentile's wealth experienced a steady and roughly linear decline until the end of the 1970s. Inequality was particularly high in the beginning of the sample period for the UK, where over 60% of the net worth was held by the top percentile of wealth holders. In Sweden and the US, the share of wealth held by the richest percentage of wealth holders was around 40%. Wealth inequality decreased over time, so that for all three countries not much more than 20% of total wealth was held by the richest percentage of wealth holders by 1980. Wealth inequality thereafter fluctuated for Sweden and the UK around 20%, while for the US wealth inequality picked up during the 1980s so that by 1992 about 32% of total net wealth was held by the top percentile of wealth holders.

We compute *real interest rates* r_t using the Fisher equation

$$(1 + r_t) = (1 + i_t) / \left(1 + \pi_t^e\right),$$

where i_t denotes the nominal risk-free interest rate and π_t^e the expected inflation rate. Assuming perfectly rational expectations, the actual inflation rate equals the expected inflation rate (i.e. $\pi_t^e = \pi_t$). To increase robustness, our analysis relies on several measures and data sources for the interest rate. In case of the US, eh.net (2006) presents data on the 3–6 months commercial paper rate from 1831 onwards, which is based on work by Macaulay (1938) and the records of the Federal Reserve Board. We also draw on the corporate bond rate, the short rate and the long rate published by Chadha and Dimsdale (1999) as well as the yield on 10-year government bonds compiled on the basis of data provided by Global Financial Data (2010) and the Federal Reserve Bank of St. Louis. For the UK, we use a time series on the 2.5% consol yield derived from Global Financial Data (2010), which is based on Neal (1990) and regular publications of The Times (London), the Bankers Magazine, the Financial Times

[9] We are aware of other data on wealth inequality, such as Kopczuk and Saez (2004) or Roine and Waldenström (2009). The series are roughly similar, in part even congruent with Wolff (2002). Yet, missing observations would only allow the use of very short time segments, thus rendering a rigorous time series analysis impossible.

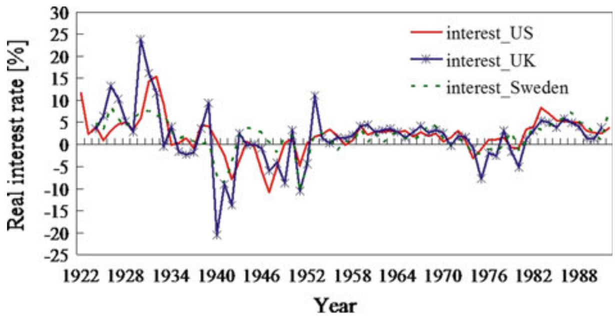

Fig. 4 Real interest rates (in %)

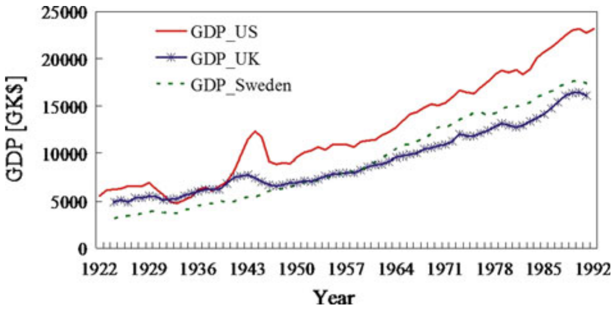

Fig. 5 Per capita GDP (in 1990 Geary Khamis dollars)

and the Central Statistical Office. For Sweden, data on the yields on 10-year government bonds from 1919 onwards comes from EcoWin (2002), Hansson and Frennberg (1992) as well as regular publications of the Swedish National Debt Office. We compute inflation rates based on CPI data that we obtain for the US and the UK from Officer and Williamson (2007), and for Sweden from Statistics Sweden (2002).

The time series graph in Fig. 4 shows that the sample mean real interest rates were positive, but fluctuated heavily during the period of the Great Depression and World War II (Fig. 4). During the sample period, real interest rates went as low as −10.83% in the US, −20.58% in the UK and −10.85% in Sweden. The sample maximum was as high as 15.40% for the US, 23.82% for the UK and 8.37% for Sweden, with a respective standard deviation of 4.18, 6.40 and 3.63.

To control for income effects that may be correlated to both changes in real interest rates and inequality we include *real per capita GDP* as an additional control variable in our baseline regressions. Real per capita GDP is measured in 1990 Geary Khamis dollars and taken from Maddison (2003). Figure 5 shows that the US had the highest average and maximum sample value of GDP per capita. After World War II per capita GDP was similar for Sweden and the UK but by the 1960s the GDP per capita level was increasingly higher in Sweden than in the UK.

3.2 Unit root tests

We investigate the stationarity of our time series data on the basis of three different unit root tests: the Kwiatkowski et al. (1992) [KPSS] test, the Clemente et al. (1998) [CMR] test,

Table 2 Unit root test results

	US (1922–1992)	UK (1924–1991)	Sweden (1924–1992)
Inequality	LLS_5: −2.540	LSS_2: −1.737	LLS_4: −2.702
	CMR_2: −3.762	CMR_2: −3.828	CMR_2: −2.996
	$KPSS_4$: 0.1489**	$KPSS_4$: 0.1768**	$KPSS_4$: 0.3124***
	$KPSS_{12}$: 0.1129*	$KPSS_{12}$: 0.0991	$KPSS_{12}$: 0.1734**
ΔInequality	LLS_0: −3.700***	LSS_1 : −4.762***	LLS_5: −2.591*
	CMR_1: −4.634***	CMR_1: −5.571***	CMR_1: −4.124***
	$KPSS_4$: 0.1094	$KPSS_4$: 0.1261	$KPSS_4$: 0.6907
	$KPSS_{12}$: 0.1296	$KPSS_{12}$: 0.1565	$KPSS_{12}$: 0.4566
Real interest rate	LLS_4: −1.604	LLS_2: −3.845***	LLS_0: −3.061**
	CMR_2: −3.490	CMR_2: −4.215	CMR_2: −5.507*
	$KPSS_4$: 0.1763**	$KPSS_4$: 0.1638**	$KPSS_4$: 0.177**
	$KPSS_{12}$: 0.1167*	$KPSS_{12}$: 0.1019	$KPSS_{12}$: 0.1355*
ΔReal interest rate	LSS_2: −8.085***	LLS_1: −7.839***	LSS_2: −3.132**
	CMR_1: −8.520***	CMR_1: −8.909***	CMR_1: −6.314***
	$KPSS_4$: 0.1435	$KPSS_4$: 0.0455	$KPSS_4$: 0.1143
	$KPSS_{12}$: 0.2270	$KPSS_{12}$: 0.0866	$KPSS_{12}$: 0.1986
GDP	LLS_3: −2.207	LLS_2: −1.347	LLS_2: −0.878
	CMR_2: −4.138	CMR_2: −3.435	CMR_2: −2.689
	$KPSS_4$: 0.2394***	$KPSS_4$: 0.3741***	$KPSS_4$: 0.3148***
	$KPSS_{12}$: 0.1688**	$KPSS_{12}$: 0.1808**	$KPSS_{12}$: 0.1659**
ΔGDP	LSS_1: −5.488***	LLS_1: −4.935***	LLS_1: −4.919***
	CMR_2: −7.381***	CMR_1: −5.155***	CMR_2: −6.146***
	$KPSS_4$: 0.1617	$KPSS_4$: 0.4048*	$KPSS_4$: 0.3004
	$KPSS_{12}$: 0.2501	$KPSS_{12}$: 0.3610*	$KPSS_{12}$: 0.2469

Note: Critical values for the KPSS test assuming level stationarity are 0.347 (10%), 0.463 (5%), 0.739 (1%) and 0.119 (10%), 0.146 (5%), 0.216 (1%) when assuming trend stationarity. For the KPSS, the subscript number denotes the truncion lag. Critical values for the LSS test assuming trend stationarity are −2.76 (10%), −3.03 (5%), −3.55 (1%) and −2.58 (10%), −2.88 (5%), −3.48 (1%) when assuming level stationarity. For the LSS, the subscript number denotes the specified number of autoregressive lags, as suggested by information criteria. Critical values for the CMR test with two structural breaks are −5.37 (10%), −5.70 (5%), −6.50 (1%). For the CMR, the subscript number denotes the specified number of break points. GDP, inequality and the real interest rate are modelled under the null as trend stationary, while ΔGDP, Δinequality and the Δreal interest rate are modelled as level stationary

and the Lanne et al. (2002) [LSS] test. The reason why we make use of the CMR and LSS test (which both have the null hypothesis that the time series is non-stationary) is to address possible structural breaks; the reason why we make use of the KPSS test (which has the null hypothesis that the time series is stationary) is that the small sample size may imply low statistical power in rejecting the null hypothesis of non-stationarity.

Table 2 displays the results of the LSS, CMR and $KPSS$ unit root tests. For all three countries, the LSS, CMR and $KPSS$ test indicate that GDP and wealth inequality contain a unit root. Taking first differences, the LSS and CMR test reject the null hypothesis of a unit root, while the $KPSS$ test cannot reject the null hypothesis that the first-differenced series are stationary. For the US, the LSS and CMR test cannot reject the null hypothesis of a unit root in the real interest rate. And the $KPSS$ test rejects stationarity at the 95 (resp. 90) percent

Table 3 Cointegration tests

	Full sample			1924–1947			1948–1991		
	US (1)	UK (2)	Sweden (3)	US (4)	UK (5)	Sweden (6)	US (7)	UK (8)	Sweden (9)
0	0.0006***	0.0506**	0.0000***	0.0000***	0.0001***	0.0000***	0.0000***	0.0000***	0.0028***
1	0.0098***	0.5322	0.0062***	0.0027***	0.0625*	0.0038***	0.0009***	0.0376**	0.0469**
2	0.3396	0.6438	0.3126	0.3725	0.4023	0.2658	0.2096	0.6792	0.1323
Observations	69	66	67	25	23	23	42	42	42

Note: * Significantly different from zero at 90% confidence, ** 95% confidence, *** 99% confidence. Listed numbers are p-values. The lag length was determined using information criteria. All estimates were computed including a linear trend and a constant in the cointegration relationship

confidence level when a truncation lag of 4 (resp. 12) is used. A similar picture arises for the UK. For Sweden, the LSS and CMR tests provide evidence for real interest rate stationarity at the 95 and 90% level, respectively, but the KPSS test also rejects the null hypothesis of stationarity. When we compute the LSS, CMR and $KPSS$ test for the first-difference of the real interest rate all three tests unanimously agree that the transformed real interest rate series is stationary. Hence, we treat the level of the real interest rate as non-stationary and the first-difference as stationary.

3.3 Cointegration analysis

We now assess whether GDP, inequality and real interest rates are cointegrated, using system cointegration tests. The implemented test procedure is based on Johansen et al. (2000) and allows for up to two structural breaks. If $X = (InterestRate, GDP, Inequality)^T$ follows a $VAR(p)$ process then we can write the $VECM$ representation as

$$\Delta X_t = \upsilon + \alpha \left[\beta^T X_{t-1} - \tau (t-1) - \theta d_{t-1}\right] + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Delta d_t + u_t \tag{8}$$

with $t = p+1, \ldots, T$, where υ is a $[3x1]$ intercept, α a $[3xr]$ vector containing the loading coefficients and β^T a $[rx3]$ vector containing the cointegration relationship. θ and τ are $[3x1]$ parameter vectors, d_t shift dummies modelling a break in the long-run relationship and Δd_t impulse dummies. The error term is $u_{\tilde{t}}$. Because GDP and our inequality measure exhibits a linear trend we include in (8) a linear trend that is restricted to the cointegration relationship to outrule quadratic terms. We determine the number of cointegration relations by applying the Johansen et al. (2000) test procedure that estimates the model in equation (8) by maximum likelihood and applies a reduced rank procedure, testing the hypothesis $H_0(r_0) : rk(\alpha\beta^T) = r_0$ versus $H_1(r_0) : rk(\alpha\beta^T) > r_0$. The Johansen et al. likelihood ratio test statistic is then computed using the estimated eigenvalues of $\alpha\beta^T$.

Table 3 provides the obtained p-values from the Johansen et al. cointegration test. We specified structural breaks to occur during the time of World War II and during the period of the Great Depression. The Johansen et al. cointegration test provides evidence for the existence of two cointegration relationships between GDP, real interest rates and inequality. The full sample estimates are listed in columns 1–3, whereas pre- (resp. post-) World War II estimates are listed in columns 4–6 (resp. 7–9). For the US and Sweden, the Johansen trace test rejects the null hypothesis of only one cointegration relationship with over

99% confidence, while it accepts the null hypothesis of two cointegration relationships at conventional confidence levels. Similarly, the trace test detects two cointegration relations for the UK during the periods 1924–1947 and 1948–1991.

4 Main results

4.1 Baseline VECM estimates

Tables 4 and 5 present the cointegration estimates for our baseline 3-dimensional VECM model as specified in Eq. 8. We impose a cointegration rank of two, as suggested by the cointegration tests. Because of non-unique estimates of the α and β^T, we follow standard procedures and set the coefficient for the real interest rate equal to one. In turn, the lag structure is determined using information criteria and a variety of misspecification tests. For all three countries, the most appropriate model turns out to be the corresponding $VAR(2)$ process. Both, a shift dummy for World War II and an unrestricted impulse dummy for the Great Depression are included in the cointegration relationship.

Column 1 of Table 4 shows the estimated cointegration relationship between the real interest rate and wealth inequality for the US during the 1922–1992 period. Both, the loading coefficient and the cointegration vector are highly significant at over 99% confidence. The long-run relationship is estimated as (1, −0.51), with a loading coefficient of −0.56. Similar effects arise for Sweden for 1924–1992: the cointegration vector is (1, −0.77) and the loading coefficient is −0.57; both of these estimates are individually significant at over 99% confidence. The estimated cointegration for the UK exhibits the largest error correcting mechanism (the estimated loading coefficient is −0.88), but the estimated cointegration vector of (1, −0.50) has a t-statistic of −1.28 and is therefore not significant at the conventional confidence levels. Nevertheless, once we split the sample into the pre- and post-World War II period (see columns 5 and 8), the cointegration vector for the UK is (1, −4.14) and (1, −0.47), and statistically significant at the 99 and 92% confidence level, respectively. Moreover, the cointegration relationships for the pre- and post-World War II sample are also highly statistically significant for Sweden and the US.

In Table 5 we report estimates of the cointegration relationship between wealth inequality and GDP per capita. The cointegration relationship between wealth inequality and GDP per capita is statistically significant for more than two-thirds of the nine different country-periods listed in Table 5. However, in contrast to our estimates of the cointegration relationship between wealth inequality and the real interest rate, the size and the sign of the cointegration relationship between GDP per capita and wealth inequality vary substantially across countries and time periods. For the US we find that during the 1922–1992 period the cointegration relationship is significantly positive, for the pre-World War II period it is significantly negative, and for the post-World War II period it is insignificant. For the UK our estimates of the cointegration relationship between wealth inequality and GDP per capita are positive regardless of which period we focus on. But statistically, they are only significantly different from zero for the post-World War II period. For Sweden, the VECM estimates yield a significant negative cointegration relationship between wealth inequality and GDP per capita for the 1924-1992 period and the post-World War II period. For the pre-World War II period the cointegration relationship is significantly positive. Hence, our cointegration analysis does not point to a clear positive or negative relationship between GDP per capita and wealth inequality in our sample of three OECD countries, which resonates the

Table 4 VECM cointegration estimates: inequality and the real interest rate

Dependent variable: first difference real interest rate

	Full sample			1924–1947			1948–1991		
	US (1)	UK (2)	Sweden (3)	US (4)	UK (5)	Sweden (6)	US (7)	UK (8)	Sweden (9)
Loading	−0.56***	−0.88***	−0.57***	−0.78***	−1.34***	−0.75***	−0.66***	−0.96***	−0.85***
coefficient (α)	(−6.04)	(−7.36)	(−4.29)	(−4.16)	(−7.37)	(−3.91)	(−3.80)	(−5.17)	(−4.24)
Interest rate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Inequality	−0.51***	−0.50	−0.77***	−3.14***	−4.14***	−4.57***	−0.28***	−0.47*	−0.72**
	(−4.03)	(−1.28)	(−2.82)	(−5.24)	(−2.70)	(−3.72)	(−3.00)	(−1.84)	(−2.50)
Observations	69	66	67	25	23	23	42	42	42

Note: *Significantly different from zero at 90% confidence, **95% confidence, ***99% confidence. The dependent variable is the first-difference of the real interest rate; t-values are provided in brackets. The lag length of the VECM was determined using information criteria. All estimates were computed including a linear trend and a constant in the cointegration relationship

Table 5 VECM cointegration estimates: wealth inequality and GDP

Dependent variable: first difference real per capita GDP

	Full sample			1924–1947			1948–1991		
	US (1)	UK (2)	Sweden (3)	US (4)	UK (5)	Sweden (6)	US (7)	UK (3)	Sweden (9)
Loading coefficient (α)	−0.17***	−0.06**	−0.08***	−0.21***	0.22***	−0.34**	−0.15***	−0.30***	−0.12**
	(−4.17)	(−2.03)	(−5.10)	(−3.27)	(−3.22)	(−2.07)	(−3.73)	(−4.63)	(−2.49)
GDP	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Inequality	−181.6**	−109.5	202.6*	215.1***	−259.3	−398.6***	11.2	−70.7*	212.2***
	(−2.43)	(−0.76)	(1−66)	(5.61)	(−1.37)	(−6.37)	(0.17)	(−1.89)	(2.84)
Observations	69	66	67	25	23	23	42	42	42

Note: * Significantly different from zero at 90% confidence, ** 95% confidence, *** 99% confidence. The dependent variable is the first-difference of real per capita GDP; t-values are provided in brackets. The lag length of the VECM was determined using information criteria. All estimates were computed including a linear trend and a constant in the cointegration relationship inequality-growth literature that has found at best a tentative negative association between (income) inequality and GDP per capita growth (e.g. Ferreira and Ravallion 2009).[10]

4.2 Robustness checks on the VECM estimates

Table 6 documents that our estimates of the positive link between wealth inequality and the real interest rate are robust to the inclusion of additional control variables that may jointly determine real interest rates and wealth inequality (beyond GDP per capita). Column 1 shows estimates of the cointegration relationship between wealth inequality and the real interest rate when controlling in the VECM estimation for government expenditures; column 2 shows the estimates of the cointegration relationship between wealth inequality and the real interest rate when controlling for tax revenues. For all three OECD countries we find a significant positive cointegration relationship between wealth inequality and the real interest rate. Quantitatively, the cointegration estimates are also quite similar in size to the cointegration estimates reported in Table 4 of our baseline 3 dimensional VECM. Columns 1 and 2 therefore show that our cointegration estimates in Table 4 are robust to wealth inequality being positively associated with government spending and tax revenues.[11]

To take into account changes in trade openness that may jointly determine wealth inequality and the real interest rate, column 3 reports the cointegration estimates between wealth inequality and the real interest rate when controlling in the VECM for changes in the share of exports plus imports in GDP. Increases in trade openness will likely be associated with increases in production efficiency, and hence the real interest rate, due to increases in the varieties of intermediate goods and the survival of the most productive firms. Moreover, increases in trade openness could have an effect on wealth inequality due to changes in factor prices; and increases in wealth inequality could be associated with decreases in trade openness due to increases in protectionistic pressures. Column 3 therefore shows that importantly we continue to find a significant positive cointegration relationship between wealth inequality and the real interest rate when controlling in our VECM for changes in trade openness.

A further robustness check on our VECM estimates is the control for changes in human capital formation. This is an important robustness check because of skill biased technological change that occurred in the US and other countries during the 1980s. Skill biased technological change could induce both an increase in wealth inequality and the real interest rate because of increases in the (relative) wage for skilled workers, and hence be an important omitted variable in our VECM estimation. Column 4 therefore reports the cointegration estimates on the link between wealth inequality and the real interest rate when controlling for the share of the population with high school education. Column 5 reports the cointegration relationship when controlling for the share of the population with university education. The

[10] Note that the lack of a clear positive or negative relationship between wealth inequality and GDP per capita could be due to a number of reasons that go beyond the interest rate channel that we described in Sect. 2. If for example greater wealth inequality is associated with greater redistribution (financed by a tax on the immobile factor labor), then greater wealth inequality could have an overall negative effect on GDP per capita despite the positive net effect on the real interest rate. Moreover, if greater wealth inequality is associated with greater social conflict, that reveals itself for example in form of labor demonstrations, then greater wealth inequality could have a negative effect on GDP per capita, despite having a positive effect on the real interest rate.

[11] We have reported the entire VECM estimates for Table 6 in an Online Appendix, available at http://gruener.vwl.uni-mannheim.de/405.0.html. Regarding the inequality–GDP relationship, there continues to be a significant positive cointegration relationship between GDP and wealth inequality for the UK. For the US the relationship between GDP and wealth inequality also becomes significantly positive once we control for government expenditures or tax revenues. For Sweden the relationship between GDP and inequality turns insignificant once we control for government expenditures, but remains significantly negative when we control for tax revenues.

Table 6 VECM cointegration estimates: inequality and the real interest rate (robustness to other control variables)

Dependent variable: first-difference real interest rate							
Controlling for	Government expenditures (1)	Government revenues (2)	Trade openness (3)	High-school education (4)	University education (5)	Relative price of capital equipment (6)	Share of IT industry in GDP (7)
US (1948–1991)							
Loading coefficient (α)	−0.69***	−0.83***	−0.70***	−0.90***	−0.73***	−074***	−0.74***
	(−7.48)	(−4.50)	(−4.47)	(−4.86)	(−3.90)	(−6.62)	(−5.63)
Interest rate	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Inequality	−0.17**	−0.46***	−0.16*	−0.30***	−0.74***	−0.14**	−0.19***
	(−2.32)	(−2.96)	(−1.87)	(−2.85)	(−2.95)	(−2.62)	(−2.84)
UK (1948–1991)							
Loading coefficient (α)	−1.14***	−1.09***	−1.25***	−1.17***	−1.40***		
	(−7.16)	(−6.45)	(−7.40)	(−7.02)	(−6.20)		
Interest rate	1.00	1.00	1.00	1.00	1.00		
Inequality	−0.50*	−0.62**	−0.75***	−0.44*	−0.42*		
	(−1.88)	(−2.17)	(−3.66)	(−1.79)	(−1.81)		
Sweden (1948–1991)							
Loading coefficient (α)	−0.75***	−0.88***	−0.47***	−0.68***	−0.60***		
	(−6.51)	(−4.37)	(−3.74)	(−5.40)	(−4.45)		
Interest rate	1.00	1.00	1.00	1.00	1.00		
Inequality	−0.69**	−0.61**	−0.59**	−0.84***	−0.78***		
	(−2.37)	(−2.11)	(−2.53)	(−3.03)	(−2.65)		

Note: *Significantly different from zero at 90% confidence, **95% confidence, ***99% confidence. The dependent variable is the first-difference of the real interest rate; *t*-values are provided in brackets. The additional regressors included in the VECM are as follows: column 1 real per capita government expenditures (IMF Statistics); column 2 real per capita government tax revenues (IMF Statistics); column 3 trade openness, computed as the ratio of exports plus imports over GDP (IMF Statistics); column 4 the share of population that has attained high-school education (Banks 2010); column 5 the share of the population that has attained university education (Banks 2010); column 6 the ratio of the price of capital equipment to the price of total industrial production (FRED); column 7 the share of IT industry output in GDP (Jorgenson & Stiroh 2007). All estimates include as an additional control variable real per capita GDP. A linear trend and constant are included also in the cointegration relationship

Table 7 VECM cointegration estimates: inequality and the real interest rate (robustness to other real interest rate measures, US: 1948–1991)

Dependent variable: first-difference real interest rate

	Long-term interest rate (1)	Short-term interest rate (2)	Corporate bond rate (3)	Commercial paper rate (4)
Loading coefficient	−0.65*** (−4.47)	−1.01*** (−5.54)	−0.64*** (−4.43)	−1.07*** (−5.88)
Interest rate	1.00	1.00	1.00	1.00
Inequality	−0.30*** (−3.53)	−0.26*** (−3.22)	−0.29*** (3.48)	−0.23*** (−2.80)

Note: * Significantly different from zero at 90% confidence, ** 95% confidence, *** 99% confidence. The dependent variable is the first-difference of the real interest rate; *t*-values are provided in parentheses. The lag length of the VECM was determined using information criteria. All estimates were computed including a linear trend and a constant in the cointegration relationship

main result is that wealth inequality and the real interest rate continue to be significantly positively cointegrated. Our main finding of a positive link between wealth inequality and the real interest rate therefore holds up when controlling for changes in human capital formation. In columns 6 and 7 we also show that the cointegration relationship between wealth inequality and the real interest rate continues to be significantly positive when controlling for the change in the relative price of equipment investment or the share of IT industry output in GDP.

As a final robustness check, we show in Table 7 that we continue to obtain a significant positive relationship between wealth inequality and the real interest rate when using alternative interest rate data to compute the return on capital. In column 1 we report the cointegration estimates between wealth inequality and the real interest when using instead of the return on 10-year government bonds the long-term interest rate; and in column 2 we report the estimates when using the short-term interest rate. In columns 3 and 4 we report the cointegration estimates between wealth inequality and the real interest rate when using the return on corporate bonds and the commercial paper rate. As can be seen, wealth inequality continues to be significantly positively linked to the real interest rate for these alternative interest rate measures.[12]

4.3 Additional evidence from panel regressions

The cointegration estimates in Sects. 4.1 and 4.2 showed that there is a robust positive relationship between wealth inequality and the real interest rate for our three OECD countries where we have sufficiently long time series data to estimate a VECM. In this section we provide further empirical evidence on the positive relationship between inequality and the real interest rate by assembling a panel dataset for 16 OECD countries that spans the period

[12] In our working paper (Brückner et al. 2007) we also reported orthogonalized impulse response functions. We found that for all three countries a positive shock to wealth inequality led to a significant increase in the real interest rate. We also found that a shock to the real interest rate significantly increased the share of net worth held by the top percentile of wealth holders for the UK and Sweden, but did not have a significant positive effect on wealth inequality in the US. Structural analysis therefore points to a causal effect going from higher wealth inequality to a higher real interest rate, and possibly to a causal effect going from a higher real interest rate to higher wealth inequality.

Table 8 Panel data estimates: inequality and the real interest rate

Dependent variable: first-difference real interest rate

	Top 10% (Leigh 2007)	Top 10% (Roine and Waldenström 2009)	Top 5% (Roine and Waldenström 2009)	Top 1% (Roine and Waldenström 2009)	Top 1% (Leigh 2007)	Gini after tax (Solt 2009)
Panel A: Static panel regression (LS)						
Inequality	0.017*** (3.71)	0.010*** (3.24)	0.010*** (4.76)	0.006* (1.82)	0.009* (1.69)	0.103** (2.03)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	439	439	421	481	481	551
Countries	12	12	11	13	13	16
Panel B: Dynamic panel regression (SYS-GMM)						
Inequality	0.012*** (2.70)	0.005* (1.82)	0.006*** (2.93)	0.003 (0.90)	0.008** (2.26)	0.076 (1.63)
Sargan Test	0.135	0.350	0.531	0.656	0.156	0.598
Ar(2) Test	0.134	0.165	0.158	0.165	0.137	0.731
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	430	430	412	471	471	551
Countries	12	12	11	13	13	16

Note: The dependent variable is the first-difference of the real return on a 10-year government bond (Global Financial Data 2010); the explanatory variable is the first-difference of income inequality. The income inequality data are in columns 1 and 5 from Leigh (2007) and measure the share of income held by the richest 10% (1% respectively) of the population. In columns 2–4 the inequality data are from Roine and Waldenström (2009) and measure the share of income held by richest 10, 5, and 1%, respectively. In column 6 the inequality data are from Solt (2009) and refer to the Gini coefficient of the after-tax income distribution. The t-values shown in parentheses are based on Huber robust standard errors that are clustered at the country level. The method of estimation in Panel A is least squares; Panel B system-GMM (Blundell and Bond 1998). All regressions control for country and year fixed effects, as well as the change in real per capita GDP

1960–2008.[13] There are no consistently long enough time series data on wealth inequality available for the 16 OECD countries in our sample, but we do have reliable and comparable cross-country data for income inequality.[14] To provide assurance that our results are robust to the specific inequality measure used, we provide estimates based on three different data sources (see Table 8). We use rigorous panel fixed effects regression techniques that account for unobservable cross-country heterogeneity as well as unobservable year-specific effects to examine the link between wealth inequality and the real interest rate. We report estimates from both a static panel regression and a dynamic panel regression. In the dynamic panel regression we use system-GMM estimation (Blundell and Bond 1998) and explicitly address

[13] The OECD countries included in our panel dataset are Australia, Austria, Canada, Denmark, France, Germany, Ireland, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the UK, and the US.

[14] Note that although income and wealth inequality reflect different mechanisms, measures of top income and wealth inequality have been shown to follow a very similar evolution in rich countries over the last century (see e.g. Leigh 2009).

a possible reverse causal effect going from the interest rate to inequality by treating the inequality series in the system-GMM regression as an endogenous regressor.

In Panel A of Table 8 we report the estimates from our static panel fixed effects regressions that link within-country changes in income inequality to within-country changes in the real interest rate.[15] In columns 1 and 2 we use as a measure of income inequality the share of income that is held by the richest 10%; in column 3 the share of income that is held by the richest 5%; in columns 4 and 5 the share of income that is held by the richest 1%; and in column 6 we use as a measure of income inequality the Gini coefficient. For all of these alternative income inequality measures we obtain a positive relationship between income inequality and the real interest rate that is statistically significant at the conventional confidence levels.

In Panel B of Table 8 we repeat the above regressions for a dynamic panel data model that is estimated by system-GMM (Blundell and Bond 1998). The system-GMM estimator uses past first-differences of the series as instruments for the levels. We test the validity of these instruments using the Sargan test and also report p-values on a test for higher order serial correlation. The main result is that for four of our six alternative measures of income inequality the link between income inequality and the real interest rate is statistically significant. For all six of these alternative measures the estimated sign of the relationship is positive. The panel fixed effects estimates therefore resonate the findings of our VECM estimates that pointed to a significant positive relationship between wealth inequality and the real interest rate.

5 Conclusion

Economic theory based on imperfect capital markets makes an ambiguous prediction about the impact of changes in the wealth distribution on real interest rates. A sound understanding of this relationship is important for governments when they design policies targeting growth or equity concerns. From a finance perspective, understanding the determinants of real interest rates is also central for deciding what elements to incorporate in general equilibrium asset pricing models.

In this paper, we find a robust positive relationship between wealth inequality and real interest rates. Our results are consistent with capital market models with moral hazard in which rich entrepreneurs' incentive compatibility constraints determine the interest rate. Our results call into question the empirical relevance of model specifications that produce negative interest rate effects of wealth inequality.[16] The trickle down effect of the wealth accumulation of the rich, analyzed in Aghion and Bolton (1997) finds no support in our data.

With higher real interest rates reflecting a more efficient allocation and use of capital as well as a higher opportunity cost of current consumption, economic growth should be higher in countries characterized by higher inequality. However, it is important to note that inequality has effects on economic growth through channels other than the real interest rate, such as social conflict for example. Hence, distributive policies reducing the wealth held by the rich may have ambiguous effects on the level of per capita income and its growth rate.

[15] The real interest rate data are computed using 10-year government bonds and the CPI. The 10-year government bonds and the CPI data are from Global Financial Data (2010).

[16] One should note that inequality might also affect the interest rate through the aggregate savings rate. More inequality may lead to higher aggregate savings if, in the relevant area, savings are increasing and convex in wealth. This would lead to a lower interest rate, whereas we find that inequality is associated with a higher interest rate.

Another issue that merits attention is the different development of inequality in Anglo-Saxon and non Anglo-Saxon countries (Leigh 2009). According to our analysis, this development may, in combination with international capital market imperfections, lead to interest rate disparities. Studies such as those of Barro (2000) also inspire to scrutinize whether our result might be confined to more developed countries. Barro obtains a significant negative effect of inequality on growth for poor countries, which vanishes above a certain per capita income level. This result was taken as a sign of worse capital market imperfections in poor countries, where capital markets are less developed. Further studies along the lines of our paper might therefore be useful in predicting returns on investments in developing countries as long time series data on inequality become available.

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References

Aghion, P., & Bolton, P. (1997). A trickle-down theory of growth and development. *Review of Economic Studies, 64*, 151–172.

Alesina, A., & Perotti, R. (1996). Income distribution, political instability, and investment. *European Economic Review, 40*, 1203–1228.

Alesina, A., & Rodrik, D. (1994). Distributive politics and economic growth. *The Quarterly Journal of Economics, 109*, 465–489.

Atkinson, A. B., & Piketty, T. (Eds.). (2007). *Top incomes over the twentieth century: A contrast between European and English-speaking countries*. Oxford: Oxford University Press.

Banerjee, A., & Duflo, E. (2005). Growth theory through the lens of development economics. In P. Aghion & S. Durlauf (Eds.), *Handbook of economic growth* (pp. 473–552). Amsterdam: North-Holland.

Banerjee, A., & Newman, A. F. (1993). Occupational choice and the process of development. *Journal of Political Economy, 101*, 274–298.

Banks, A. (2010). *Cross-national time-series data archive*. Binghamton NY: Databanks International, Data File.

Barro, R. (2000). Inequality, growth and investment. *Journal of Economic Growth, 5*, 5–32.

Benabou, R. (1996). Inequality and growth. In B. Bernanke & J. Rotemberg (Eds.), *NBER macro annual 1996* (pp. 11–74). Cambridge: MIT Press.

Bertola, G. (1993). Factor shares and savings in endogenous growth. *American Economic Review, 83*, 1184–1198.

Besley, T., & Burgess, R. (2000). Land reform, poverty and growth: Evidence from India. *Quarterly Journal of Economics, 105*, 389–430.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*, 115–143.

Brückner, M., Gerling, K., & Grüner, H. P. (2007). Wealth inequality and credit markets: Evidence from 3 industrialized countries. CEPR DP 6485.

Chadha, J. S., & Dimsdale, N. H. (1999). A long view of real interest rates. *Oxford Review of Economic Policy, 15*, 17–45.

Clemente, J., Monatnes, A., & Reyes, M. (1998). Testing for a unit root in a variable with a double change in the mean. *Economics Letters, 59*, 175–182.

Corneo, G., & Grüner, H. P. (2000). Social limits to redistribution. *American Economic Review, 90*, 1491–1507.

Corneo, G., & Grüner, H. P. (2002). Individual preferences for political redistribution. *Journal of Public Economics, 83*, 83–107.

Deininger, K., & Olinto, P. (2000). *Asset distribution, inequality, and growth*. The World Bank Policy Research Working Paper Series 2375.

Deininger, K., & Squire, L. (1998). New Ways of looking at old issues. *Journal of Development Economics, 57*, 259–287.
EcoWin. (2002). Table swe14025: Yields on 10-year government bonds. ecowin.com.
eh.net. (2006). What was the Interest Rate Then. http://eh.net/hmit/paperrates.
Fajnzylber, P., Lederman, D., & Loayza, N. (1998). Determinants of crime rates in Latin America and the world: An empirical assessment. A World Bank Latin America and the Caribbean Viewpoints Series Paper.
Ferreira, F. (1999). A brief overview to theories of growth and distribution. World Bank, PREM Network, Poverty Group, Washington, DC.
Ferreira, F., & Ravallion, M. (2009). Poverty and inequality: The global context. In W. Salverda, B. Nolan, & T. Smeeding (Eds.), *The oxford handbook of economic inequality*. Oxford: Oxford University Press.
Galor, O., & Zeira, J. (1993). Income distribution and macroeconomics. *Review of Economic Studies, 60*, 35–52.
Global Financial Data. (2010). Yield on 10-Years government bonds. globalfindata.com.
Grüner, H. P. (2003). Redistribution as a selection device. *Journal of Economic Theory, 108*, 194–216.
Grüner, H. P., & Schils, R. (2007). The political economy of wealth and interest. *The Economic Journal, 117*, 1403–1422.
Hansson, B., & Frennberg, P. (1992). Swedish stocks, bonds, bills and inflation (1919–1990). *Applied Financial Economics, 2*, 79–86.
Johansen, S., Mosconi, R., & Nielson, B. (2000). Cointegration analysis in the presence of structural breaks in the deterministic trend. *Econometrics Journal, 3*, 216–249.
Jorgenson, D., & Stiroh, K. (2007). Information technology and growth. Online Database.
Kopczuk, W., & Saez, E. (2004). Top wealth shares in the united States, 1916–2000: Evidence from estate tax returns. *National Tax Journal, 57*, 445–487.
Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review, 45*, 1–28.
Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics, 54*, 159–178.
Lanne, M., Lütkepohl, H., & Saikkonen, P. (2002). Comparison of unit root tests for time series with level shifts. *Journal of Time Series Analysis, 23*, 667–685.
Leigh, A. (2007). How closely do top income shares track other measures of inequality. *The Economic Journal, 117*, 589–603.
Leigh, A. (2009). Top incomes. In W. Salverda, B. Nolan, & T. Smeeding (Eds.), *The oxford handbook of economic inequality*. Oxford: Oxford University Press.
Maddison, A. (2003). *The world economy: Historical statistics*. Paris: OECD.
Macaulay, F. R. (1938). *The movements in interest rates, bond yields, and stock prices*. New York: NBER.
Neal, L. (1990). *The rise of financial capitalism: International capital markets in the age of reason*. New York: Cambridge University Press.
Officer, L. H., & Williamson, S. H. (2007). Annual inflation rates in the United States, 1774–2006, and United Kingdom, 1265–2006. Online data available at measuringworth.com.
Ohlsson, H., Roine, J., & Waldenström, D. (2008). Long-run changes in the concentration of wealth: An overview of recent findings. In J. Davies, *Personal wealth from a global perspective*. Oxford: Oxford University Press.
Perotti, R. (1996). Democracy, income distribution and growth: What the data say. *Journal of Economic Growth, 1*, 149–187.
Persson, T., & Tabellini, G. (1994). Is inequality harmful for growth?. *American Economic Review, 84*, 600–621.
Piketty, T. (2003). Income inequality in France, 1901–1998. *Journal of Political Economy, 111*, 1004–1042.
Piketty, T. (1997). The dynamics of the wealth distribution and the interest rate with credit rationing. *Review of Economic Studies, 64*, 173–201.
Piketty, T., & Saez, E. (2003). Income inequality in the United States, 1913–1998. *Quarterly Journal of Economics, 118*, 1–39.
Rodrik, D. (1999). Where did all the growth go? External shocks, social conflict and growth collapses. *Journal of Economic Growth, 4*, 385–412.
Roine, J., Vlachos, J., & Waldenström, D. (2009). The long-run determinants of inequality: What can we learn from top income data?. *Journal of Public Economics, 93*, 974–988.
Roine, J., & Waldenström, D. (2009). Wealth concentration over the path of development: Sweden, 1873–2006. *Scandinavian Journal of Economics, 11*, 151–187.
Statistics Sweden. (2002). Inflation i Sverige 1831–2006.
Stiglitz, J., & Weiss, A. (1981). Credit rationing in markets with imperfect information. *American Economic Review, 71*, 393–410.

Solt, F. (2009). Standardizing the world income inequality database. *Social Science Quarterly, 90*, 231–242.

Townsend, R., & Ueda, K. (2006). Financial deepening, inequality, and growth: A model-based quantitative evaluation. *Review of Economic Studies, 73*, 251–293.

Wolff, E. N. (2002). *Top heavy: The increasing inequality of wealth in America and what can be done about it*. New York: New Press.