1 Introduction

Does an increase in income inequality at the top-end distribution 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 has been shown to 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.

The purpose of this paper is to provide confirmatory evidence of a relationship between income inequality at the top-end of the distribution and adult mortality rates. 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[1]. The data was obtained from the World's Top Income database which was derived using multiple sources – including survey and fiscal data, national accounts and wealth rankings. It used a methodology based on Distributional National Accounts

---

[1] The Pareto-Lorenz coefficient follows the distribution formula: $1 - \mathrm{F(y)} = (k/y)^{\alpha}$ where y is income, F(y) is the distribution function and α is the Pareto-Lorenz coefficient. The ratio of the average income of people earning more that y to y does not depend on the threshold value y. In the database used in this study, the Pareto-Lorenz coefficient was calculated using the top shares estimates (from the top 0.1% share within the top 1% share).

concept (Alvaredo, 2016) to describe how the different percentiles change over time. The top income shares itself was derived using Kuznets (1953) approach using both income tax and national accounts data and Pareto interpolation to figure out the share of total income that goes to the top percentile. It is generally accepted that that the upper tail of the income distribution is Paretian while the middle part is lognormal. Since the objective of this paper is to evaluate the effect of rising income inequality arising from the top shares, the use of inverted-Pareto-Lorenz coefficient measure is appropriate for the study.

Second, the outcome variable selected for the measure of mortality was 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 have 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 rates separately for men and women. This is because the trajectory of reduction in mortality rates for men and women differ over time and this study attempts to explore if this different trajectory leads to differing findings.

The econometric methodology included several different specifications including a panel cointegration specification to address some of the econometric challenges (Herzer, 2015). Focussing the study at the population level also enabled the inclusion of socio-economic controls.

Finally, the study investigated causality between income inequality and mortality by doing Granger tests. 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 in advanced economies by using new data sources, new measures for both income inequality for the top distribution and mortality rates and varied methodological approaches.

2 Literature Review

A scoping review of the extensive literature in this area show both positive and negative effects of income inequality on mortality. 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) confirmed 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 (2014, 2015) used panel co-integration techniques to analyze the impact of income inequality on mortality for developed and developing countries. The panel co-integration technique overcomes critical econometric challenges including significant bias associated with cross–country panel studies due to omitted country-specific factors, endogeneity and 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 differences between the two groups were found to be robust to specification, methodological choices and measurement choices. Herzer noted that this issue is likely to be empirical-based, due to the theoretical ambiguity of the effects of income inequality.

Some of the reasons for these varied results seen the literature review could be due to the following reasons: The use of cross-sectional data verses longitudinal data can result in different findings as the latter enables the observation of trends over time in both health outcomes and income inequality. Further, accurate income inequality data over long time periods of time for many countries is difficult to obtain and varied results could be attributed to the reliability of the source data and type of income inequality measures used in the studies. The outcome measure is also another possible factor (e.g. infant mortality rate, adult mortality rate, life-expectancy). The choice of countries too can result in varied results. Using advanced developed countries verses using both developed and developing countries can result in different findings. Finally, some of the studies that do use panel data have encountered various econometric challenges including omitted variable bias and endogeneity. Though the investigating of income inequality on health is challenging, this paper attempts to address these issues through the choice of the population health outcome measure, income inequality measure, source of data for income inequality, selection of countries under study and different specification and empirical methodology choices

3 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[2]. In some of the previous income inequality studies, an infant mortality rate was selected at the choice variable for mortality. In this study, mortality rate at aged sixty-five was the preferred indicator for health as the measure takes into account an individual's health and quality of life gained from earlier stages of life and it incorporates the benefits from access to medical care and social welfare within the country. The data for these rates is also available for all countries across extended time periods. In developed countries, infant mortality rates are extremely low and show little variability across countries. The use of the adult mortality rates as the outcome measure also enables the analysis of income inequality separately on men and

[2] 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.

women to see if differences in mortality rate reduction trajectory over time for each the countries under study can result in differences in findings.

The inverted Pareto-Lorenz coefficient data for income inequality was obtained from the World Top Incomes Database.[3] The Pareto-Lorenz coefficient was calculated using the top shares estimates (from the top 0.1% share within the top 1% share). The inverted form of the Pareto-Lorenz coefficient (used for easier interpretation) 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).

GDP data was mined from the Penn World Table (version 8)[4] which provided data on purchasing power parity and national income accounts converted to international prices.

Health capital index refers to the specific measure for capturing education attainment using census data, household surveys and extrapolation methods for missing data and it provides a proxy for the stock of human capital that can be used in empirical analysis (Barro, 2013). The measure used a perpetual inventory method that incorporated census and survey data on the educational attainment of the adult population as benchmark stocks and used new school entrants as flows that were added to the stocks with a time lag. The choice of the name of variable in the model was driven by the Grossman (1972) theory which implied that the effect to unequal access to education can result in wider disparity in health capital formation within the country. Those with higher education will choose a higher level of optimal health stock. The greater the disparity in education, the wider the disparity in optimal health stock in the population resulting in wider disparity in health.

4 Specification

The base specification selected for the analysis was a pooled OLS model. The specification for the pooled OLS took the following form where *Health* refers to the mortality rate and *Inequality* to the inverted Pareto-Lorenz measure of income inequality. GDP is the gross

[3] 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

[4] 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.

domestic product, *Population* refers to the population of the country and *HC* is the health capital 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 model using a panel co-integration method. 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 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 in the robustness analysis, a parsimonious equation using dynamic OLS methodology was selected in line with Herzer (2015). 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. 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."

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.

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

To run this regression, several conditions need to be met. Unit root testing was first conducted using the Dickey-Fuller tests to test that income inequality and mortality rate variables were non-stationary integrated processes i.e the variables exhihit a stochastic (not deterministic) trend. If both variables exhibit trends, then the linear combination of both variable will be stationary. Co-integration analysis was then conducted to identify countries which have cointegrated series before the dynamic OLS model was run for cointegrated countries.

5 Results

A graphical plot of income inequality and mortality rates for all countries shows the downward trend of mortality probability over the time period (Figure 1) and the mortality rates trend for males and females (Figure 2). Mortality rates for each of the ten countries show a gradual decline over the study period. Table 1 provide summary statistics of all the variables and Table 2 shows summary statistics by country. The mean male mortality rate was 0.140 (sd = 0.036) and the mean female mortality rates was lower at 0.080 (sd = 0.024). The lowest male mortality rates over this time period were found in Sweden, Norway and Switzerland. The highest male mortality rates were found in Australia, United States and Great Britain. For females, the lowest rates were found in Norway, Switzerland and Sweden and the highest rates were found in United States, Denmark and Great Britain.

This downward trend in mortality rates coincides with the upward trend of the income inequality. Figure 3 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. Countries with the lowest income inequality over the entire six decades were Sweden, New Zealand and Japan and those with the highest income inequality were Canada, United States and Switzerland. Most of the sharp rise in income inequality started occurring in the mid-1980s.

Table 3 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 a larger amount of 0.052 percentage points ($p \leq 0.001$). These findings seem to support the long-run negative relationship between income inequality and mortality rates.

The fixed-effects model (Table 4) controls for time-invariant and subject-specific characteristics of the model. The results showed 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 5 (female mortality rate) and Table 6 (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 base 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 these covariates in the DOLS did not change the significant negative relationship between income inequality and male and female mortality rates.

6 Discussion and Conclusion

The key findings from this study show that there exists a long-run negative relationship between income inequality and mortality rates for OECD countries. Results from both the base specification and the dynamic OLS model show that income inequality appear to lower mortality rates with larger decreases in mortality rates for males compared to females. However, these findings need be situated in context of the social welfare policies already in place in these advanced economies and not be construed as rising income inequality being good for the health of the population. These social welfare policies enabled the provision of a base level of protection for all income levels of the population including access to some form of minimum income and health services. However, similar studies conducted in countries without such social welfare policies (e.g. developing countries) can yield the opposite result (Herzer, 2015). Similarly, when social support weakens in these advanced countries, rising income inequality arising from top incomes can have a different effect on the health of the population.

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. 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 7). 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. This is a novel finding of the paper that there is the difference in effect of slow-rising verses fast-rising income inequality on mortality rates. Possible mechanisms whereby rising income inequality can be detrimental to health can occur through potentially decreasing social cohesion and trust (d'Hombres, 2010). Rapid rise in income inequality can also lead to an increasing heterogeneous population with varying preferences for public investments and less value being placed on public goods including public health investments. Other potential routes include crime (Fanjzylber (2002) as increases in income inequality can result in spatial concentrations of race and poverty. In the longer-run, it can lower the extent of intergenerational earnings mobility (Corak, 2013) which in turn effects population health. The rapid rise in income inequality in the latter half of the study could exacerbate any of these effects.

Though findings from the robustness analysis showed that there exists a long-run positive relationship existed between income inequality and longevity for countries with co-integrated series. Granger causality tests were conducted for all countries and the findings show that it was not possible to state that income inequality ‘granger-causes’ lower mortality rates for any of these countries.

One major limitation of this study is that it this empirical study was conducted in the absence of a comprehensive economic theoretical framework linking income inequality and health. 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’. The emphasizes the eventual need for the development of such a theory model in the future so that future empirical testing can occur in the context of a sound theory.

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

7 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: Summary Statistics by Country

Country	Male Mortality Rate	Std.Dev	Female Mortality Rate	Std.Dev	Inverted Pareto Coefficient	Std. Dev
Australia	0.148	0.046	0.08	0.026	1.742	0.252
Canada	0.136	0.031	0.078	0.021	1.868	0.277
Switzerland	0.133	0.036	0.073	0.028	2.127	0.141
Denmark	0.142	0.018	0.09	0.014	1.742	0.121
Great Britain	0.162	0.041	0.091	0.019	1.829	0.285
Japan	0.135	0.049	0.078	0.041	1.634	0.097
Norway	0.126	0.021	0.071	0.016	1.791	0.453
New Zealand	0.146	0.037	0.085	0.022	1.627	0.168
Sweden	0.121	0.023	0.073	0.021	1.619	0.208
United States	0.151	0.034	0.087	0.017	2.052	0.412

Table 3: 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 4: 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 5: 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 6: 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 7: 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: Mortality Rates over time (1950-2008)

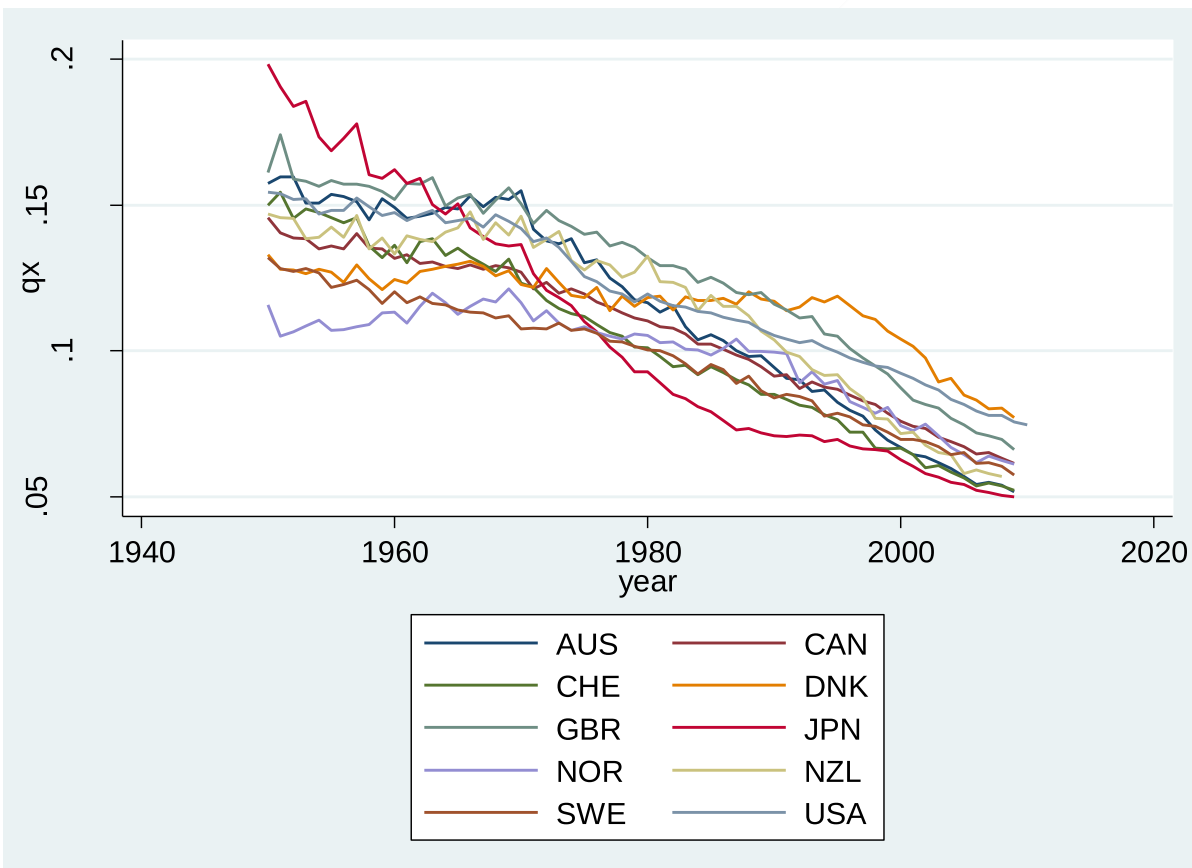
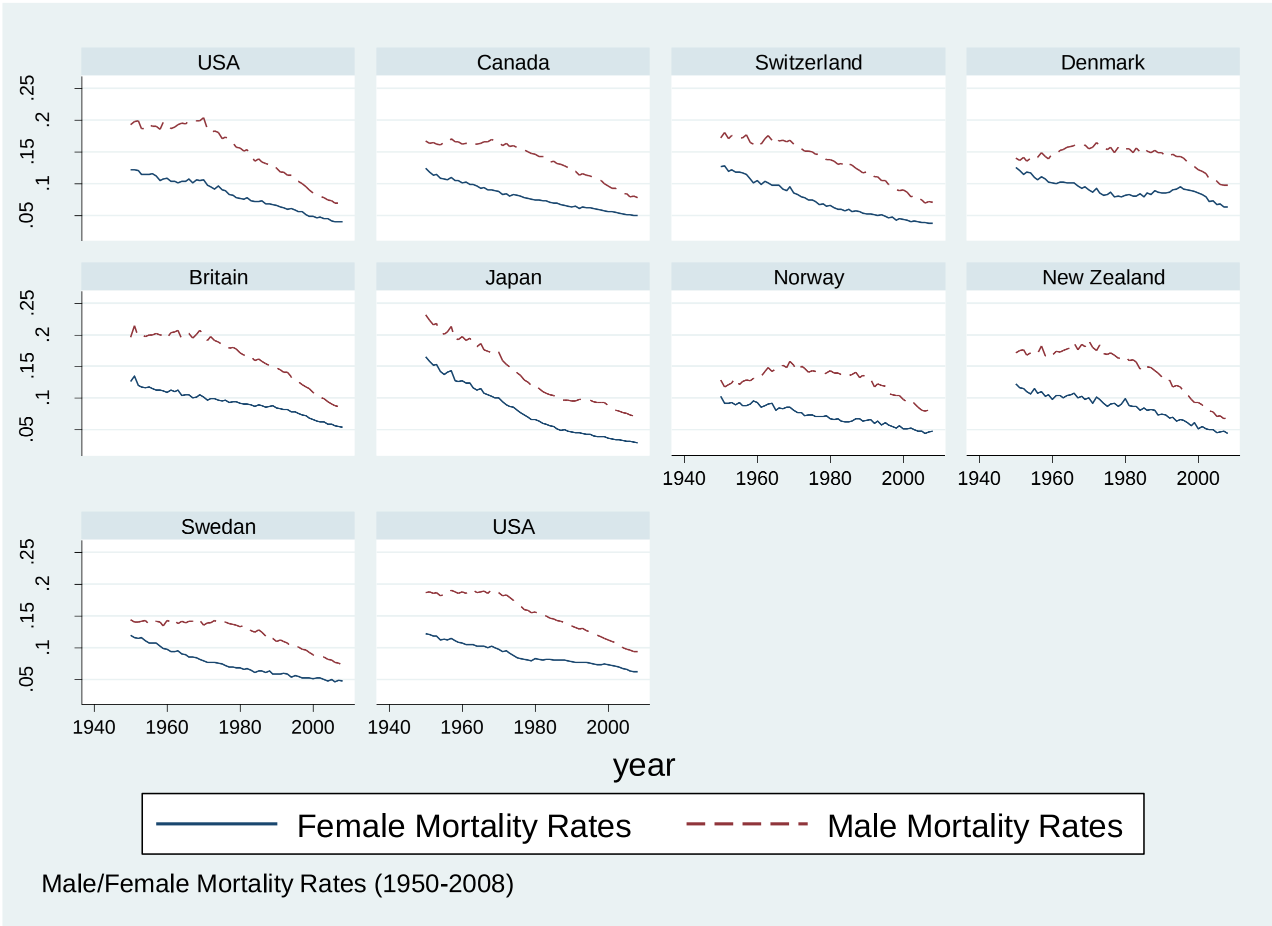
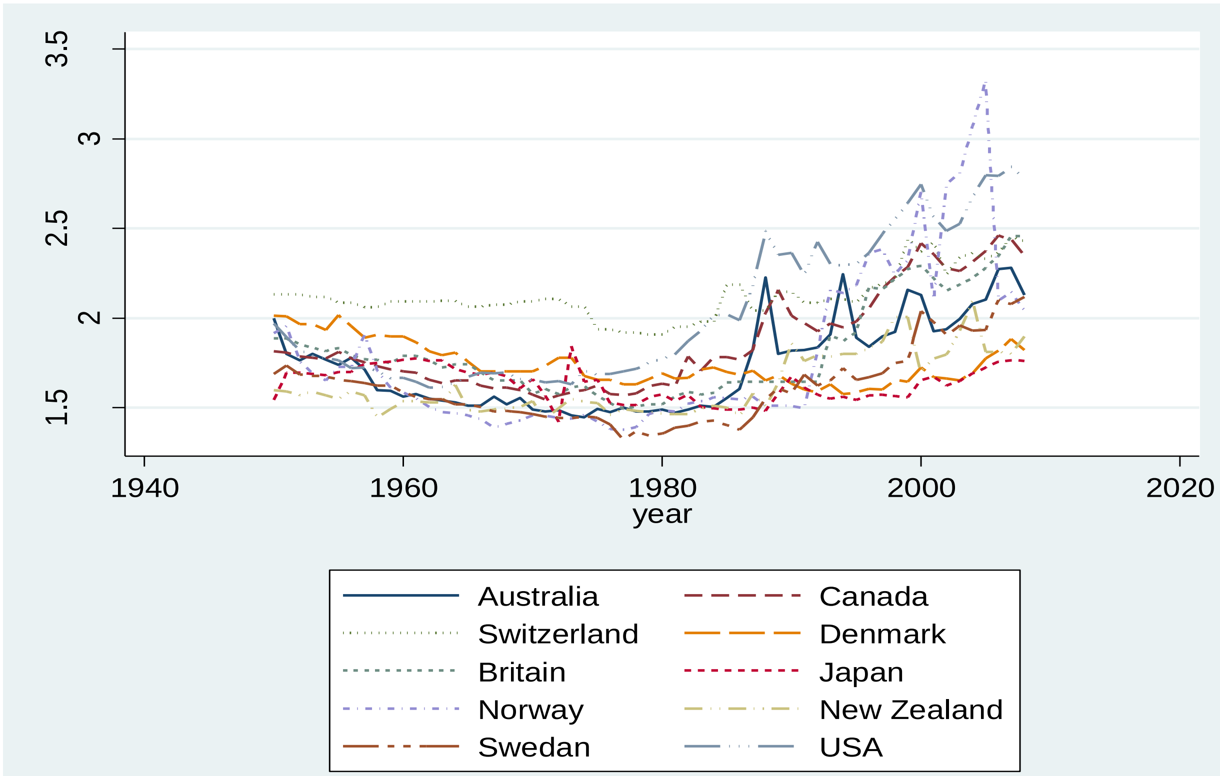


Figure 2: Male and Female mortality rates over time



Index: 1=Australia, 2= Canada, 3=Switzerland, 4=Denmark, 6=Britain, 7=Japan, 9=Norway, 10=New Zealand, 11=Sweden, 12=USA

Figure 3: Income Inequality over time (1950-2008)



References

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. http://knoema.de/PWT2012/penn-world-table-7-1

Alvaredo, Facundo, Anthony B. Atkinson, Thomas Piketty and Emmanuel Saez, The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/ .

Alvaredo, F., Atkinson, A. B., Chancel, L., Piketty, T., Saez, E., Zucman G., "Distributional National Accounts (DINA) Guidelines : Concepts and Methods used in WID.world", WID.world Working Paper, 2016/2

Atkinson, A. B., Piketty, T., & Saez, E. (2011). Top incomes in the long run of history. *Journal of Economic Literature*, 49(1), 3-71. https://eml.berkeley.edu/~saez/atkinson-piketty-saezJEL10.pdf

Avendano, M. (2012). Correlation or causation? Income inequality and infant mortality in fixed effects models in the period 1960-2008 in 34 OECD countries. *Social Science and Medicine*, *75*(4), 754-760. http://www.sciencedirect.com/science/article/pii/S0277953612003711

Barro, R. J., & Lee, J. W. (2013). A new data set of educational attainment in the world, 1950–2010. Journal of development economics, 104, 184-198.

Beckfield, J. (2004). Does income inequality harm health? New cross-national evidence. *Journal of Health and Social Behavior*, *45*(3), 231-248. http://journals.sagepub.com/doi/abs/10.1177/002214650404500301

Corak, M. (2013). Income inequality, equality of opportunity, and intergenerational mobility. The Journal of Economic Perspectives, 27(3), 79-102.

Deaton, A. (2003). Health, inequality, and economic development. *Journal of Economic Literature*, *41*(1), 113-158. https://www.aeaweb.org/articles?id=10.1257/002205103321544710

d'Hombres, B., Rocco, L., Suhrcke, M., & McKee, M. (2010). Does social capital determine health? Evidence from eight transition countries. Health economics, 19(1), 56-74.

Dorling, D., Mitchell, R., Pearce, J., & Tumwine. (2007). The global impact of income inequality on health by age: An observational study. *BMJ: British Medical Journal*, *335*(7625), 873-875. http://www.bmj.com/content/335/7625/873

Gravelle, H. (1998). How much of the relation between population mortality and unequal distribution of income is a statistical artefact? *BMJ: British Medical Journal, 316*(7128), 382-385. http://www.bmj.com/content/316/7128/382

Gravelle, H., Wildman, J., & Sutton, M. (2002). Income, income inequality and health: What can we learn from aggregate data? *Social Science & Medicine, 54*(4), 577-589. http://www.sciencedirect.com/science/article/pii/S0277953601000533

Grossman, M. (1972). On the concept of health capital and the demand for health. Journal of Political economy, 80(2), 223-255

Herzer, D. and Nunnenkamp, P. (2014). Income inequality and health: Evidence from developed and developing nations, Working Paper No.141, Helmut Schmidt Universitat Hamburg.

Herzer, D. and Nunnenkamp, P. (2015). Income Inequality and Health: Evidence from Developed and Developing Countries. *Economics: The Open-Access, Open-Assessment E-Journal*, 9 (2015-4): 1—57. http://dx.doi.org/10.5018/economics-ejournal.ja.2015-4

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 (data downloaded on [date]).

Judge, K., & Wilkinson, R. G. (1995). Income distribution and life expectancy: A critical appraisal. *BMJ: British Medical Journal, 311*(7015), 1282-1287. http://www.bmj.com/content/311/7015/1282

Kawachi, B P Kennedy, K Lochner, and D Prothrow-Stith. Social capital, income inequality, and mortality. *American Journal of Public Health*, September 1997: Vol. 87, No. 9, pp. 1491-1498.doi: 10.2105/AJPH.87.9.1491 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1380975/

Kawachi, I., & Kennedy, B. P. (1997). The relationship of income inequality to mortality: Does the choice of indicator matter? Social Science and Medicine, 45(7), 1121-1127. http://www.sciencedirect.com/science/article/pii/S0277953697000440

Kennedy, B. P., Kawachi, I., & Prothrow-Stith, D. (1996). Income distribution and mortality: Cross sectional ecological study of the Robin Hood index in the United States. *BMJ: British Medical Journal*, 312(7037), 1004-1007. http://www.bmj.com/content/312/7037/1004

Kennedy, B. P., Kawachi, I., Prothrow-Stith, D., Lochner, K., & Gupta, V. (1998). Social capital, income inequality, and firearm violent crime. Social science & medicine, 47(1), 7-17. http://www.sciencedirect.com/science/article/pii/S0277953698000975

Kuznets, S. (1955). Economic growth and income inequality. *The American Economic Review*, 1-28. http://blog.bearing-consulting.com/wp-content/uploads/2012/09/Economic.Growth.and_.Income.Inequality.pdf

Kuznets, S. S., 1901. (1953). *Shares of upper income groups in income and savings: By Simon Kuznets assisted by Elizabeth Jenks*. New York: National Bureau of Economic Research.

Leigh, A., & Jencks, C. (2007). Inequality and mortality: Long-run evidence from a panel of countries. Journal of Health Economics, 26(1), 1-24. http://www.sciencedirect.com/science/article/pii/S0167629606000750

Lynch, J. W., Kaplan, G. A., Pamuk, E. R., Cohen, R. D., Heck, K. E., Balfour, J. L., et al. (1998). Income inequality and mortality in metropolitan areas of the United States. *American Journal of Public Health, 88*(7), 1074-1080. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1508263/

Lynch, J., Smith, G. D., Kaplan, G. A., & Wolfson, M. (2004). Is income inequality a determinant of population health?: Part 1. a systematic review. *The Milbank Quarterly, 82*(1), 5-99. https://www.ncbi.nlm.nih.gov/pubmed/15016244

Mellor, J. M., & Milyo, J. D. (2001). Income inequality and health. *Journal of Policy Analysis and Management, 20*(1), 151-155. http://onlinelibrary.wiley.com/doi/10.1002/1520-6688(200124)20:1%3C151::AID-PAM2008%3E3.0.CO;2-H/abstract

Miller, D. L., & Paxson, C. (2006). Relative income, race, and mortality. *Journal of Health Economics*, 25(5), 979-1003. http://old.econ.ucdavis.edu/faculty/dlmiller/research/papers/Miller_Paxson_JHE2006.pdf

Piketty, T., & Saez, E. (2003). Income inequality in the United States, 1913 - 1998. The *Quarterly Journal of Economics*, 118(1), 1-39. https://eml.berkeley.edu/~saez/pikettyqje.pdf

Piketty, T. and Saez, E. (2006). The evolution of top incomes: a historical and international perspective. *American Economic Review: Papers and Proceedings*, 96, 2 (May): 200-205. https://www.aeaweb.org/articles?id=10.1257/000282806777212116

Ram, R. (2005). Income inequality, poverty, and population health: Evidence from recent data for the United States. *Social Science and Medicine, 61*(12), 2568-2576. http://www.sciencedirect.com/science/article/pii/S0277953605002091

Rodgers, G. B. (1979). Income and inequality as determinants of mortality: An international cross-section analysis. *Population Studies, 33*(2), 343-351. http://www.tandfonline.com/doi/abs/10.1080/00324728.1979.10410449

Rodgers, G. B. (2002). Income and inequality as determinants of mortality: An international cross-section analysis. 1979. *International Journal of Epidemiology, 31*(3), 533-538.

Stock, J. H. (1987). Asymptotic properties of least squares estimators of cointegrating vectors. *Econometrica*, 55(5), 1035-1056. http://scholar.harvard.edu/files/stock/files/asymptotic_properties_of_least_squares_estimators_of_cointegrating_vectors.pdf

Wagstaff, A., & van Doorslaer, E. (2000). Income inequality and health: What does the literature tell us? *Annual Review of Public Health, 21*(1), 543-567. https://www.ncbi.nlm.nih.gov/pubmed/10884964

Waldmann, R. J. (1992). Income distribution and infant mortality. *The Quarterly Journal of Economics*, *107*(4), 1283-1302. http://darp.lse.ac.uk/PapersDB/Waldmann_(QJE_92).pdf

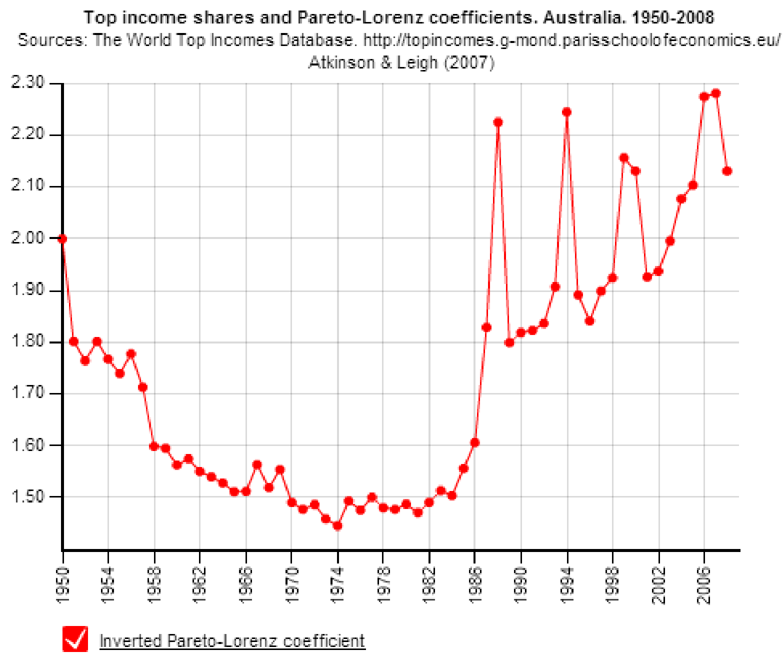
Wilkinson, R. G. (1996). *Unhealthy societies: The afflictions of inequality*. New York: Routledge.

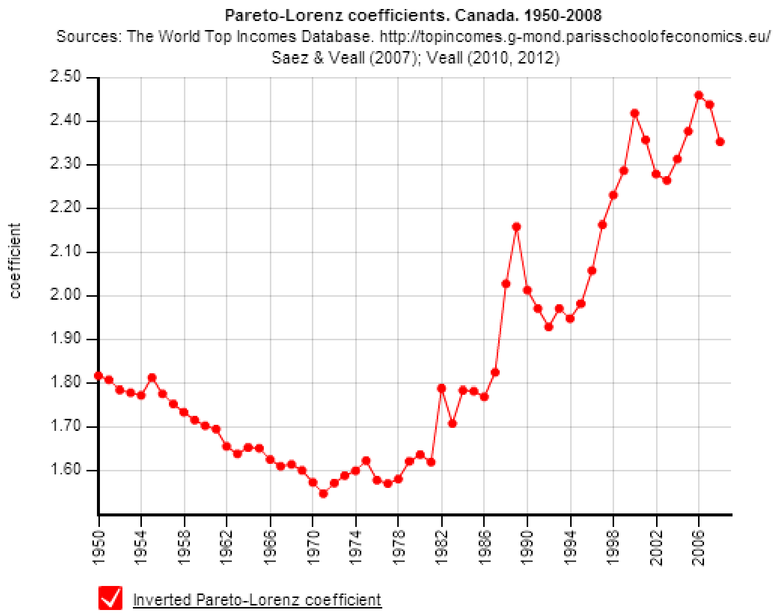
Wilkinson, R. G., & Pickett, K. E. (2006). Income inequality and population health: a review and explanation of the evidence. *Social Science & Medicine*, 62(7), 1768-1784. https://www.ncbi.nlm.nih.gov/pubmed/16226363

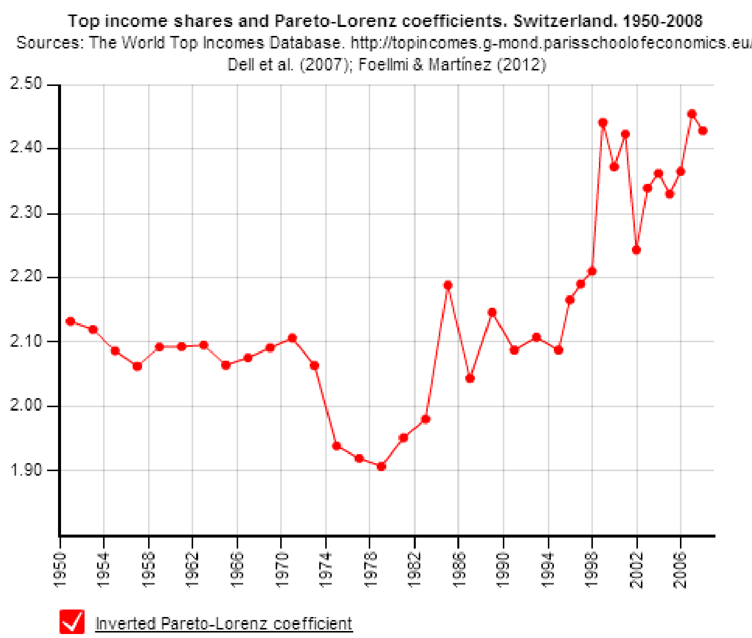
Wolfson, M., Kaplan, G., Lynch, J., Ross, N., & Backlund, E. (1999). Relation between income inequality and mortality: Empirical demonstration. *British Medical Journal*, 319(7215). http://www.bmj.com/content/319/7215/953

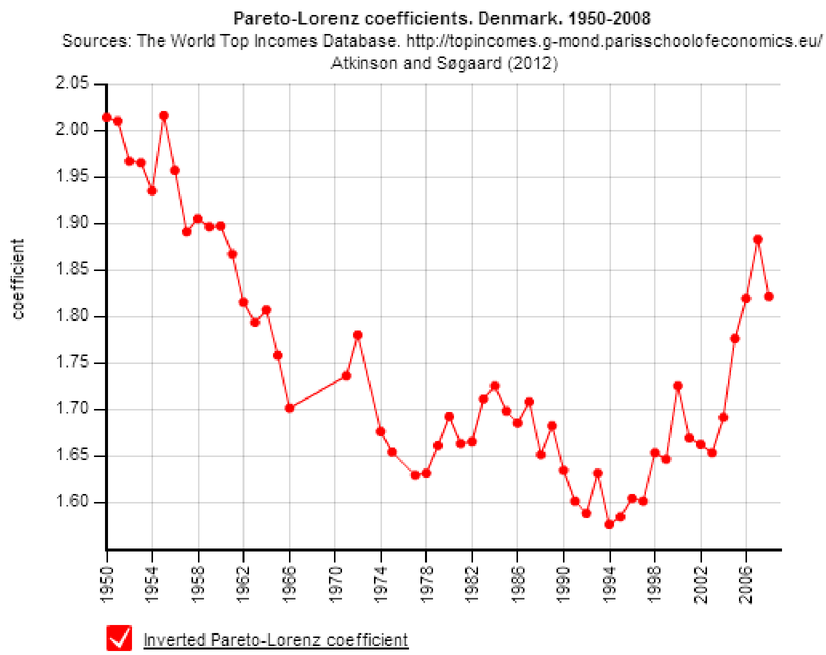
Supplemental Table and Graphs (Effect of Income Inequality on Mortality)

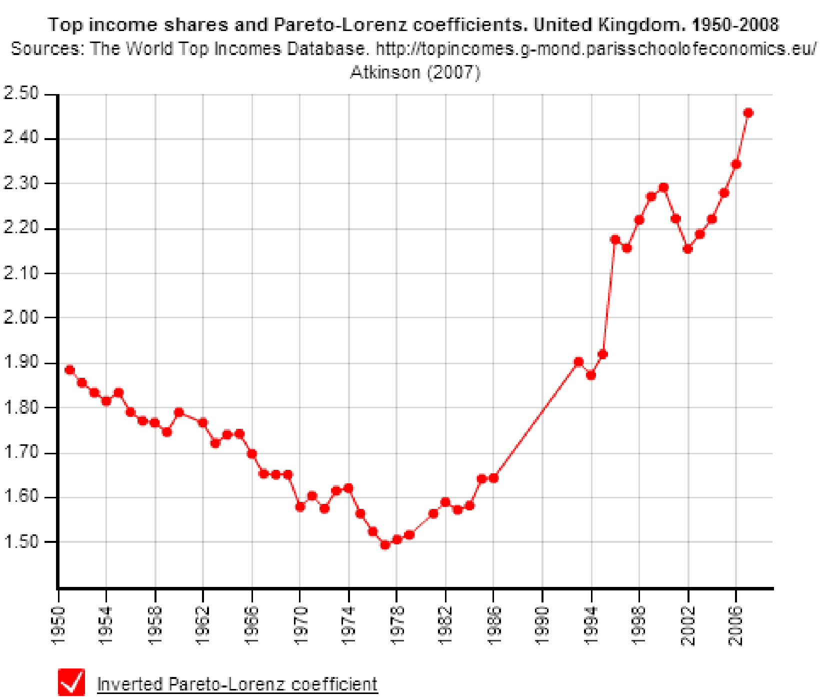
Figure 1: Income Inequality over time by country

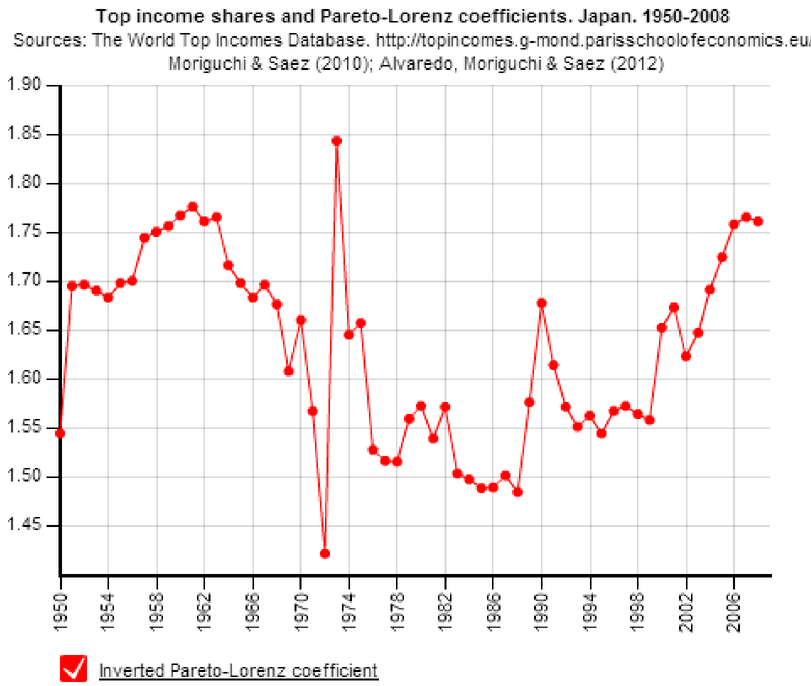


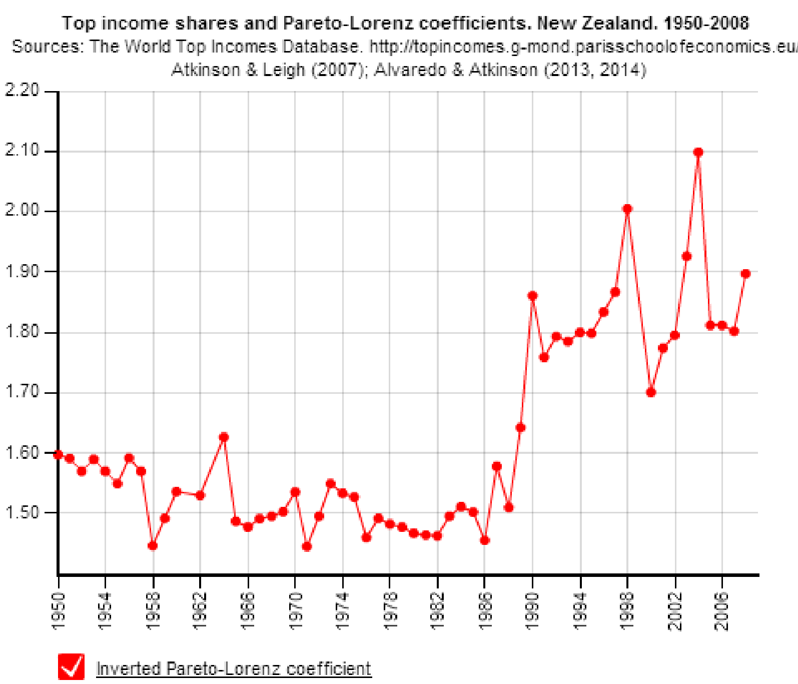

Pareto-Lorenz coefficients. Canada. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Saez & Veall (2007); Veall (2010, 2012)
coefficient
2.50
2.40
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
Inverted Pareto-Lorenz coefficient

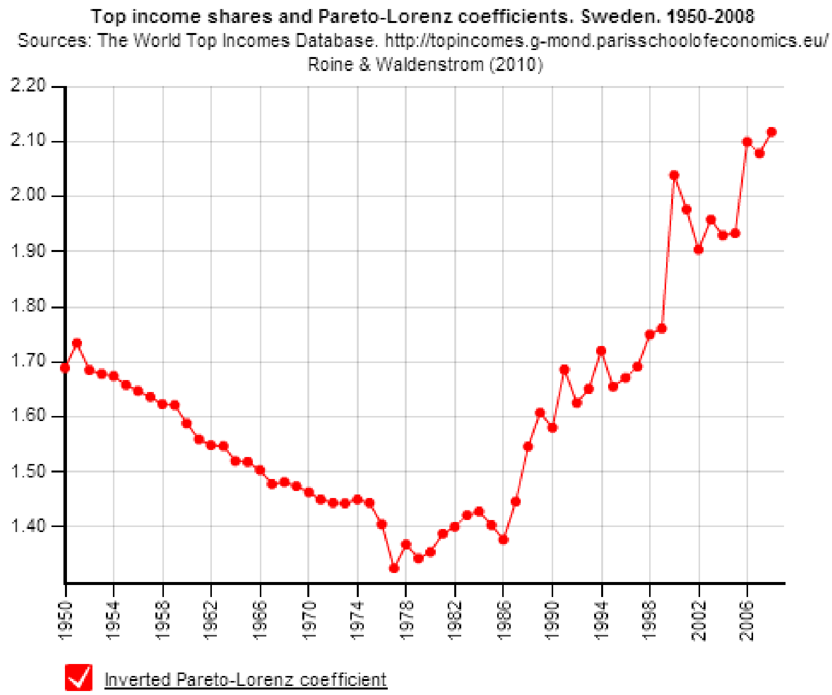

Top income shares and Pareto-Lorenz coefficients. Switzerland. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Dell et al. (2007); Foellmi & Martínez (2012)
2.50
2.40
2.30
2.20
2.10
2.00
1.90
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990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

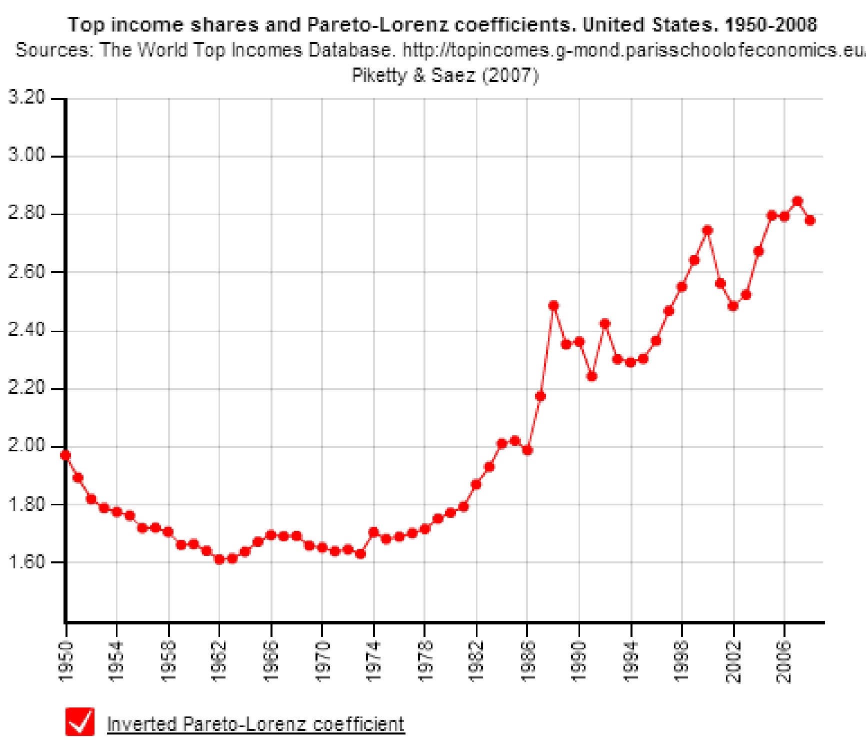

Top income shares and Pareto-Lorenz coefficients. United Kingdom. 1950-2008
Sources: The World Top Incomes Database. http://topincomes.g-mond.parisschoolofeconomics.eu/
Atkinson (2007)
2.50
2.40
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998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

Table A: Granger Causality (by country)

Country	Equation	Excluded	chi2	df	Prob
Swedan	Mortality	Income Inequality	0.387	3.000	0.943
	Mortality	ALL	0.387	3.000	0.943
	Income Inequality	Mortality	12.551	3.000	0.006
	Income Inequality	ALL	12.551	3.000	0.006
Japan	Mortality	Income Inequality	6.691	7.000	0.462
	Mortality	ALL	6.691	7.000	0.462
	Income Inequality	Mortality	4.891	7.000	0.673
	Income Inequality	ALL	4.891	7.000	0.673
GBR	Mortality	Income Inequality	1.707	4.000	0.789
	Mortality	ALL	1.707	4.000	0.789
	Income Inequality	Mortality	7.766	4.000	0.101
	Income Inequality	ALL	7.766	4.000	0.101
USA	Mortality	Income Inequality	0.048	1.000	0.826
	Mortality	ALL	0.048	1.000	0.826
	Income Inequality	Mortality	14.189	1.000	0.000
	Income Inequality	ALL	14.189	1.000	0.000
DNK	Mortality	Income Inequality	0.329	2.000	0.848
	Mortality	ALL	0.329	2.000	0.848
	Income Inequality	Mortality	5.209	2.000	0.074
	Income Inequality	ALL	5.209	2.000	0.074
CHE	Mortality	Income Inequality	1.152	2.000	0.562
	Mortality	ALL	1.152	2.000	0.562
	Income Inequality	Mortality	5.484	2.000	0.064
	Income Inequality	ALL	5.484	2.000	0.064
CAN	Mortality	Income Inequality	0.703	2.000	0.704
	Mortality	ALL	0.703	2.000	0.704
	Income Inequality	Mortality	10.272	2.000	0.006
	Income Inequality	ALL	10.272	2.000	0.006
AUS	Mortality	Income Inequality	0.949	1.000	0.330
	Mortality	ALL	0.949	1.000	0.330
	Income Inequality	Mortality	12.687	1.000	0.000
	Income Inequality	ALL	12.687	1.000	0.000
NZL	Mortality	Income Inequality	1.771	2.000	0.413
	Mortality	ALL	1.771	2.000	0.413
	Income Inequality	Mortality	17.164	2.000	0.000
	Income Inequality	ALL	17.164	2.000	0.000