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Does rising income inequality affect mortality rates in advanced economies?

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Abstract
What effect does rising income inequality have on mortality rates in developed countries? In particular, does the rise of the super-wealthy or the top 0.01% of the population effect overall health of the population? This paper focuses on the effect of rising income inequality on mortality rates of men and women in a subset of OECD countries over six decades from 1950–2008. The authors used adult mortality as the outcome measure and the inverted Pareto-Lorenz coefficient as the preferred measure of income inequality and obtained the latest and precise data on the income inequality measure. They used a panel co-integration econometric framework to address some of the challenges posed by more conventional methods. The findings show that for industrialized countries with co-integrated series, income inequality appears to have a long-run significant negative effect on mortality risk for both men and women, that is, an increase in income inequality does not appear to lower annualized adult mortality rates.

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Keywords Income inequality; mortality; health; panel co-integration

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1 Introduction

Does an increase in income inequality result in a decrease in longevity? As income inequality has increased steadily over the past few decades globally, this question has gained prominence in current public discourse and academic research. This growing wealth gap is partly attributed to increases in top wage incomes from the 1970s to the 1990s (Piketty and Saez, 2006). Income inequality can affect economic growth (Kuznets, 1955), social capital and social cohesion (Kennedy, 1988). Another area that income inequality can affect is health and longevity which is the focus of this paper.

The research question is as follows: 'What is the effect of income inequality on adult male and female mortality rates in a sample of industrialized countries?' The study uses cross-sectional panel data from OECD countries (Canada, UK, USA, Germany, Norway, Sweden, Denmark, Japan, Switzerland and New Zealand) from 1950 to 2008.

A scoping review of the extensive literature in this area show both positive and negative effects of income inequality on mortality. Some of the studies that support the conclusion that income leads to higher mortality include Wilkinson, 2006; Rodgers, 1979; Waldmann, 1992; Lynch, 1998; Judge et al, 1998; Ram, 2005 and Dorling, 2007. Wilkinson (1996) in particular argues that developed countries with low income inequality show better health outcomes than societies with a greater wealth gap. Egalitarian societies tend to be more socially cohesive with stronger communities, which results in a higher quality of life and better overall health. Some of the later studies which moved away from cross-sectional data, did not find a significant association between income inequality and health (Wagstaff, 2000; Beckfield, 2004; Subramanian, 2006). Gravelle (1998) pointed out that a statistical artefact as a result of using population data instead of individual data could account for the association between income inequality and health. Avendano (2012) analyzed OECD countries from 1960 to 2008 and found that a one-point increase in the Gini coefficient was associated with an increase of 7% in infant mortality rates.

Some of the other studies that have found the reversed effects of income inequality on longevity include Mellor (2001), Leigh (2009) and Leigh (2007). In more recent work, Herzer (2015) used panel co-integration techniques to analyze the impact of income inequality and found that income inequality has a statistically significant positive effect on population health in developed countries (i.e. higher life-expectancy). Herzer postulated that there might be certain health risks that are stress-related that affects high-income ranks if the society is unstable. Another possible reason provided was that richer people will demand more medical services (Miller et al, 2006) resulting in improved access to medical services for the entire population including the poor.

The purpose of this paper is to provide confirmatory evidence of a relationship between income inequality and population health. This study differentiates itself from other similar studies in that it uses the inverted Pareto-Lorenz coefficient as a thorough measure of income inequality. The use of this measure based on tax records was made possible due to the comprehensive, balanced dataset that has been made publicly available and this study is the first the uses this data to study health effects. Further, the outcome variable selected for the measure of mortality was the five-year mortality rate at age sixty-five. This offers a more concise measure of mortality for developed countries as it captures premature mortality and incorporates a measure of quality of life. The study tracks five-year mortality separately for men and women as the trajectory of reduction in mortality rates for men and women differ, as seen in the mortality graphs of these countries over time. This is the first study of its kind to explore the impact of income inequality separately on mortality rates of men and women.

2 Literature Review

The studies that support the conclusion that income inequality influences population health (that is, higher income inequality leads to higher mortality) include Wilkinson, 2006; Rodgers, 1979; Waldmann, 1992; Lynch, 1998; Judge et al, 1998; Ram, 2005 and Dorling, 2007. Wilkinson (1996) argues that developed countries with low income inequality show better health outcomes than societies with a greater wealth gap. Egalitarian societies tend to be more socially cohesive with stronger communities, which results in a higher quality of life and better overall health. Wilkinson (2008) conducted a natural experiment test using data from UK's Health and Lifestyle Survey showed that changes in mortality were significant and positively related to changes in the proportion of low relative earnings within each occupation. Rodgers (1979) showed that the differences in life expectancy between high and low income inequality countries can be as high as five to ten years. Waldmann (1992) compared two countries where the disadvantaged have similar real incomes and found that countries with higher income inequality have higher infant mortality rates, after controlling for education, medical personnel and fertility.

Lynch (1998) studied the association between income inequality and mortality in US using census data, and showed that high income inequality is associated with higher mortality for all capita income levels. The largest impact was in areas with both high income inequality and low average wages: the difference was 140 deaths per 100,000. Ram (2005) confirm the findings by Rodgers and Waldmann, which suggest a negative relationship between income inequality and health. The study also showed the association remained significant after controlling for ethnic heterogeneity. Dorling (2007) used observational study of 126 countries at different stages of development and found that income inequality is closely correlated with mortality, especially for younger adults and those living in less developed countries. Further, the findings show higher mortality for any specific level of income in countries with higher income inequality.

However, some of the later studies which moved away from cross-sectional data, did not find a significant association between income inequality and health. Wagstaff (2000) conducted a review of literature on the observed negative association between income inequality and population health and found that population level data are not sufficiently strong. Gravelle et al (2002) developed a model using a new cross-sectional dataset and found that the relationship between income inequality and population health was not significant. In addition, Gravelle found conceptual issues when using cross-sectional data to test the hypothesis of the effect of income inequality on the health of individuals. Gravelle (1998) pointed out that a statistical artefact as a result of using population data instead of individual data could account for the association between income inequality and health. Using US census data, Wolfson (1999) showed that observed associations at the population state level between income inequality and mortality at the state level cannot be completely explained as statistical artefacts (Deaton, 2013).

Subramanian (2006) analyzed lagged effects of state income inequality on individual self-rated health in the US and the findings did not indicate a strong statistical result for the differential effects of state income inequality across the various population groups. Using Gini coefficient and the share of income received by the lowest population quintile as measures of inequality, Beckfield (2004) could not find an association between inequality and health. More recently, Avendano (2012) analyzed OECD countries from 1960 to 2008 and found that a one-point increase in the Gini coefficient was associated with an increase of 7% in infant mortality rates. However, when controlled for country fixed-effects, income inequality was not associated with infant mortality rates.

Several studies have found the reversed effects of income inequality on longevity (that is, higher income inequality leads to lower mortality). Mellor (2001) reported the positive relationship between the inequality of income distribution and life-expectancy, once education was controlled for, in samples of up to 47 countries. Leigh (2007) investigated 12 developed countries from 1903 to 2003 and found that income inequality is negatively related to life expectancy. In more recent work, Herzer (2011, 2014) used panel co-integration techniques to analyze the impact of income inequality for developed and developing countries. The panel co-integration technique overcomes significant bias associated with cross–country panel studies due to omitted country-specific factors in panel data analysis as well as reverse causality. Herzer showed that income inequality increases life expectancy in developed countries but had a negative effect on longevity in developing countries. Though the magnitude was small, the difference between the two groups were found to be robust to specification, methodological choices and measurement choices. Herzer noted that this issue is more likely to be empirical-based, due to the theoretical ambiguity of the effects of income inequality.

3 Rationale

The purpose of this paper is to provide confirmatory evidence of a relationship between income inequality and population health. The study does this through the use of sound methodology focused solely on advanced, developed countries with similar high standards of living that minimizes the effects of other factors on health outcomes. It also uses robust measures for both income inequality and mortality that span over a long period of time to take into account structural changes in income and wealth distribution. The study differentiates itself from other similar studies that investigate the effect of income inequality on health by the following ways:

First, the study uses the inverted Pareto-Lorenz coefficient as a measure of income inequality and using the latest time-series data for the inequality measure for the OECD countries from Piketty's World's Top Income database. The data was collected by Piketty and others from detailed income tax records of each of these countries. This is the first study of its kind to use Piketty's data on income inequality to study longevity.

Second, the outcome variable selected for the measure of mortality was adult mortality. More specifically, I use the five-year mortality rate at age sixty-five. The use of an adult mortality index offers a more concise measure of mortality for developed countries. Previous studies that combine both developed and developing countries used infant mortality rates. However, in developed countries, infant mortality is extremely low and consistent across all the countries in the study sample; the choice of adult mortality in this paper can offer greater precision in addressing the issue at hand.

Third, the study tracks five-year mortality separately for men and women. This is because the trajectory of reduction in mortality rates for men and women differ, as seen in the mortality graphs of these countries over time. It should be noted that this is the first study of its kind to explore the impact of income inequality separately on mortality rates of men and women.

The econometric methodology selected for robustness analysis attempts to address some of the econometric challenges faced in addressing this question including omitted variable bias (Herzer, 2015).

Finally, the study uses the Granger tests in order to determine causality between income inequality and mortality. Given the aforementioned differences between this research and the available literature on the subject, this paper attempts to fill a gap in our understanding of this topic with new data, new measures and new methodological approaches.

4 Data

The data was extracted from various different sources to form a consolidated dataset. A complete balanced panel dataset was obtained from 1950 to 2008. The mortality rates data was obtained from the Human Mortality database with mortality data sourced directly from each country[1]. The inverse Pareto-Lorenz coefficient data for income inequality was obtained from

[1] Human Mortality Database. University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany). Available at www.mortality.org or www.humanmortality.de.

the World Top Incomes Database[2] and GDP data was mined from the Penn World Table (version 8)[3] which provided data on purchasing power parity and national income accounts converted to international prices. Health capital index data was based on a measure for capturing and tracking the index of health capital per person based on years of schooling in each of the OECD countries[4]. In the database, the Pareto-Lorenz coefficient was calculated using the top shares estimates (from the top 0.1% share within the top 1% share). Inverted Pareto-Lorenz coefficient generally ranges from 1.5 to 3 with the range of 1.5 to 1.8 considered as low inequality (with the top one-percent of income shares ranging from 5% to 10%) and values of 2.5 and higher considered as high inequality (with the top one-percent of income shares around 15% to 20% or higher)

5 Study Variables

The independent variable selected for the model is the inverted Pareto-Lorenz coefficient; this coefficient is one of the standard measures of income inequality and the inverted form is used for ease of interpretation.

The indicator of health for this study selected was the five-year mortality probability at age sixty-five years for males and females. In some of the previous income inequality studies, infant mortality rates was selected at the choice variable for mortality. In this study, mortality rate at aged sixty-five was the preferred indicator for health for the following reasons: it is not dependent on the mortality rates from one's early phase in life; mortality rates at aged sixty-five take into account one's health at all stages in life which incorporates the benefits from access to medical care within the country. Second, adult mortality rates is commonly reported and available for all countries across extended time periods. In OECD countries, infant mortality rates are extremely low and mortality rates in the early stages of life are stable and consistent throughout the years. Further, the use of the adult mortality measure enables the analysis of

[2] http://topincomes.g-mond.parisschoolofeconomics.eu/#Home – Project started by Thomas Piketty on the long-run distribution of top incomes in France. Alvaredo, Facundo, Anthony B. Atkinson, Thomas Piketty and Emmanuel Saez, The World Top Incomes Database, http://topincomes.g-mond.parisschoolofeconomics.eu/, June 2014
[3] Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 7.1, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, Nov 2012.
[4] URL: http://www.barrolee.com/data/dataexp.htm

income inequality separately on men and women to see if these gender differences matter when analyzing the effect of income inequality on health in the population.

The base specification selected was a pooled OLS model. Covariates that were included in subsequent models were population of the country, per capital GDP measured in US$ at 2005 purchasing power parity (PPP) rates and the health capital index.

For robustness checks, a parsimonious equation using dynamic OLS methodology was selected in line with Herzer (2015). Dynamic OLS (DOLS) does offers some distinct advantages. Previous analysis of this question often encounter econometric challenges that weaken the findings. Dynamic OLS was proposed by Stock and Watson (1994) as a solution to find a simple, efficient estimator where the dependent variable was regressed on the independent variable and its leads and lags. For an OLS regression equation to be meaningful, all variables need to integrated of the same order. In the case of most economic variables, their tendency to trend through time means that all the variables in the model need to be non-stationary integrated processes, i.e. variables that exhibit a stochastic (not deterministic) trend. In order to test for this, unit root testing was conducted. If the variables are nonstationary, then a linear combination of both variables can be stationary. When this is true the linear relationship describes cointegration, evidence of the existence of a long-run relationship between mortality rates and income inequality and implies that the regression coefficient of income inequality on mortality rates is not spurious. As noted by Herzer (2014), “a regression consisting of co-integrated variables has the property of super-consistency such that the coefficient estimates converge to the true parameter values at a faster rate than they do in standard regressions with stationary variables. The estimated co-integration coefficients are super-consistent even in the presence of temporal and/or contemporaneous correlation between the stationary error term and the regressor(s) (Stock, 1987), implying that co-integration estimates are not biased by omitted stationary variables…the fact that a regression consisting of co-integrated variables has a stationary error term also implies that no relevant non-stationary variables are omitted. Any omitted non-stationary variable that is part of the co-integrating relationship would become part of the error term, thereby producing non-stationary residuals, and thus leading to a failure to detect co-integration.”

A fixed-effects OLS was also selected as a form of conventional panel regression for robustness. The fixed-effects OLS model enabled control for unobserved heterogeneity in the model over time. The choice of control variables were based on literature and past studies in this area rather than theory due to the lack of a comprehensive economic framework that covers the relationship between income inequality and health.

6 Methodology

The base specification selected was a pooled OLS model. The specification for the pooled OLS took the following form where the description of *Health* and *Inequality* are the same as Equation (1) and GDP is the gross domestic product, *Population* is the population of the country and *HC* is the health index of country *i* and time *t*.

$$Health_{it} = \alpha_i + \beta\, Inequality_{it} + \gamma\, GDP_{it} + \delta\, Population_{it} + \zeta\, HC_{it} \quad (1)$$

In addition, two other specifications were selected for robustness analysis - a fixed-effects model and dynamic OLS using panel co-integration were conducted as part of the analysis. In the fixed-effects OLS model, the regression model took the following form:

$$Health_{it} = \alpha_i + \beta\, Inequality_{it} + \mu_{i1}\, 1950 + \mu_{i2}\, 1951 + \ldots + \mu_{iT}\, 2008 + \epsilon_{iT} \quad (2)$$

Where μ_{it} are dummy variables for each year t=1,2,…,T (T=59 as the panel dataset has data for 59 years) and country i=1,2,…,10 representing the ten countries and ϵ is the error term.

Though the coefficient estimates of an OLS equation are super consistent, the standard errors may be biased by correlations arising from income inequality over time. As such, in order to address this, the dynamic OLS includes leads and lags of income inequality. The specification of the dynamic OLS took the following form where $\Delta Inequality_{it-j}$ is the difference between the inverted Pareto-Lorenz coefficient at time (it-j) and (it-j-1); k is the number of leads and lags; α_i is the country fixed-effects and $\mu_i t$ represent the county-specific time trends.:

$$Health_{it} = \alpha_i + \mu_i t + \beta\, Inequality_{it} + \sum_{j=-k}^{k} \Theta_{it}\, \Delta Inequality_{it-j} + \epsilon_{it} \quad (3)$$

7 Results

A graphical plot of income inequality and mortality rates for all countries shows the downward trend of mortality probability over the time period. This coincides with the upward trend of the income inequality measure that started occurring from the 1980s. Figure 1 show income inequality over the years for these countries with steep rises seen in the US, Britain, Norway and Canada. Income inequality remained relatively stable over time for Japan and Denmark. Smaller rises were seen in New Zealand and Switzerland. Most of the sharp rise in income inequality started occurring in the mid-1980s.

Mortality probability rates for each of the ten countries show a gradual decline from 1950 to 2008. Tables 1 provides summary statistics of all the variables. The mean male mortality rate was 0.140 (sd = 0.036) and the mean female mortality rates was 0.080 (sd = 0.024). Switzerland has the highest level of income inequality with a mean Pareto-Lorenz coefficient of 2.127 (sd=0.142) followed by the United States at 2.050 (sd=0.412), Canada at 1.868 (sd=0.277) and Great Britain at1.818 (sd=0.267).

Table 2 shows the pooled OLS results. It indicates that income inequality has a statistically significant negative effect on overall mortality rates. For every one unit increase in income inequality, all-mortality probability rates decrease by 0.038 percentage points ($p \leq 0.001$). The effect is less but still significant when all covariates are included (-0.023, $p \leq 0.001$). Similarly, for every for every one unit increase in income inequality, female mortality probability rates decreased by 0.024 percentage points ($p \leq 0.001$) and male mortality probability rates decreased by 0.052 percentage points ($p \leq 0.001$). These findings support the long-run negative relationship between income inequality and mortality.

The fixed-effects model (Table 3) controls for time-invariant and subject-specific characteristics of the model. The results show a gender difference on the effect of income inequality on mortality - income inequality had a positive effect on female mortality rates (0,0061, $p \leq 0.01$) and it had a negative effect on male mortality rates (-0.0075, $p \leq 0.05$).

In order to determine the long-run effect of income inequality on mortality, countries with panel co-integrated series need to be established. This involves first establishing that mortality rates and income inequality are non-stationary. For countries which exhibit non-stationary values, the panel co-integration test is then conducted. Dynamic OLS was conducted for countries where income inequality and mortality were co-integrated. The pre-test for unit roots for each of the country was conducted using the augmented Dickey-Fuller tests. For female mortality rates, all countries show non-stationary trends except for Norway. For male mortality rates, all countries show non-stationary trends. In order to test for co-integration, OLS regression was run separately for each country and the augmented Dickey-Fuller test was run on the residuals for each country. The tests show that the co-integration was only found in the following countries – for female mortality, co-integration occurred in Japan and New Zealand while for male mortality rates, co-integration occurred in Australia, Japan, New Zealand, Britain, US and Norway.

The results from the dynamic OLS are shown in Tables 4 (female mortality rate) and Table 5 (male mortality rate). The results show that there exists a statistically significant long-run negative effect of income inequality on mortality that is, higher income inequality is associated with reduced mortality for countries with co-integrated series. For every unit increase in income inequality, male mortality probability reduced by 0.067 percentage points ($p \leq 0.001$) and female mortality probability reduced by 0.0324 percentage points ($p \leq 0.001$). The dynamic OLS model uses a parsimonious framework to obtain the above results. Several other analyses were conducted with controls that included population, health capital index and GDP. The addition of covariates did not change the significant negative relationship between income inequality and male and female mortality.

8 Discussion

The key findings from this study show that there exists a long-run negative relationship between income inequality and mortality rates for OECD countries. Rising income inequality does not appear to negatively impact life-expectancy over the six decades.

There have been sharp variations in income inequality over the study period. The graphs show a distinct change in trajectory in income inequality across most countries starting around 1987 with income inequality rapidly increasing in this time period (Figure 1). In order to determine if income inequality had a different effect on mortality pre and post 1987, fixed-effects OLS was run on the panel dataset from 1950-1986 and from 1987-2008. This was run separately for males and females (Table 6). The results show that prior to 1987, income inequality had a negative effect on male mortality (-0.03, $p \leq 0.001$) and female mortality rates (-0.006, $p \leq 0.001$). Post 1987, income inequality had a positive effect on male mortality (0.002, $p \leq 0.5$) and female mortality (0.02, $p \leq 0.001$). The results seem to indicate that when income inequality was rising slowly or stable in developed countries, the effect of income inequality on mortality (and health) is negative. However, as income inequality increases rapidly, the effect is positive meaning that high income inequality has a detrimental effect on mortality.

One major limitation of this study is that it lacks a comprehensive theoretical framework. As Deaton (2003) noted, 'the literature does not specify the precise mechanisms through which income inequality is supposed to affect health. In consequence, there is little guidance on exactly what evidence we should be examining, or whether the propositions are refutable at all'. Future research that focus on deriving a unifying theory on income inequality and health is needed in this area in order to conduct sound empirical research on this topic. Additionally, though the findings from this study showed that a long-run positive relationship existed between income inequality and longevity for countries with co-integrated series, the causal relationship from income inequality to mortality was not present. Granger causality tests were conducted for all countries and the findings show that it was not possible to state that higher income inequality 'granger-causes' lower mortality rates for any of these countries.

In conclusion, the study shows that for developed countries, rising income inequality does not appear to have a detrimental effect on male and female mortality rates.

9 Appendix: Tables and Figures

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
year	600	1980	17.3	1950	2008
Mortality-Female	600	0.081	0.025	0.029	0.165
Mortality-male	600	0.140	0.037	0.065	0.231
Mortality-All	600	0.110	0.030	0.050	0.198
Income Inequality	600	1.804	0.313	1.325	3.326
Population	600	46.84	71.74	1.90	310.38
Health Index	600	2.88	0.35	2.07	3.62
GDP	600	20981	9364	1942	53100

Table 2: Results - Pooled OLS

Dependant	Model (1)	Model (2)
All Mortality Rates	Coefficient	Coefficient
Income Inequality	-0.03868***	-0.0237***
Population		0.0002***
Health Capital		-0.0438***
GDP		-4.48E-09***
_constant	0.1808***	0.274***
R-Squared	0.16	0.47

Female Mortality Rates	Coefficient	Coefficient
Income Inequality	-0.02452***	-0.0111***
Population		0.0001***
Health Capital		-0.0424***
GDP		-2.25E-09**
_constant	0.1254***	0.219***
R-Squared	0.10	0.46

Male Mortality Rates	Coefficient	Coefficient
Income Inequality	-0.0528***	-0.0363***
Population		0.003***
Health Capital		-0.0452***
GDP		-6.41E-09***
_constant	0.2362***	0.329***
R-Squared	0.20	0.45

*** p<0.001 ; ** p<0.01 ; * p<0.05

Table 3: Fixed Effects Ordinary Least Squares

Female Mortality	Coef.	P>|t|	**Male Mortality**	Coef.	P>|t|	**All Mortality**	Coef.	P>|t|
Income Inequality	0.006129	0.006		-0.00748	0.033		-0.00067	0.805

Table 4: Dynamic OLS (Female Mortality)

	Dependant	Model (1)		Model (2)		Model (3)		Model (4)	
	Female Mortality Rates	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Income Inequaltiy		-0.0325**	0.01	-0.036***	0.01	-0.0244***	0.00	-0.026***	0.00
Population				-0.0004	0.00	-0.0004 -	0.00	0.0004	0.00
Health Capital						-0.033*	0.01	-0.019	0.01
GDP								-0.0000278	0.00
R-Squared		0.1416		0.5168		0.6321		0.7312	

*** p<0.001 ; ** p<0.01 ; * p<0.05

Table 5: Dynamic OLS (Male Mortality)

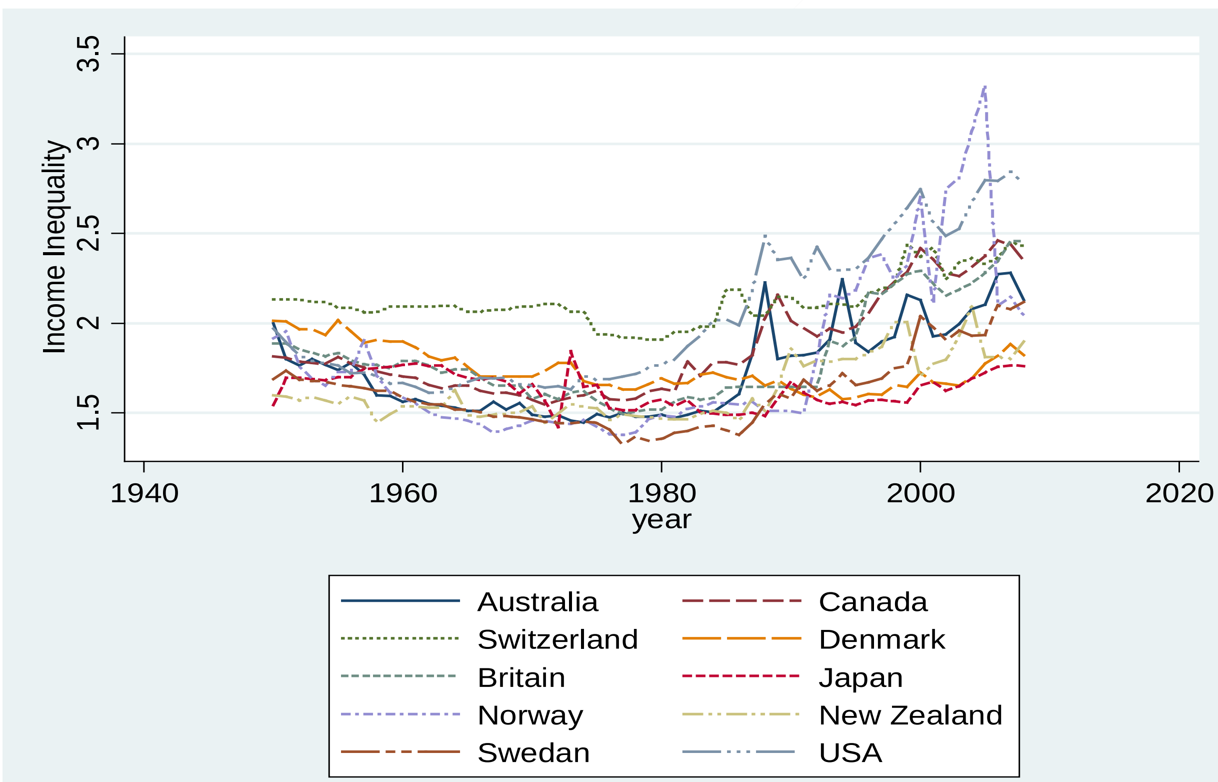
	Dependant	Model (1)		Model (2)		Model (3)		Model (4)	
	Male Mortality Rates	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Income Inequaltiy		-0.067***	0.02	-0.073***	0.01	-0.0638***	0.01	-0.0659***	0.01
Population				-0.0006	0.00	-0.0006 -	0.00	0.0004	0.00
Health Capital						-0.0304	0.02	-0.014	0.02
GDP								-0.0000278	0.00
R-Squared		0.2401		0.5403		0.6389		0.6994	

*** p<0.001 ; ** p<0.01 ; * p<0.05

Table 6: Fixed-effects OLS (Pre and Post 1987)

1950-1986	Income inequality	S.E	t	P>|t|	95% Confidence Interval	
All mortaltiy	-0.0195	0.0027	-7.1400	0.0000	-0.0249	-0.0142
Male	-0.0327	0.0036	-9.1600	0.0000	-0.0397	-0.0257
Female	-0.0064	0.0021	-3.0200	0.0030	-0.0106	-0.0022
1987-2008						
All mortaltiy	0.0141	0.0035	4.0800	0.0000	0.0073	0.0209
Male	0.0019	0.0039	0.5000	0.6160	-0.0057	0.0096
Female	0.0262	0.0034	7.6900	0.0000	0.0195	0.0329

Figure 1: Income Inequality (1950-2008)



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Supplemental Table and Graphs (Effect of Income Inequality on Mortality)

Table A: Mean of mortality probability rates (male)

cc	Summary of qxmale Mean	Std. Dev.	Freq.
AUS	.14767283	.04587005	60
CAN	.136357	.0304812	60
CHE	.13330833	.03560017	60
DNK	.14188217	.01847078	60
GBR	.16248317	.04011897	60
JPN	.13551267	.04916838	60
NOR	.12579233	.02157389	60
NZL	.14599831	.03714727	59
SWE	.12121517	.02325462	60
USA	.1516641	.03393454	61
Total	.14019805	.03660008	600

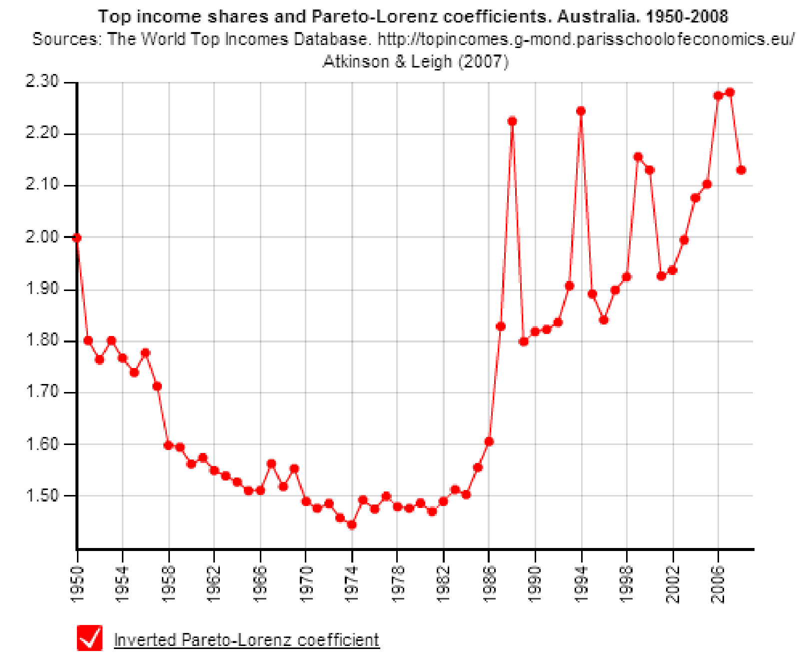
Table B: Mean of mortality probability rates (female)

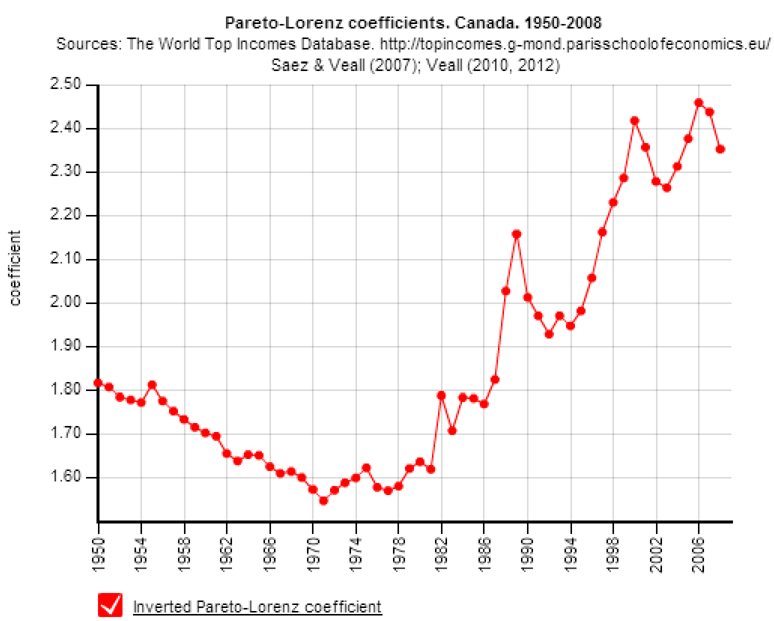
cc	Summary of qxfemale Mean	Std. Dev.	Freq.
AUS	.080426	.0258968	60
CAN	.0783215	.02059373	60
CHE	.07265417	.02805205	60
DNK	.09003683	.01423544	60
GBR	.09121017	.01991239	60
JPN	.0785335	.04092807	60
NOR	.07108933	.01573479	60
NZL	.08490085	.02173417	59
SWE	.07344017	.02145947	60
USA	.08735934	.01730222	61
Total	.08080128	.02455442	600

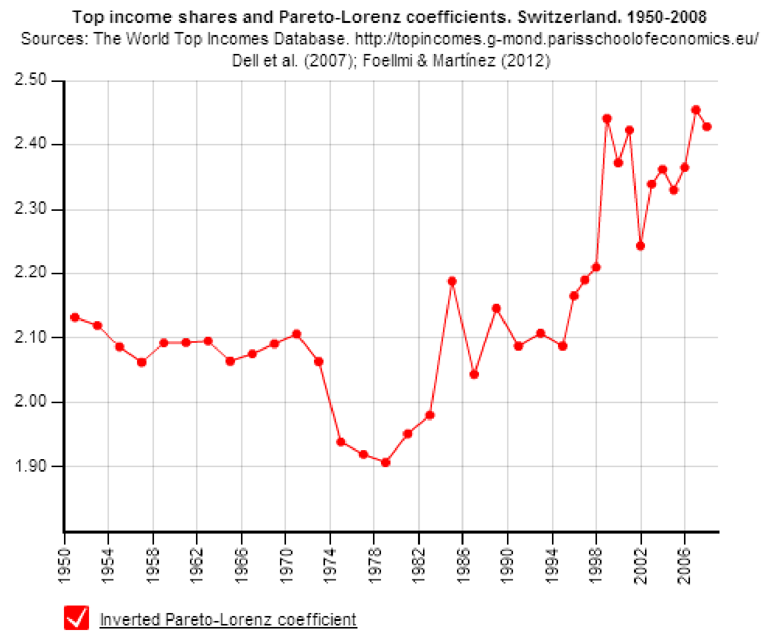
Table C: Income Inequality (inverse Pareto-Lorenz coefficient) by country

cc	Summary of invertedplc Mean	Std. Dev.	Freq.
AUS	1.7416333	.25250007	60
CAN	1.8687328	.27798545	60
CHE	2.127357	.14163802	60
DNK	1.7427283	.12102154	60
GBR	1.8291403	.28573488	60
JPN	1.6341232	.09740811	60
NOR	1.7907053	.45333278	60
NZL	1.6268395	.16889938	59
SWE	1.6197243	.20830376	60
USA	2.0524738	.41221961	61
Total	1.8040552	.31304329	600

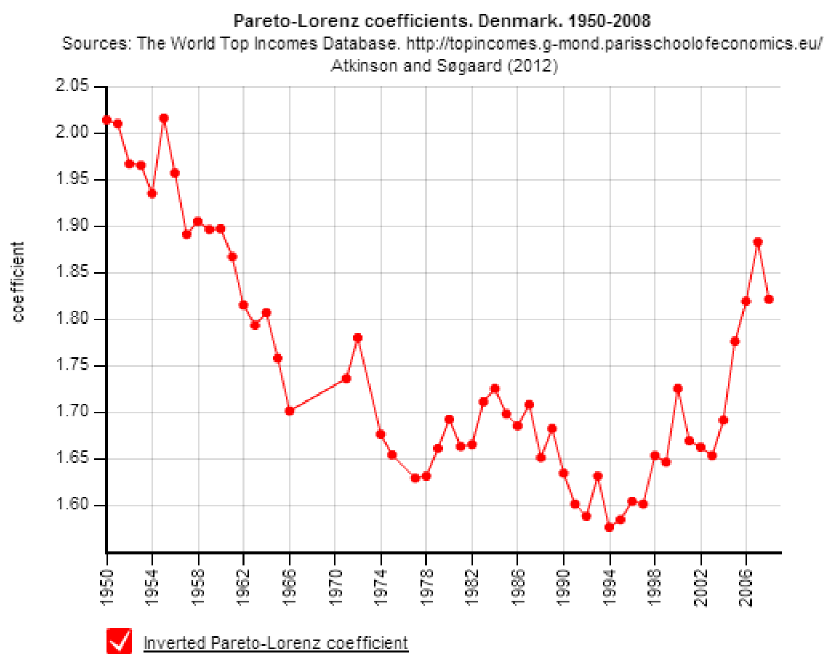
Figure 1: Income Inequality over time by country



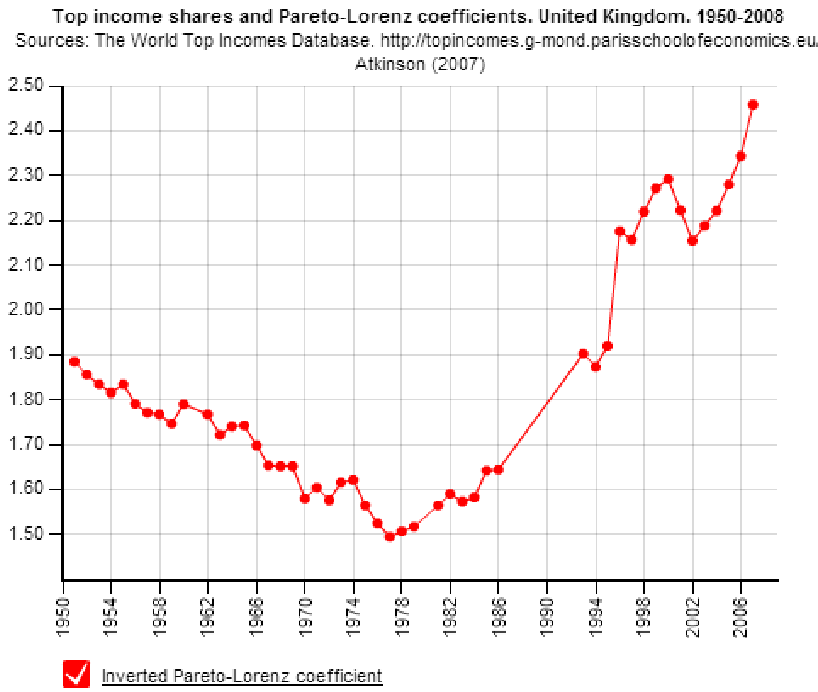


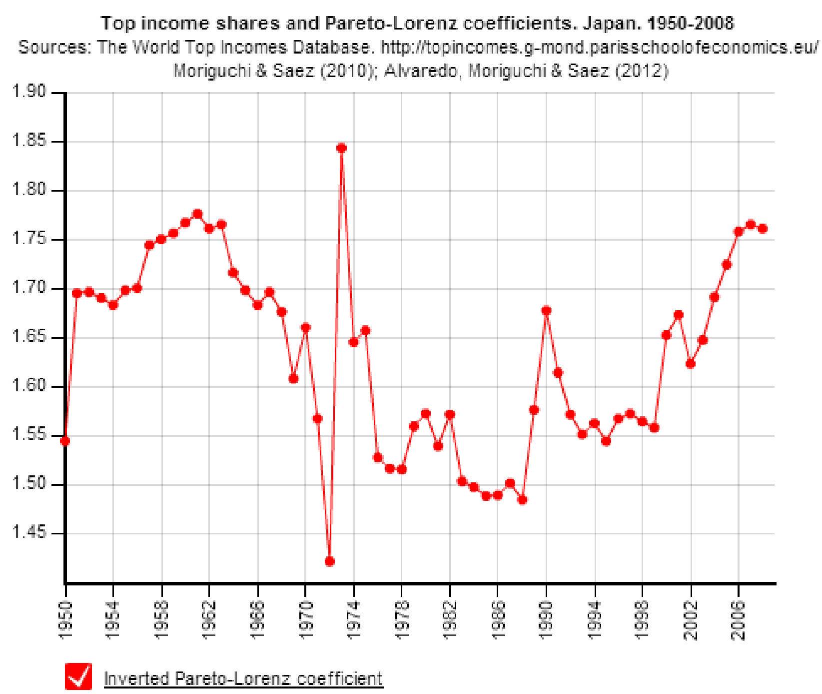


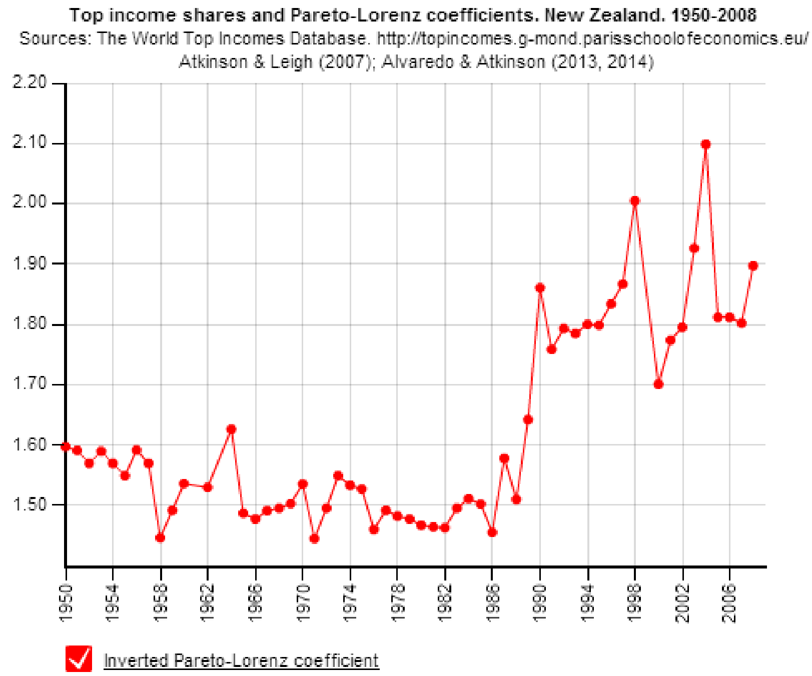
Top income shares and Pareto-Lorenz coefficients. Switzerland. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Dell et al. (2007); Foellmi & Martínez (2012)
2.50
2.40
2.30
2.20
2.10
2.00
1.90
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Inverted Pareto-Lorenz coefficient

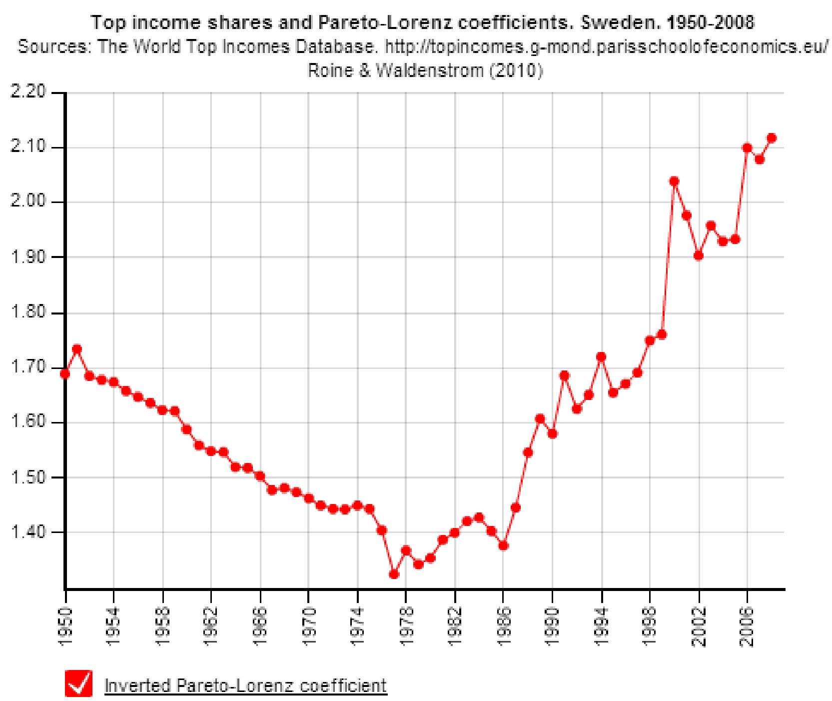


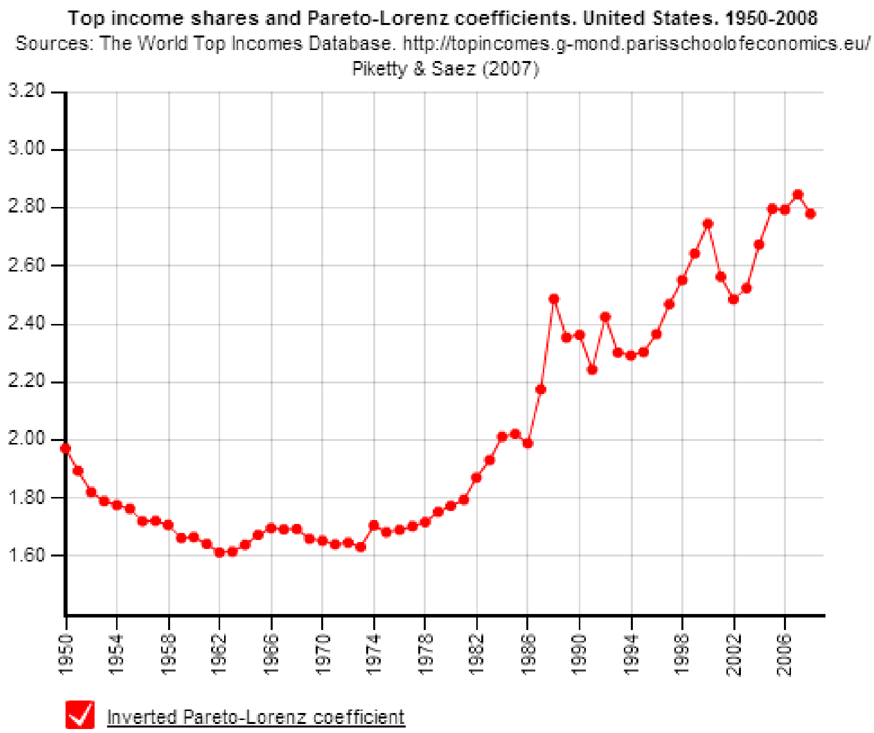
Pareto-Lorenz coefficients. Denmark. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Atkinson and Søgaard (2012)
coefficient
2.05
2.00
1.95
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Inverted Pareto-Lorenz coefficient


Top income shares and Pareto-Lorenz coefficients. United Kingdom. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Atkinson (2007)
2.50
2.40
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Inverted Pareto-Lorenz coefficient


Top income shares and Pareto-Lorenz coefficients. Japan. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Moriguchi & Saez (2010); Alvaredo, Moriguchi & Saez (2012)
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Inverted Pareto-Lorenz coefficient


Top income shares and Pareto-Lorenz coefficients. New Zealand. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Atkinson & Leigh (2007); Alvaredo & Atkinson (2013, 2014)
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Inverted Pareto-Lorenz coefficient


Top income shares and Pareto-Lorenz coefficients. Sweden. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Roine & Waldenstrom (2010)
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Inverted Pareto-Lorenz coefficient



Top income shares and Pareto-Lorenz coefficients. United States. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Piketty & Saez (2007)
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Inverted Pareto-Lorenz coefficient

Appendix A

Background Information: Panel Cointegration (Robustness)

For robustness check, a panel cointegration model was used with two variable of interest – income inequality measure and mortality probability rates in line with key established literature in this area (Herzer, 2014, Deaton, 2003 and Pedroni, 2004). Based on the theoretical framework the base model is structured as shown in Equation (1).

$$Mortality_{it} = \alpha_i + \mu_i t + \beta\, Inequality_{it} + \epsilon_{it} \qquad (1)$$

Where i represents the cross-sectional unit and ranges from i=1,2,3...N and t represents time and ranges from t=1,2,…,T. *Mortality* refers to the measure of longevity or health (mortality rate) and *Inequality* is the income inequality measure. β is the permanent change in the mortality rate associated with a one unit increase in the income inequality measure. County-specific fixed effects are captured by α_i and country-specific time trends are captured by $\mu_i t$. As noted by Herzer (2014), country fixed effects could be geography, culture, norms and institutions specific to the country and time trends could be the rate of health technological progress in the country.

To determine if a long-run relationship exists between income inequality and mortality rates, a dynamic OLS (DOLS) estimation was proposed for the analysis. This form of estimation of regression equation expands on (1) by including the current, lead and lag values of the first differences. The regression is as shown below:

$$Health_{it} = \alpha_i + \mu_i t + \beta\, Inequality_{it} + \sum_{j=-k}^{k} \Theta_{it}\, \Delta Inequality_{it-j} + \epsilon_{it}$$

(2)

Here $Health_{it}$ is the five-year mortality rate of adults aged 65 years for country *i* at year *t*; $Inequality_{it}$ is the income inequality measure which is the inverted Pareto-Lorenz coefficient for country *i* ; $\Delta Inequality_{it-j}$ is the difference between the inverted Pareto-Lorenz coefficient at time (it-j) and (it-j-1); k is the number of leads and lags; α_i is the country fixed-effects and μ_it represent the county-specific time trends.

Panel co-integration requires a balanced dataset over a substantial period of time for all the variables. As such, a parsimonious model was selected to ensure complete data availability on income inequality and mortality rates.

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