Increasing Inequality in Joint Income and Wealth Distributions in the United States, 1995 to 2013[1]

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Abstract

The study of joint income and wealth distributions is important to the understanding of economic inequality. However, these are extremely skewed variables that present tails containing strategic information that usual methods – such as percentile grouping – cannot easily underline. In this paper, we propose a new method that is able to provide a thorough examination of tails: the isograph and the logitrank. These tools entail a more detailed conception of inequality by describing inequality at different points of the distribution. Using US data 1995-2013 from the Luxembourg Wealth Study (LWS), we find first that income inequality increased significantly, in particular in the upper middle classes. Second, the wealth-to-income ratio measuring the importance of wealth relative to income, increased significantly. The association between high wealth and high incomes, fourth, increased as well. Based on our analysis, we can conclude that this increase in the association between wealth and income is not a trivial consequence of increasing inequality, but a stronger coherence of the diagonal at the top of the income and wealth distributions.

JEL codes: D31, C16, C46.

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1. Introduction: income and wealth inequality and the study of power tails

Wealth and income distributions in the US exemplify the deep trend of inequality in contemporary capitalism (Atkinson, 2016; Atkinson & Bourguignon, 1995; Piketty, 2014; Wolff, 2016). Even if income is better known empirically than wealth, there is evidence pointing towards transformations in the latter (Piketty, 2014; Saez & Zucman, 2016). The link between the trends in income and wealth are not fully understood (Jenkins, 2009), although in recent years, a few scholars, among which foremost Sir Anthony Atkinson, have enormously advanced the academic as well as the political debate on economic inequality. The joint analysis of income and wealth inequality is important to improve the diagnosis of the current economic trends in terms of shrinking middle class (Cowell & Van Kerm, 2015; Semyonov & Lewin-Epstein, 2013; Skopek, 2015), in which the role of wealth has not been fully considered. Wealth may be buffering or delaying the repercussions of a shrinking middle (income) class. As inheritance plays a key role (Cowell et al 2017), wealth inequality has also implications for intergenerational equity. A better *methodological* understanding of the nexus of income and wealth (Jäntti, Sierminska, & Smeeding, 2008; Jäntti, Sierminska. & Van Kerm, 2013, 2015) could furthermore provide tools to improve our knowledge in multidimensional inequality (Fisher et al., 2016).

In his last book, Tony Atkinson emphasized that we can learn much from the past, by analyzing economic as well as political circumstances from periods where inequality was low, in order to combat rising inequality in the future. In this paper, we analyse the development in income and wealth inequality over the last two decades in the US. The US is an interesting case, as wealth is disproportionally more unequally distributed than income, compared to other countries (Cowell et al, 2017).

A general problem in the study of income and wealth distribution is to assess where the most important changes on the resource scale happened. Previous studies recommended to analyse detailed percentiles of income or wealth (Díaz-Giménez, Quadrini, & Ríos-Rull, 1997; Wolff, 1998) better than general indices like the Gini. We propose here a new method that is suitable to measure inequality at each point of the distribution and apply it to income, wealth, and their relation. This proposal offers a more detailed analysis of power tail distributions, with confidence intervals, and improve analyses based on percentiles. Our results not only confirm the increasing inequality trends, but also reveal a large overlap between these two forms of inequality and the way they overlap: top wealth earners are not merely richer in accumulation; they are also the highest income receivers.

2. Method

To give an overview over the inequality trends, we first make use of the Atkinson family of inequality measures (Atkinson, 1970), which are defined as follows:

$$A_\varepsilon(\mathbf{x}) = 1 - \left[\left(\frac{1}{N}\right)\sum_{i=1}^{N}(x_i/\mu)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}, \ \varepsilon \geq 0, \varepsilon \neq 1$$

$$A_1(\mathbf{x}) = 1 - \exp\left[\left(\frac{1}{N}\right)\sum_{i=1}^{N}\log(x_i/\mu)\right], \ \varepsilon = 1$$

Compared to the Gini, the advantage of the Atkinson measures is their flexibility in terms of sensitivity to different parts of the distribution specified with the parameter ε. Briefly, ε represents the degree of inequality aversion, where larger values imply more sensitivity to income differences at the bottom of the income distribution (see Jenkins and Van Kerm, 2008, for a more detailed discussion of the properties of inequality measures). We calculate the Atkinson indices with $\varepsilon=.5$, $\varepsilon=1$ and $\varepsilon=2$ respectively.

For the central part of our analysis, we use the isograph, which has important advantages when analysing income and wealth. Due to the power tail characteristics of both distributions, a small fraction of the populations can control a considerable share of the resources. This extremely skewed structure of distribution has been first statistically described by Pareto density curves (Pareto, 1897, p. 305-24; Pareto, 1896, p. 99), where, if p is the proportion of individuals below income *I* (or wealth *W*), we have ln(*I*)= -α ln(1-p) + cst where α is a constant between 0 and 1. When *p* converges to 1, *I* increases following a power tail: the power of income *I* is a linear function of the logarithm of the small proportion *q=p-1* of individuals with income above *I*. If the richer population *q'* above *I* is ten times smaller than *q*, they are above income *I' = (10^α) I* . The accuracy of this formulation has been confirmed for the analysis of the general shape of the upper power tail in the size of cities, companies, financial markets, income, wealth, amongst other variables (Gabaix, 1999, 2009; Chauvel 2016), but the Pareto laws often fail to represent the rest of the distribution. A more general problem in empirical cases is that even in the tail *α* is generally close but often significantly different to a constant, and the residual could contain important information, neglected by conventional tools. Thus, the shape of the distribution can change substantially over the income (or wealth) distribution. Earlier papers confirmed that the isograph is a highly useful tool to study patterns of distributions (Chauvel, 2016; Chauvel & Bar-Haim, 2016). It describes inequalities at different income or wealth levels, thus providing the level-specific inequality patterns together with the overall inequality, serving as a sort of generalization of Gini index (in the sense that, if ISO is a constant, *Gini = ISO*) that is variable across the resource scale. The formal definition of *Isograph* is as follows:

$$ISO_i = \frac{\ln(\frac{income_i}{median(income)})}{logit(p_i)}$$

where logit(p) = ln(p/(1-p)) and $p_i \in\ ]0,1[$ is the fractional rank order of income or wealth percentiles.[2] For individual i of $income_i$, the fractional rank is p_i. The value $X_i = logit(p_i)$, the "logit rank", varies from minus to plus infinite, with a value of 0 for the median (see Table A.1 in the annex for the conversion). Note that the point estimate of the median itself is not defined in this equation as the denominator equals zero in this case.

In a nutshell, logit rank is particularly useful to standardize variables in comparative inequality contexts, and it is a strong tool for the exploration of income tails. This X = logit(p) allows the comparative analysis of country variation, e.g. comparing the bottom five percent of country A to the bottom five percent of country B.[3]

The log-medianized income of individual i is $Y_i = \ln(\frac{income_i}{median(income)})$. Chauvel (2016) suggests that Y is a monotonous, generally close to a linear function of X with constant equal to zero where $Y \approx \alpha X$. When Y is a perfectly straight line, income is a Champernowne-Fisk distribution with Gini = α.

We define ISO = Y/X at different income levels. Chauvel (2016) shows that ISO provides the level of inequality for this percentile level X. The isograph depicts the ISO_i for all the ranks of the social order, here income percentiles. In the isograph, X is the horizontal axis and ISO=Y/X the vertical one: the isograph is higher at a given income percentile X when inequality increases at this level. The values of ISO are analogous to the Gini index of the distribution. When ISO is a constant, the value of ISO is the Gini index of the distribution (Dagum, 1977, 2006).

This tool is able to detect where the income distribution stretches and has higher income gaps between percentile levels. Put simply, the higher the isograph at such logitrank level X of the distribution, the larger the gaps between the percentiles near p=logit^{-1}(X).

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[2] The corresponding program *isograph* is available as an ado module in Stata (ssc install isograph).
[3] The logit rank procedure is implemented in Stata as a subroutine of the Stata module abg.ado (ssc install abg / help logitrank). Download available at https://ideas.repec.org/c/boc/bocode/s457936a.html

3. Data and variables

Data

We use the harmonised datasets of the Luxembourg Wealth Study (LWS) for the US 1995 to 2013, based on the Survey of Consumer Finances (SCF). The data contain detailed information regarding income and wealth of U.S. households and oversample wealthy households to provide better coverage of the top of the distribution. See Wolff (2016) for a more detailed description of the data source.

Variables

We regard *income* as the disposable household income (after tax and transfers) per single-adult equivalent (divided by the square root of the size of the household). Compared to other sources such as LIS, Gini indices of income inequality are higher here not only because of better coverage of top incomes, but since social redistributions are underestimated in the LWS: the Gini of the American equivalized disposable income near to 2010 is typically close to .37 in the US LIS series and above .45 for the US LWS. A part of this gap comes for underestimations of tax and transfers redistributions in LWS compared to LIS.

The *wealth* variable is the current value of total marketable wealth and assets, net of debt (Kennickell et al., 2000). We follow the same definitions than the recent study by Wolff (2016), even if we do not disentangle here the different sources of wealth (housing, financial assets, etc.). We focus in the following on the upper half of the distribution, as wealth in the US is extremely low among in the lower part of the distribution.

4. Results: broad increase in wealth inequality

Trends of overall wealth inequality

The first descriptive measures of wealth inequality for the upper half of the distribution (Figure 1) reveal that wealth inequality has increased between 1995 and 2013. Comparing the different indices, inequality rises if we increase the sensitivity of the Atkinson measures to inequality at the bottom (increasing ε from .5 to 2). The Atkinson measure saturates with $\varepsilon=2$ when we consider the entire distribution (output in annex), which emphasize the lower end of the distribution. The reason is that in the case of wealth, inequality is intrinsically high due individual with zero or even negative wealth. Due to the extreme shape of wealth distribution, values below the median rapidly converge to zero that imply deep impact on measures of inequality based on logged values that tend to saturate. Therefore, the observation of changes in wealth inequality is in our view more meaningful in the upper part of the wealth distribution, where the estimate is not saturated due to negative and zero wealth. In countries where wealth inequality is extreme, like in the U.S. (Cowell et al 2017), traditional tools have difficulties to measure the intensity of change and locate where the changes happen in the distribution.

Figure 1: Trends in overall inequality in wealth: Gini and Atkinson indices for the upper half of the distribution
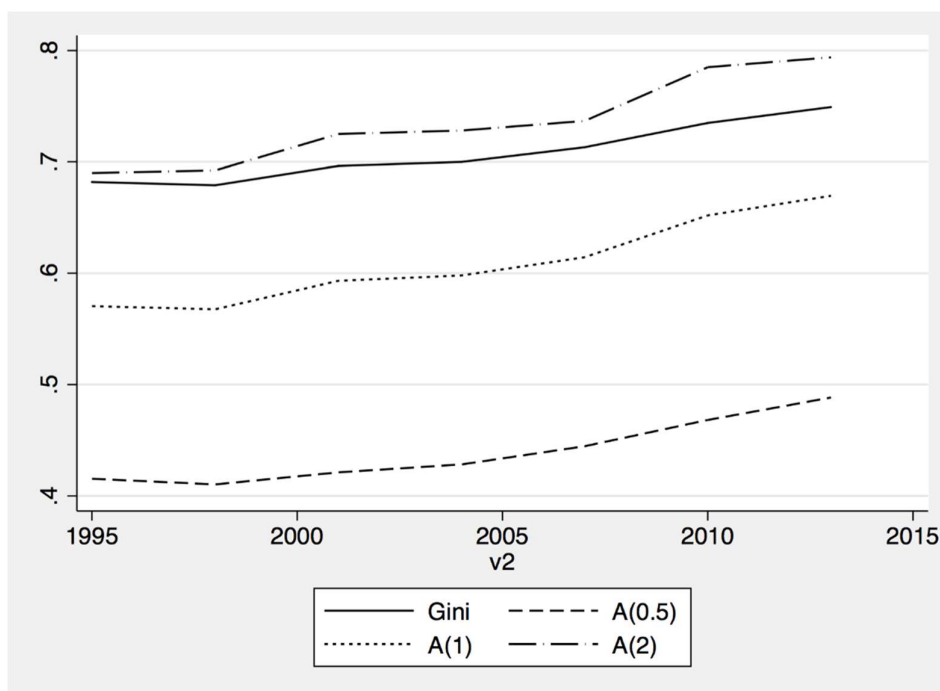
Source: LWS (US-SCF). Note: See Figure A.1 in the annex for the trends for the entire wealth distribution.

As the indicators already diverge when different parts of the distribution are weighted more, they confirm that inequality is not uniformly distributed. We are particularly interested in localising low and high levels of inequality, to which we turn next. In doing so, we restrict ourselves to the upper half of the distribution for the reason mentioned above.

Increasing income and wealth inequality

Figure 2 characterizes the dynamics of inequality in income and in wealth. It depicts the Isographs of wealth and of income in 1995 and 2013 at different points of the respective distribution. Overall, we find significant increase in income and wealth inequality in line with previous studies (Kristal & Cohen, 2016; Looney & Moore, 2016). Figure 2 shows that the largest increases in income inequality can be located directly above the median as well as around the top percentile (logitrank≈5). This first result on increasing inequality looks underestimated through the SCF source since LIS data, based on the CPS, show very significant increase in income inequality. Anyway, the second result is clearly established: wealth inequality has increased at all points in the window of observation between 1995 and 2013, except at the very top. Compared to other countries isographs we dispose of (see annex A3 and A4) in the U.K. 2011 (Source Wealth and Assets Survey WAS accessed from LWS), the intensity of the U.S. wealth inequality is extreme with values of ISO above 1 on a large span of the distribution when in the U.K. it rapidly converges to .5. With the observed trends of the U.S. isograph, we detect now a distribution comparable to a Zipf curve (Gabaix, 2009), exceptional by the intensity of its inequality in the set of LWS countries. The second result (massive increase of the U.S. wealth inequality) is particularly robust whatever the variants of measurement and tools we considered.

Figure 2: Isographs of income (left) and wealth (right) for the upper half of the respective distribution, 1995-2013
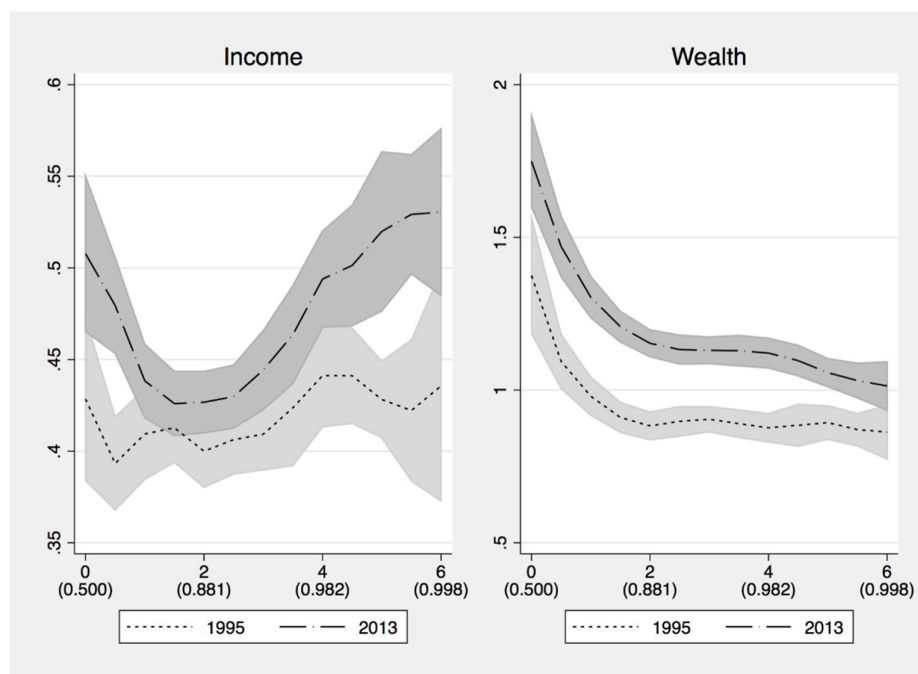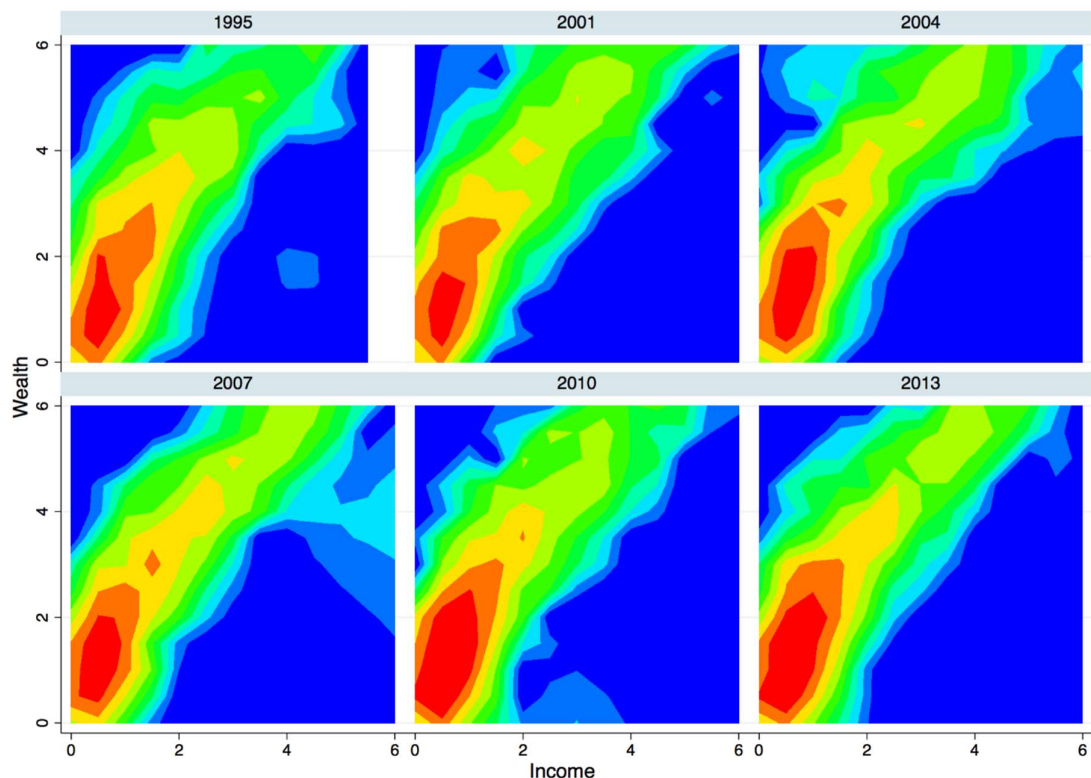

Note: The X-axis represents the logitranks of income and wealth. The Y-axis represents the level of ISO. The higher the curve at a given level of X (logit rank), the greater are the income or wealth inequalities at this level. Source: LWS (US-SCF).

Increasing consistence of the income and wealth diagonal

We now turn to the consistency of the relation between income and wealth. The usual representation of the joint distribution of income and wealth, based on 3D plots of percentiles, generally present diagonal distributions where top and bottom 5% corners are over-represented (relatively to the benchmark of independence), but the year to year comparison of these graphs remain difficult. As a consequence, it is virtually impossible to measure changes in the tails where millionaires and billionaires are mixed.

An option is to draw the linear association between logged-income and logged-wealth, as shown in Figure 3, preferably above the median since the structuration of society in terms of income and wealth is less clear below the median as the log of low incomes are unstable and undefined for zero and negative wealth. Structuration of higher income and wealth is much clearer. This strategy of analysis on a log-log graph is convenient since it theoretically allows a power tailed analysis of the joint distribution. A difficulty in this type of analysis is to compare transformations over time: income and wealth distribution have their own structural dynamics of inequality so that it is difficult to assess where the shifts happened. Due to the double shift in wealth and in income Gini indices, and to the changing wealth-to-income ratio, the variation of the R-squared of the relation between wealth and income is unclear: is it reflecting stronger relation or increasing inequality? Therefore, a standardised measure of income and wealth is needed.

Figure 3: Heat map of the density of the joint distribution of income and wealth for the upper half of the respective distributions (logarithmic)

Note: The X-axis represents the natural log of income. The Y-axis represents the natural log of wealth. Red areas represent high density. Blue areas represent low density. Source: SCF.

Figure 4 shows the same results with the logitrank transformation that allows comparing the observed moves over time using a standardised scale. Logitranks of income and of wealth rescale the two resources in a space where the diagonal becomes a transparent notion, where income and wealth rankings coincide to a larger degree in the later observations than in 1995 and 2001. Moreover, compared to the conventional 3D plots (Figure 3), the upper part of the distribution keeps its detailed power tailed structure.

Figure 4: Heat map of the density of the joint distribution of income and wealth for the upper half of the respective distributions (logitrank)
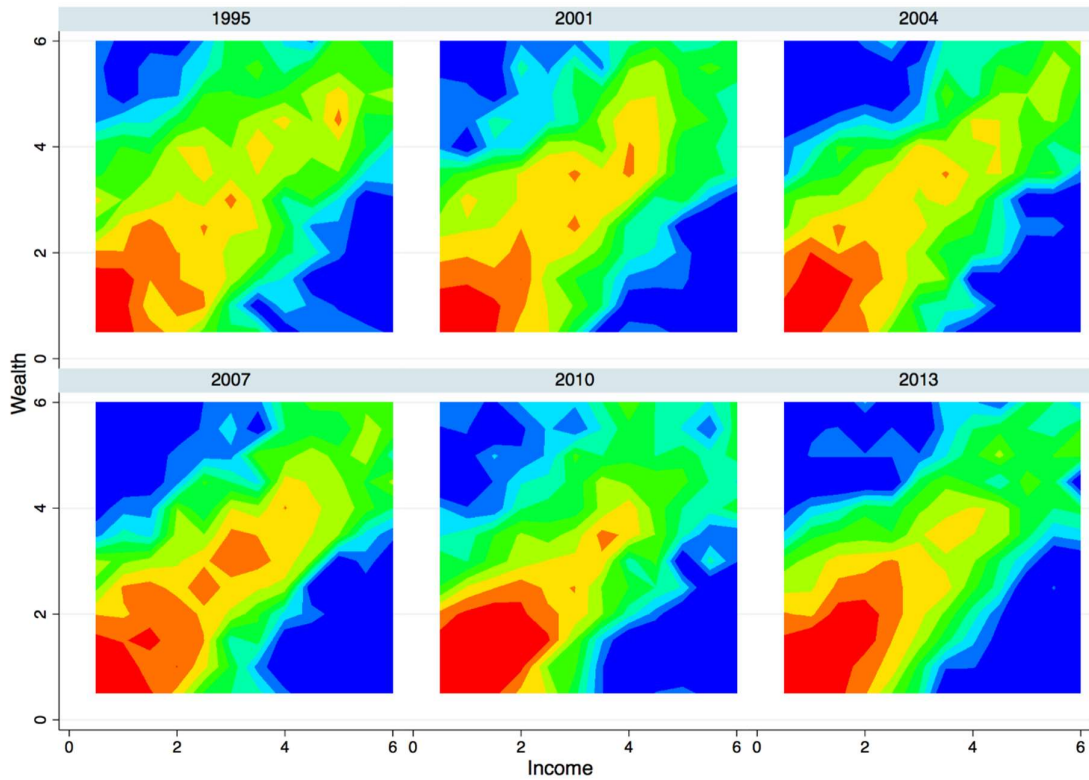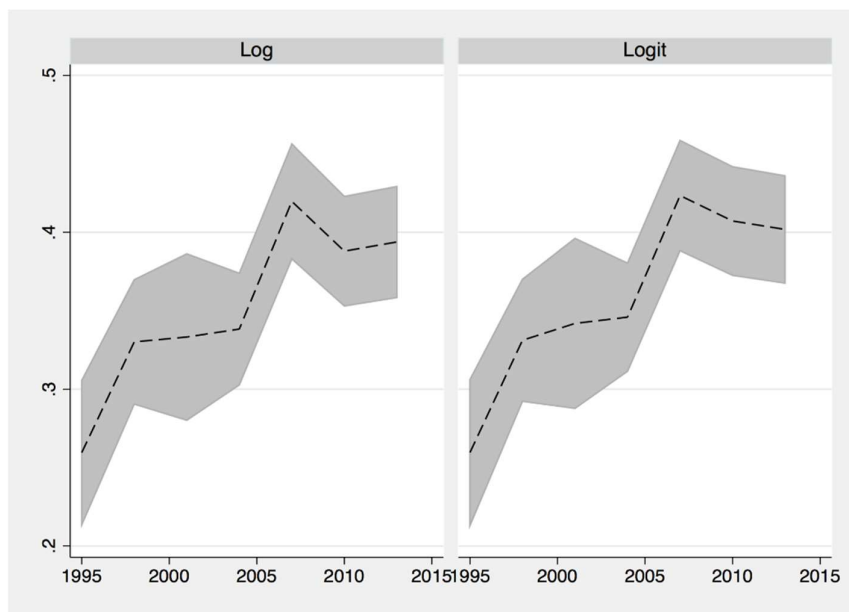

Note: The X-axis represents the logitrank of income above the median (X=0). The Y-axis represents the logitrank of wealth above the median (Y=0). Red areas represent high density. Blue areas represent low density. Interval width=.25 Source: SCF.

A relevant definition of income and wealth relevance is the degree to which ranks in income and in wealth coincide in the upper half of the distribution. We consider the explained variation (R-squared) of the linear regression as a measure of coherence between income and wealth ranks or the degree to which the two rankings coincide in the upper half of the income and wealth distribution. Figure 5 depicts changes in these coefficient of determination between the variables income and wealth, in log and logitranks respectively, for values above the median. It confirms the third aspect of income and wealth inequality, namely an increasing coherence in

the rankings of income and wealth peaking in 2007 and remaining stable in the years after[4]: the Income rich and the wealthy are more often the same ones.

Figure 5: Income-Wealth associations in log (left) and logitranks (right) in the upper half of the respective distribution (1995-2013)

Note: the X-axis represents the year of survey. The Y-axis represents the value of the R^2. Source: LWS (US-SCF).

Increasing importance of wealth (over income) in inequality

The fourth aspect of this analysis is devoted to the wealth-to-income ratio (Stiglitz, 1969). This ratio is of importance for three main reasons. First, at the macro level, the increase of this ratio is associated to a change in the economic process from a wage based society (wage being for a majority of the population the main source of income) to a capital-based society where merit based on work tends to decline (Piketty, 2014), in particular if wealth is inherited (Killewald, Pfeffer, & Schachner, 2017; Ponomarenko, 2017). The second one is empirical at the

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[4] This diagnose is confirmed by a categorical analysis of the diagonality (Shorrocks, 1978) of the income and wealth group matrix. Based on the *unidiff* model (Pisati, Schizzerotto, & Breen, 2004; Xie & Killewald, 2010), we show that over the period, logitrank groups of income and of wealth coincide significantly better: the kappa coefficient of the *unidiff* analysis is significantly increasing between X=0 and X=6 (output available upon request).

mesohistorical level: we know that in many countries this ratio doubled over the last 30 years (Piketty, 2014). The third reason is that, due to the structure of inequality specific to wealth compared to income, a wealth based society is massively more unequal than an income based society (Chauvel & Hartung, 2016), since the leptokurticity of wealth is considerably stronger (Solomon & Richmond, 2001). In density plots, we can detect a middle class in income but not in wealth as the density of wealth increases only towards the upper part of the distribution.

Next, we calculate W/I ratio. On the complete joint income and wealth distribution, this task is complicated since we have a two dimensional distribution where W/I ratio culminates for higher accumulations and lower incomes, through the adjacent diagonal of the income/wealth tables underlying the heat maps of Figure 3 and 4. The solution to this potential problem is to measure this ratio along the diagonal of the logitrank-income and logitrank-wealth table. We therefore measure transformations of the W/I ratio only for individuals who have a consistent position on income and on wealth rankings. In other words, we consider the diagonal "tiles" of the logitrank-income and logitrank-wealth table underlying the plot of Figure 4, and compute the average logarithm of the W/I ratio along these tiles, which is shown for 1995 and 2013 in Figure 6. Note that this cannot be interpreted as a measure of to what degree households need more or less income than before to achieve a certain level of wealth but rather how much income households at a particular point in the income distribution need for achieving the *same* ranking in wealth – compared over the years.

This increase across the income and wealth diagonal of the wealth to income ratio means a "sling effect" (Chauvel, 2016: 56) where inequality of resources increase more than proportionally with the distance to the median.

Figure 6: Wealth-to-Income ratio along the income distribution (logitrank), 1995 and 2013
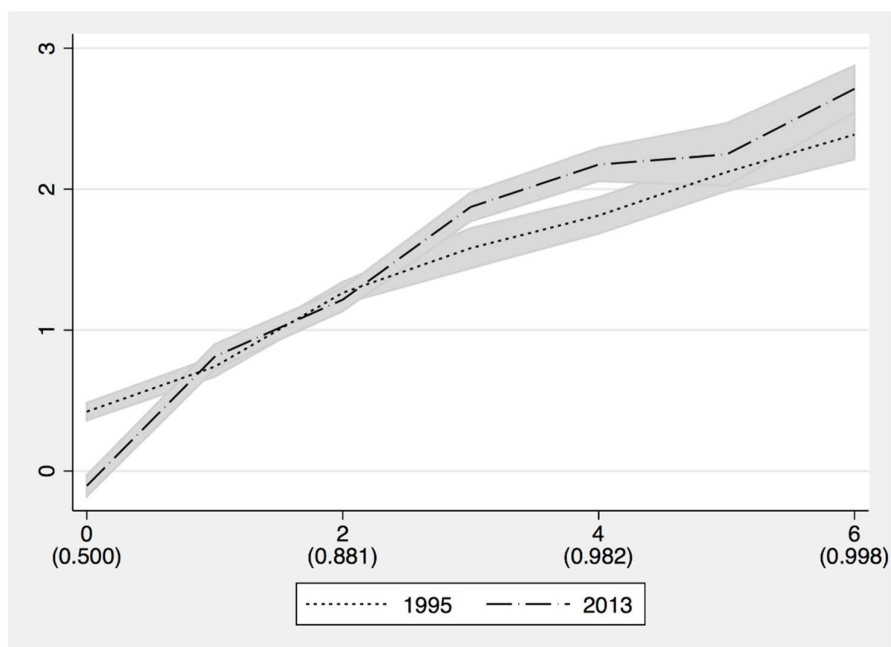
 Note: The X-axis represents the logitranks of income. The Y-axis is the natural log of the W/I ratio. Source: LWS (US-SCF).

Figure 6 shows that for households just above the median until approximately the circa 60th percentile (0<x<.5), the W/I ratio decreased. The largest decrease, from .4 in 1995 to -.1 in 2013, can be located just above the median, where households' wealth relative to income decreased from 1.5 to .9 years of income in two decades (from circa .42 to -.11 on the logarithmic scale). This implies that their wealth expressed in terms of income decreased substantially, by 40%. While the W/I ratio depends on changes both in income and in wealth, it is more likely that it is affected by decreasing wealth among the middle class: Studies show that the median income has remained rather stable comparing these years (U.S. Bureau of the Census, 2018), while the economic crisis and the housing bubble has rendered many families without homes and thus less wealth (Fligstein and Rucks-Ahidiana, 2015). Due to a diversification of assets and wealth, households in the top 10% of the wealth distribution soon

recovered their losses of the economic crisis, contrary to the bottom 80% of the wealth distribution who lost greater parts of their wealth as tied to home ownership (ibidem).

Upper middle class households approximately between percentiles circa 60th and 95th percentile, however, could maintain their wealth levels of 1.5 to 6 years of income depending on the position in the distribution. In the top 5-2% of the population, on the contrary, households managed to accumulate increasing levels of wealth. The strongest increase of the W/I ratio is located near a logitrank of 4 or the top 2%, where households increased their wealth by 44% from 6.1 to 8.8 annual incomes (from 1.81 to 2.17 on the logarithmic scale). At the very top, the increase in the W/I ratio seems unsignificant.

5. Discussion and conclusion: a self-accelerating trend of inequality?

This paper shows four main results on inequality trends in the income and wealth above the median in the US. Similar to previous studies (Kennickell, 2009), both income and wealth are showing substantial and significant increase in inequality as measured by the isograph method. The linkage between income and wealth above the median increased substantially and significantly; the growth of the log-log coefficient of determination is confirmed by logit-rank measures that are not affected by inequality changes. The joint income and wealth distribution is more diagonal, with a more coherent (or rigid) relation between income and wealth. Last but not least, the log of the W/I ratio, measured on the diagonal of the joint income and wealth distribution, shows an increasing accumulation of wealth in the top 3-5% of the distribution (logitranks between 3 and 4). Near the 95th percentile, wealth has risen by 44% from 6.1 to 8.8 annual incomes, while it decreased in households in the decile above the median by up to 40%.

The main conclusion of these four trends is that the median class of the U.S. population and the upper-middle class, the top 3-5% percent, are driven increasingly apart. That is, in addition to

16

the steep increase in inequality over the last decades in the US, the convergence of income and wealth trends also seems to ascertain the social persistence of economic power, and its tendency to accumulation. In the top percentiles, except the top percent, income and wealth are more extreme than before, with rankings that are more consistent on both scales, and where wealth represents an increasing number of years of earnings and thus savings. Others have shown that these levels of income and wealth fit with the educational levels of the upper category of university students, whose parents are more consistently richer in income, able to afford higher tuition and fees for their children in more selective universities, before these children can enter in the most lucrative occupations (Corak, 2013; Chetty, 2017; Jencks et al, 1972; Jerrim & Macmillan, 2015; Aisch et al, 2017). These four trends may promote a spiral of deepening social immobility, contrary to the meritocratic dream.

This means a trend to the self-acceleration of a process to extreme inequality (Piketty 2014) since the wealthiest and income-richest groups of the population benefit from even more opportunities of accumulation. It is precisely what we find with the sling effect, even if we still have difficulties to observe trends above the top 1% (X=5).

These findings should therefore also be relevant for policy making. While income inequality has become a recognised issue -albeit still lacking policy responses- there is less awareness about wealth inequalities, let alone public debate on how to tackle it (Atkinson, 2016; Cowell et al., 2017). In his last book, Tony Atkinson (2016) promoted the idea –among others- to examine the option of an annual wealth tax and how it can be successfully (re- introduced to reach a more equal distribution of wealth.

At this stage, the diagnosis on the top one percent of the income and wealth scale remains uncertain. Even if the LWS is designed to represent better the top of resource distributions, the size of the sample is limited. Administrative or Census data could remedy this limitation and give robust insights to inequality at the top. Another interesting addition to the literature would

be an international comparison based on the other countries that are represented in the LWS, which could advance our current understanding of the exceptionalism of the US.

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Annex

Table A.1: Conversion between logit(rank) and percentiles

Logit(rank)= ln(p/(1-p)	Percentile/rank p
-7	0.001
-6	0.002
-5	0.007
-4	0.018
-3	0.047
-2	0.119
-1	0.269
0 (median)	0.500
1 (approx. top quartile)	0.731
2 (approx. top decile)	0.881
3 (approx. top ventile)	0.953
4	0.982
5 (approx. top 1%)	0.993
6	0.998
7 (approx. top 0.1%)	0.999

Fig A,1: Trends in overall inequality in wealth: Gini and Atkinson indices
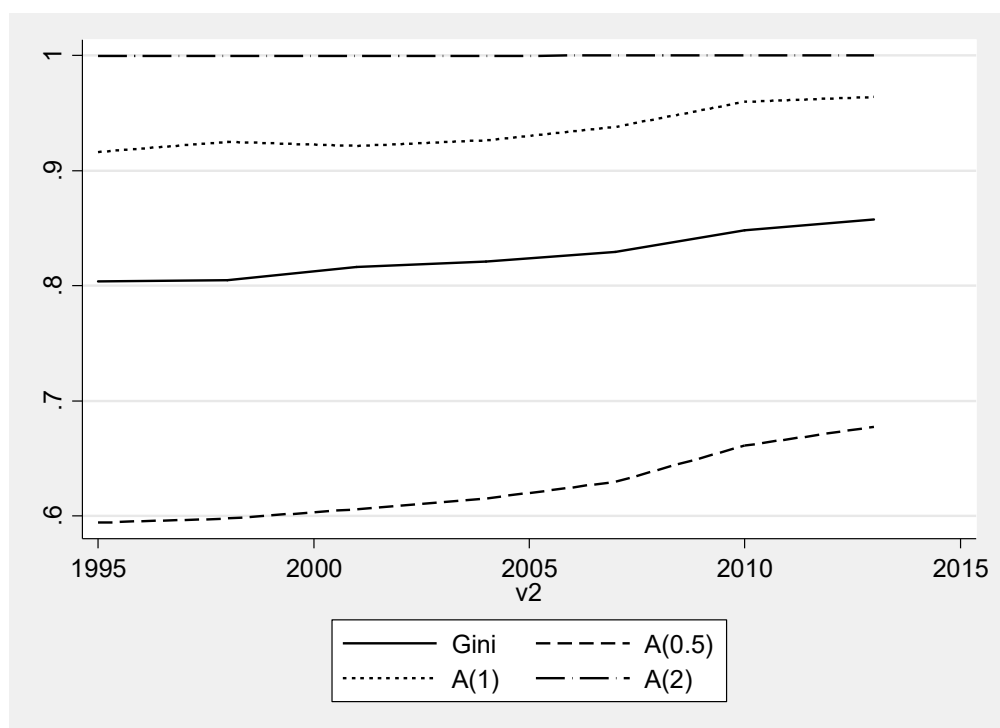

Source: LWS (US-SCF). Note: Compared to figure 1 in the text (pertaining to above the median wealth) we consider here all the negative and zero values. The A(2) measure is entirely saturated and A(1) and Gini take extreme values difficult to differentiate.

Fig A.2. Isographs of income and wealth for the upper half of the respective distribution, 1995 to 2013
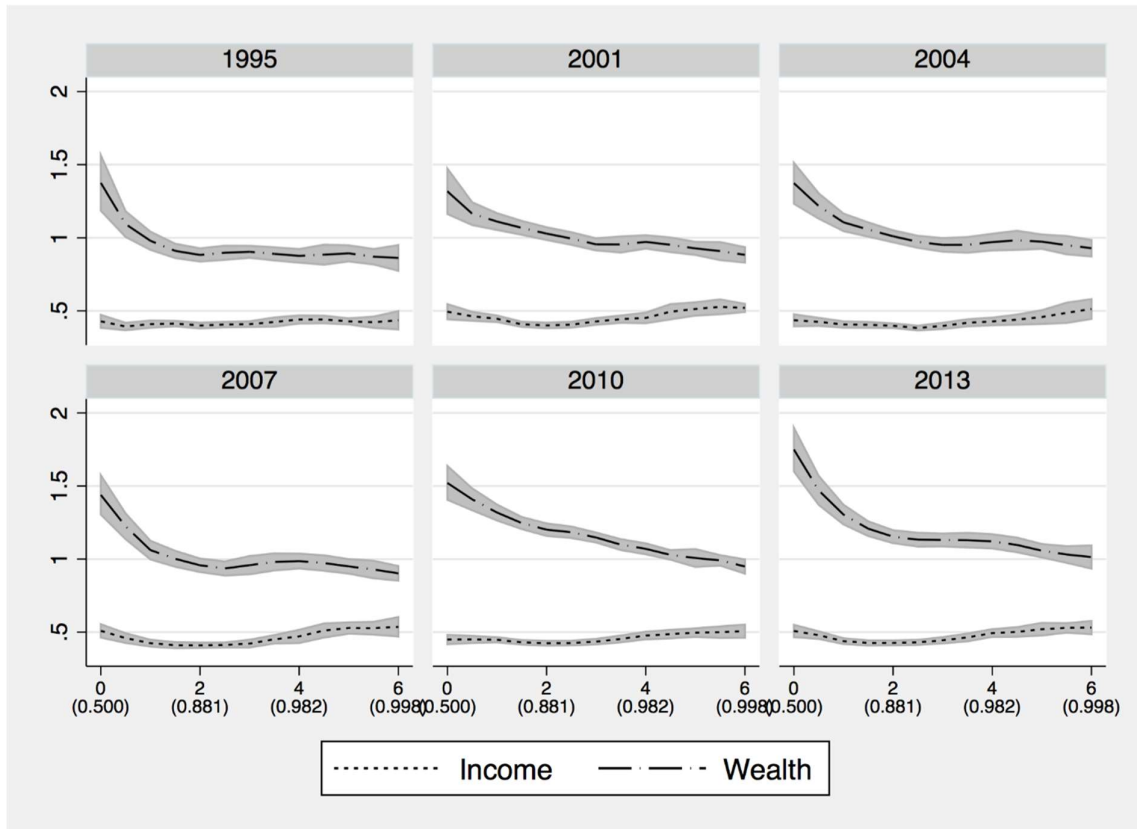
Source: LWS (US-SCF).

Fig A.3. Isographs of income and wealth for the upper half of the respective distribution, U.K. and U.S
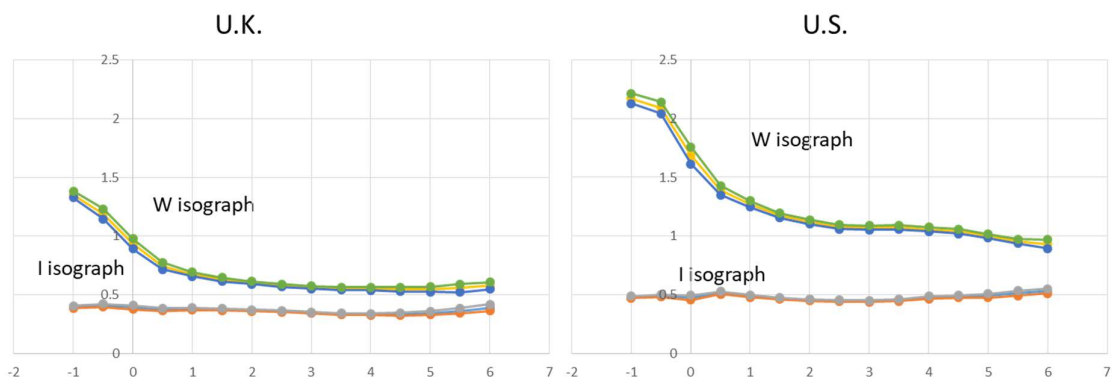
Source: LWS (US-SCF 2013 & UK-WAS 2011).

Fig A.4. Threshold values of wealth (ratio to the median) in the U.K. and the U.S

		U.K.	U.S.
X	top p	x times med	x times med
1	0.269	2.0	3.6
2	0.119	3.3	9.4
3	0.047	5.4	24.9
4	0.018	9.1	68.4
5	0.007	15.4	147.4
6	0.002	31.9	268.3

Source: LWS (US-SCF 2013 & UK-WAS 2011).