

Statistical clues to social injustice

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This paper is based on a talk. The talk presented 25 figures and several tables of figures to a group of statisticians and other interested people all taken from the book: *'Injustice, Why Social Inequality Persists'* (published in April 2010 by Policy Press, Bristol). This written version of that talk just takes ten of those figures and none of the original tables and tells a story with this subset. It is a story that travels from how huge numbers of children can be written off statistically and falsely as having scant ability, to end up showing how the statistical autopsy of a financial crash can reveal the crisis still occurring long after the 'economic recovery' has been announced. It is a story of how statistics have been used and continues to be used to promote particular agendas, often in the most unscrupulous of ways.

There is no such thing as a neutral social statistic. We all have models in our minds of what it is we think makes the human world tick. Those who do not recognise this are simply deceiving themselves more than most of us do – and we all do. It is a valuable human trait to each believe we are a little special, that we know many of the answers, that it is others that are making most mistakes, that those who are misguided are those who don't vote for the same political party as us, who don't agree with us when we argue about intelligence, economic development and income inequality - to pick just three topics about to be covered.

There is no easy way of being at all sure that it is not you who is misguided and propagating untruths, as - while attempting to uncover reality - because of the way in which you work, you are just fabricating your own reality. However, what you can do is try to be open in everything you do, give all the sources, make all the data and models available – before you even publish your findings if possible. Listen to others' criticisms no matter how objectionable you might at first find them. Remember that we are all human and it is very unlikely that others are super-human (but not certain, as a good agnostic might say of the existence of god). Look for basic mistakes in the work of others, especially the most august of organisations. They are least likely to have their results questioned. We can use statistical clues in the search for the origins of social injustice. Ask why a certain curve appears to fit so well, look out for when other distributions are assumed to exist, the assumptions glossed over in the summary reports.

Don't be afraid of social statistics – they are simply agricultural, biological, theoretical or industrial statistics made more interesting.

These are ways of describing the world that collectively we have only just invented. Social statistics were created less than a flutter ago in human history. When my grandmother's great-grandfather was born there were almost none. Of all those printed he could possibly have memorised them, had he been able to read. Most of what we currently recognise as statistics was invented during my grandmother's lifetime. How many things do you get right first time you try them? It is hardly surprising that so many of the early social statistics that we hold up as exemplars often conceal many faults, prejudices and in many cases, deceit.

The new statistics we are creating today will be criticised, pulled about, described as inhuman, insensitive, uncaring, the products of minds warped by the idea that counting people could ever result in good. In much of social science this is already the prevailing view of social statistics that numbers are for those with strangely adjusted minds, ones that cannot appreciate the higher things in life – art, theory, semi-structured interviews. Social statistics could be much better used than they are, far more nuanced, collectively-clever, appropriately applied, carefully used, but they are not inherently evil ways of trying to understand one-another. There are now quite a lot of us. We can no longer know all our neighbours. Social statistics extend your eye-sight and your hearing. At their best they can give you an enhanced sense of empathy when you recognise through the simple comparison of numbers that something is wrong.

In spring 2010 the structural deficit of the UK government was said to be about £70bn – the amount that would not be repaid even if economic growth occurred. In the same week that number was revealed we learned that in just one year the wealth of the richest 1,000 individuals in the country had risen by £77bn (£77million each), the net extra amassed in just 12 months. Just two numbers: £70,000,000,000 and £77,000,000,000. So, where on earth are we going to find the money to pay back the structural deficit?

But the population of the UK have problems with numbers with more than half a dozen noughts. There is a role to play for social statisticians - from the straightforward task of simplifying large numbers to the equally hard problem concerning the fitting of multi-dimensional distributions. If you think the latter is harder then ask why so few people complained when they first heard of the huge rise in the assets of the very richest – in fact the relatively fastest and absolutely greatest rise in the 22 years in which the Sunday Times had been compiling these figures?

This story starts with questions concerning how many people can understand millions and billions, how many think they know what a structural deficit is or would look behind the statement “even if

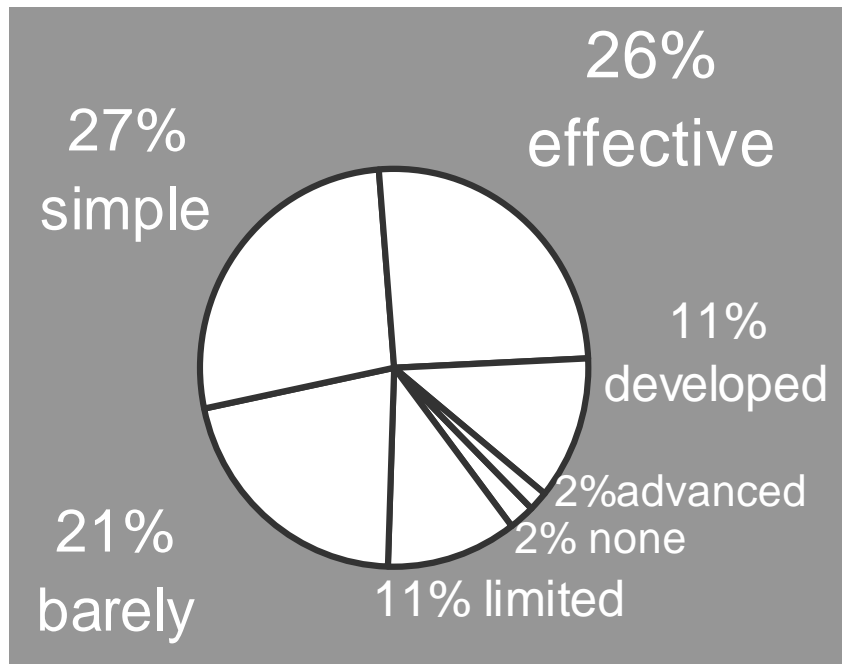
economic growth occurred” and have the confidence to ask if that really is the solution in an age of mass over-consumption? Most people may find it hard to understand such things but that does not mean they are stupid. It most likely means that someone never sat with them as a child showing how two rods of one length added up to a rod of another length which in turn... I don't know if children in the Netherlands are ever exposed to Cuisenaire Rods, but imagine for a moment that they are. Which do you think most likely to get to play with the rods when young. If you don't know what they are then well done, you got to where you are without that extra little bit of help, but you probably (very probably) had other help. How much help do you think children in the Netherlands get at home and in school with science and maths? How much do you think it might vary? Take a look at Figure 1.

We tend to take the statistics international bodies present to us with far too few grains of salt. Figure 1 shows one such set of numbers. This is how children have been described in the Netherlands in the latest of the PISA international studies of children. This particular study concerned science and maths. Like me you probably don't know very much about children in the Netherlands. Perhaps there really are 2% with no ability at all, a further 11% who are very limited in their abilities, a further 21% who are 'barely able' and 27% who do better than these but can only understand 'simple concepts'? That's 61% of all children being dullards.

This is important information if you visit the Netherlands. Look out for all those stupid children. Let's hope that the Dutch are being careful enough to ensure that none of these young people end up in any positions of power. Fortunately some 2% of their offspring appear to be 'advanced' according to these statistics. Obviously they need to carefully ensure that these few are rapidly promoted to positions of responsibility. Those few will need to be supported by some others who can understand their instructions.

Oh Look! There are another 11% beneath them who could fulfil that role, and under them! An even bigger group, some 26% who can be 'effective' if properly instructed. Perhaps we can place them between those destined to govern and the 61% who need to be looked after? Perhaps in future generations we could teach children better so that a few more could climb up the ranks (hand out a few more Cuisenaire Rods), but in the meantime we have a big problem in the Netherlands with that 61% incapable of looking after themselves in any intellectual sense. But what about other countries? What about the UK where most people reading this journal live? Have a look at figure 2.

Figure 1: Children by student proficiency in science in the Netherlands, according to the OECD, 2006 (%) ¹



Notes:

‘None’ implies possessing no knowledge as far as can be measured.

‘Limited’ implies possessing very limited knowledge.

‘Barely’ stands for barely possessing adequate knowledge in the minds of the assessors.

‘Simple’ means understanding only simple concepts.

‘Effective’ is a little less damning.

‘Developed’ is better again;

but only ‘Advanced’ pupils are found to be capable, it is said, of the kind of thinking that might include ‘critical insight’.

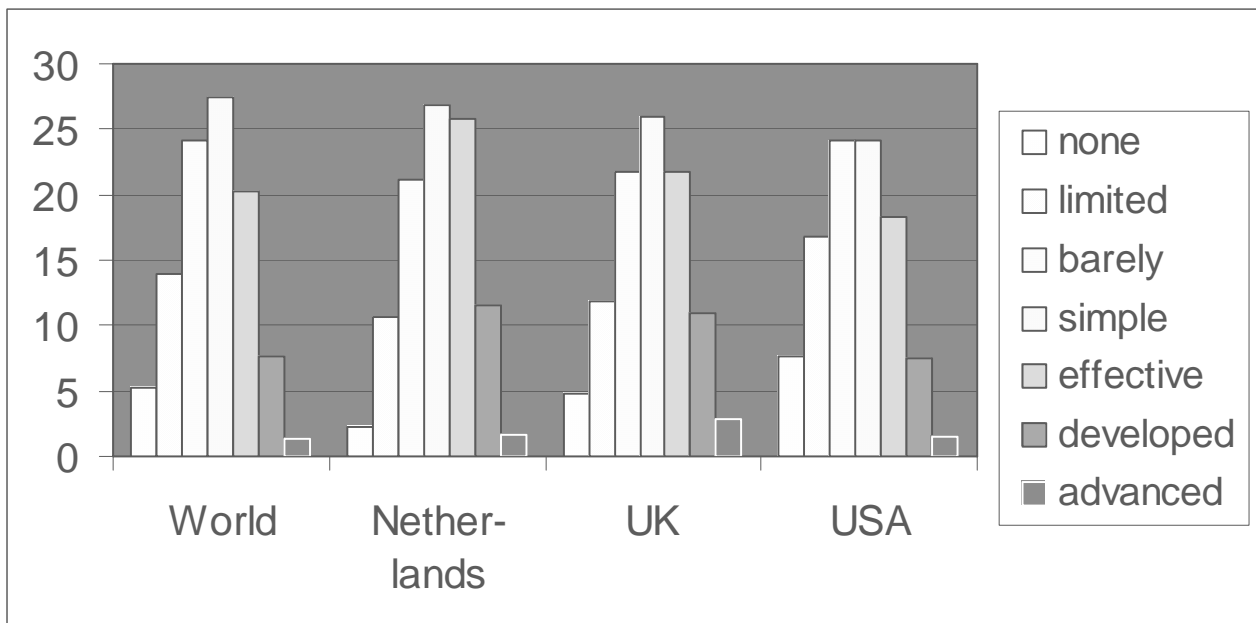
The Appendix gives the PISA study report's own descriptions of these categories (annotated by me). I have given my own interpretations above. You should judge whether these are justifiable.

If you want to know how the young people of Britain are doing and others across the rich world in general and the USA in particular then almost all who want international comparisons have to look at Figure 2 and the table beneath it. Take a deep breath first though. If you thought things were bad in the Netherlands, well, you are not going to be happy with the state of education in the UK.

¹ **Source:** OECD (2007) The Programme for International Student Assessment (PISA), OECD's latest PISA study of learning skills among 15-year-olds, Paris: OECD, derived from figures in table 1, p 20.

It's terrible! What have our schools been doing? Our teachers must be awful! More than twice as many young people in Britain have no measurable ability. Hold on though, look to the other end of the table. There's some hope, some 2.9% of our young people are 'advanced'. Make's you proud to be British don't you think? - more than in both the USA and the Netherlands, clearly we must be doing something right. Maybe it's our excellent private schooling at the very peak of our system, Eton, Harrow, Westminster, our "very best" comprehensives contributing too, all creating the cream-of-the-cream. Maybe having more at the bottom is a sacrifice we have to make for bringing on excellence at the top?

Figure 2: Distribution of children by proficiency in science, according to the OECD, 2006 (%) Children ²



%		World	Netherlands	UK	USA
0	none	5.2	2.3	4.8	7.6
1	limited	14	10.7	11.9	16.8
2	barely	24.1	21.1	21.8	24.2
3	simple	27.4	26.9	25.9	24.1
4	effective	20.3	25.8	21.8	18.3
5	developed	7.7	11.5	10.9	7.5
6	advanced	1.3	1.7	2.9	1.5
		100	100	100	100

² Source: Data given in OECD (2007) The Programme for International Student Assessment (PISA), OECD's latest PISA study of learning skills among 15-year-olds, Paris: OECD, derived from figures in table 1, p 20. See the Appendix for the PISA study report's descriptions of these groups.

Or maybe this is all b- b- b- baloney (mustn't use a rude word now, not if we are well-educated).

Look again at Figure 2. Look at the shape of those curves. They are all very similar aren't they? Surprisingly similar you might say. That is, if you had a feel for these things, if you had played about with numbers and surveys before. You don't often get a pattern that good. Maybe they had a massive sample (they didn't). Maybe children really are so reliably spread out by ability (they aren't). Ok then? So how did the three curves of ability shown in Figure 2 get to be that shape? Easy – they were made to be that shape.

What?

Yep – that isn't the data you are seeing, there isn't some international test where children in all these countries are asked exactly the same questions, simply translated and the results tabulated and reported.

So they made it up?

Not exactly.

What did they do then, these people who claim that so many children are barely able to think clearly?

They did what they thought they should do – when they saw that the raw data that they got was a mess – the 'remodelled it', they made it fit to a normal distribution. What you are seeing in Figure 2 are three normal curves and a further one summed from those (and many other normal curves) to produce the (rich) 'world distribution'.

But wouldn't it be obvious to people what they were doing?

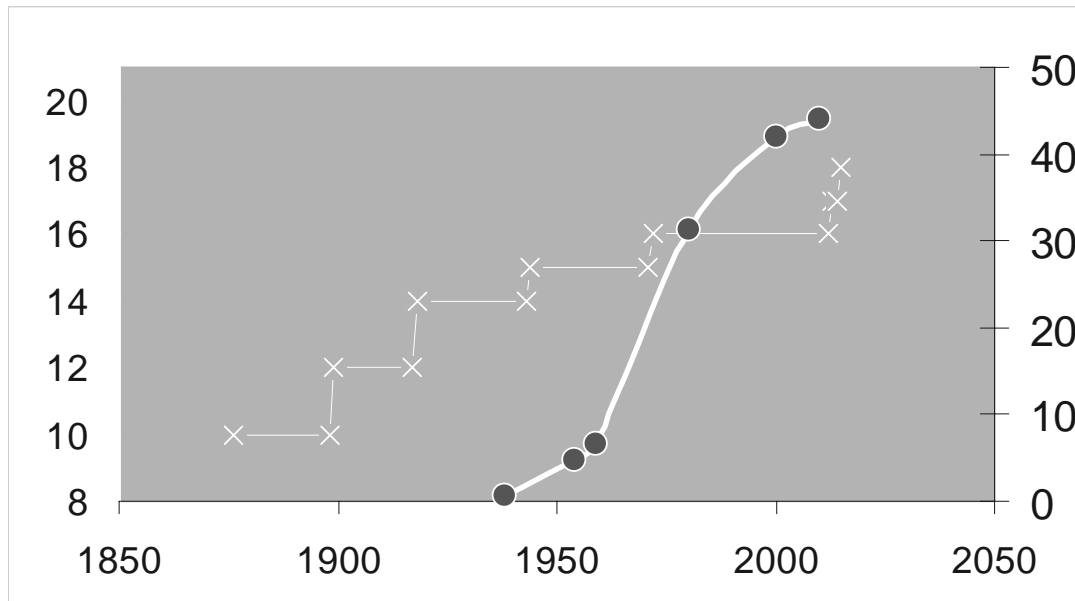
No – firstly because in the PISA reports the OECD economists tabulated their data but do not draw these curves of it. You can only speculate why. Secondly, although the results were published in 2006 the technical report on how they were produced was not published until 2009, by which time most scrutiny of these numbers would have ended (details are in the book 'Injustice' that formed the basis for the talk this paper is drawn from).

But young people are like this aren't they? I've met a few. Barely able to string a sentence together some of them. In my day standards were so much better, we had the 11 plus you know...Standards really have fallen, I know they have, grammar, we used to be taught grammar.

You might have been taught grammar – how to follow rules and keep in line, but how free were you to really think? - and how did going to that selective school change how you thought of others? Oh – let's have a sentence without a verb just for fun. Select age 11 not good. There – you see, the sky did not fall down. Yes, I know it helps if your writing is clear, but there are others things you can learn in life than

diction, past-pronouns, and a little too much superiority. What were we talking about? Oh yeah, selective education. It's not your fault if you went there, or some great achievement if you didn't, your parents chose if you did and for most in Britain the other option, of going to a secondary modern, spelled out a life of servitude. But before you start thinking standards have fallen have a look at Figure 3.

Figure 3: School-leaving age (years) and university entry (%), Britain, 1876-2013 ³



Note - school leaving age in years, left hand axis and line marked by X's; university entry % by age 30, right hand axis and line marked by filled black circles.

If you think standards are falling how long have they been falling? Just how high do you think 'standards' were when just 1% of young people were allowed into universities in the 1930s. Was that 'Brideshead revisited' set super-human? What about when just around 7% went to 'uni' (before anyone called it 'uni') at the start of the 1960s and most children left school at age 15, was that the golden age of high standards? Currently 44% of people go to university by the time they are 30, 38% by the time they are 19.

Universities are not what they used to be...

³ Sources: BBC (2007) 'School leaving age set to be 18', report, 12 January; Meikle, J. (2007) 'Education dropouts at 16 will face sanctions', The Guardian, 23 March; Timmins, N. (2001) The five giants: A biography of the welfare state (new edn), London: HarperCollins, pp 2, 73, 198 and 200; and latest official estimates, see Higher Education Funding Council for England website on widening participation of local areas: www.hefce.ac.uk/Widen/polar/

You might be thinking, but be careful not to confuse your rose-tinted recollections of late puberty with some wonderful period of cerebral learning in British social history. School leaving age rises slowly and steadily over time. It is unlikely to stop rising at age 18 just because this is the age of majority. The rise in university entry may have been temporarily curtailed but universities are far from the only post-18 options. Universities today are very much like grammar schools were for my parents' generation.

Universities, like grammar schools before them, separate you off from the rest of your cohort. Such separation makes sense if children at age 15 really are as divided by ability as suggested in Figures 1 and 2 above. Not everybody would manage at university you might say, and they would not like it, they wouldn't enjoy the experience. And you would be right. Just as not everybody liked and would have liked going to a grammar school between the ages of 11 and 18 in the past. But grammar schools changed. Once everybody was granted free secondary education after 1944, and once almost all areas of Britain abolished segregation in secondary education by the mid 1970s (and most young people attended their nearest secondary school) the grammars had changed, they had become 'comprehensive'. Still the same bricks and mortar, still the same teachers with degree level qualifications, just as before, but no longer the exclusivity and division.

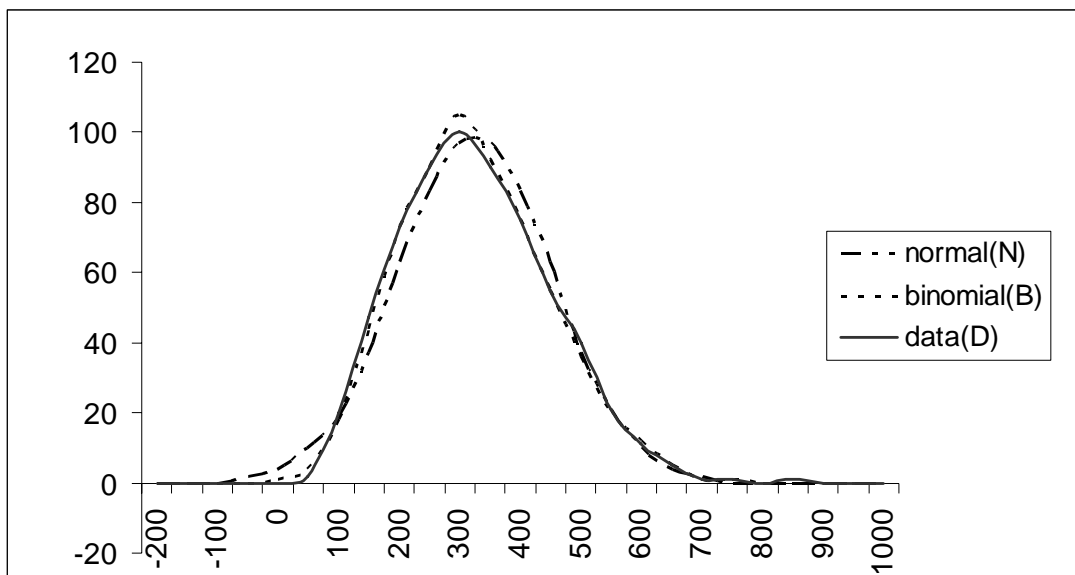
Expanded universities in the future would be very different places to today. They would involve teaching very different things and perhaps doing many things which we would not currently consider as teaching within their walls. Their walls would be much the same, the brickwork of British society changes far more slowly than the software, but what happened within those walls would be greatly different. Universal university access (what raising the school leaving age above 18 means) would not mean making working class children middle class, as university admission currently does (and as grammar school admission did in the past). Instead the nature of what it would mean to be middle class or working class would change.

What do many people who are now going for the first time want to study in universities? Things like Beauty Therapy, Film Studies, Childcare. Are these more or less worthy than Geography, Anthropology and Economics? Comprehensive universities in the future would not force so many people to attend at ages 18 or 19, learning could be slow or later. If there was not such a need to get the qualifications quickly to get above others in the labour market students could begin to learn and think rather than increasingly cram and drink. When everyone can go, you can begin to ponder rather than simply compete.

Almost exactly the same arguments that were currently raised against extending elementary education in the 1890s and secondary education in the 1950s are now used to argue against extending access to tertiary education sixty years on. In the 1890s you would have been saying that older children should be working in factories or in the fields. In the 1950s you would have said that what most children needed from school was to be instilled with a sense of discipline so that when they went to work on the production line or when they became a mother they would be well behaved and respectable. You don't want to start putting fancy ideas in people's head (they said). People look back in anger at the inequities of education in the 1950s and 1960s because they remember such prejudice.

Statisticians have been implicated in holding back progress in education since the beginnings of their subject; most of the discipline's founding fathers (they were almost all men) were complicit - far more complicit than the usual Victorian academic. Have a look at figure 4 and think again of those curves the OECD statistician of the 'economics of education' created some 105 years later. We have what is known as 'form' in our statistical crimes.

Figure 4: Geographical distribution of paupers, England and Wales, 1891 ⁴



A bell curve again. Look you might think – that shows they are 'normal'. This one is of the proportion of Paupers found in each poor law union area in 1891. It was drawn, as far as I can see, to try to further its creator's arguments about the inheritability of intelligence.

⁴ Source: Figure redrawn from the original. Pearson, K (1895) 'Contributions to the mathematical theory of evolution – II. Skew variation in homogeneous material', *Philosophical transactions of the Royal Society of London, Series A, Mathematical*, vol 186, pp 343-414, Figure 17, plate 13)

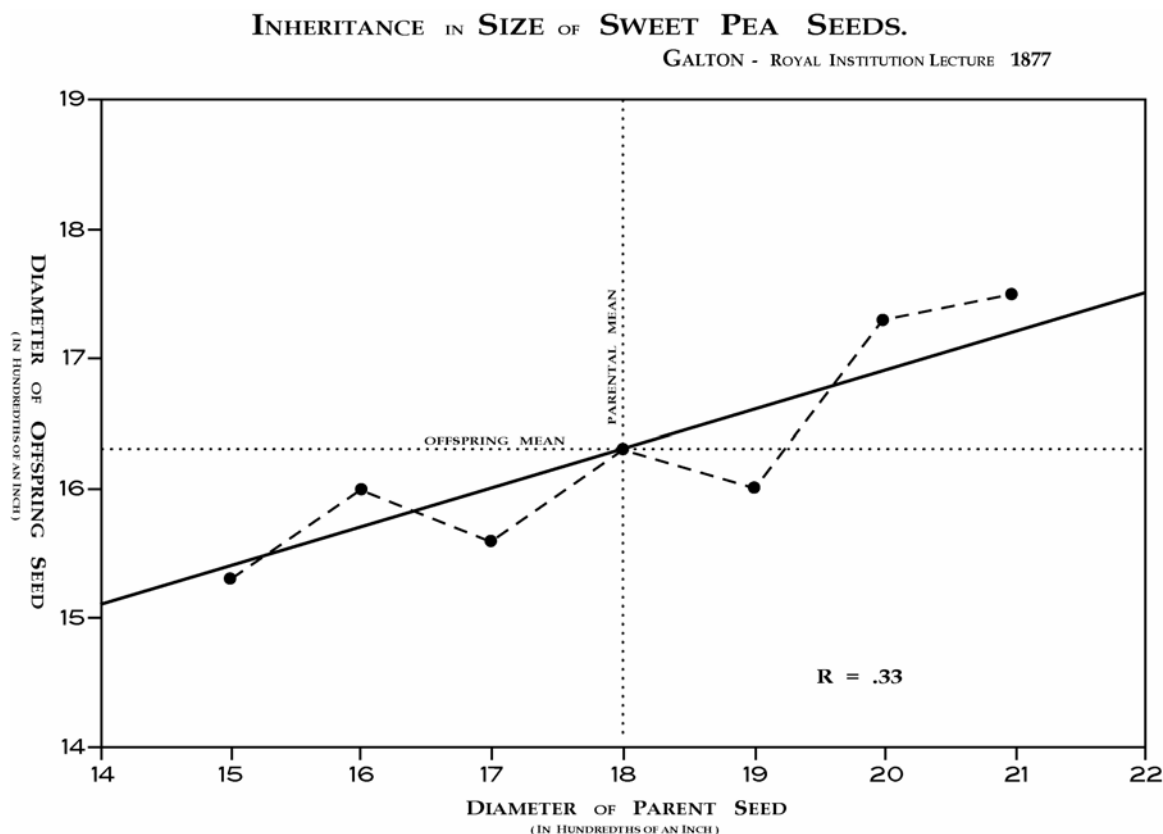
In this case paupers are seen to be concentrated in certain areas and almost absent from others with remarkable statistical reliability. The reliability is so remarkable, in fact, that the fit of the data to the curve is unlikely to have happened by chance. I speculate in more detail in my book, "Injustice" why the fit is so good, but it is worth saying for now that you can find many examples of Victorian academics being a little over-enthusiastic with their graphs.

Karl Pearson's teacher, Francis Galton, drew a graph concerning sweet peas and their hereditary properties where one of the very limited number of sample points hits the mean of both distributions exactly spot on (The graph is reproduced faithfully from an original A4 copy in Magnello and Loon, 2009, page 123). The chance of that part of the sample being so perfectly arranged was pretty low before the event. You might say that the chance of anything is 100% after the event, but Galton's original data is available should you be interested to check whether that is the case. Take a look at the graph (in Figure 5). Don't the little dots form a pleasing pattern? - maybe a little too pleasing. I just point this out to suggest someone checks.

If someone finds that Galton's famous sweet pea graph was a little too good to be true this does not mean that sweet peas did not behave in this way. It is just an example of what was then normal and what, in a slightly tempered form, is still normal amongst many statisticians: to get a little carried away with underlying theories that everything is normally distributed and, if that is not found to be the case then fit the data to such a curve to make it 'normal'. Often when such enthusiasm has occurred but the example is still well known, the theory may be correct, as in the Galton case, it is true that sweet peas behave in this way, but for every true case there will have been thousands of fabricated studies.

Those best remembered are studies on human skull sizes and even penis length correlations to apparent intelligence which were and are still false. (The penis length correlation was negative just in case you were wondering but also fabricated so please don't start worrying about your intelligence if you think you have a long penis - well, on the other hand...). The best known current example of what appears to be fabricated evidence, which nevertheless was used to argue for a real phenomena, was John Snow's map of cholera cases in Soho centred around a water pump in Broad Street. The fact that the cases of cholera were reducing long before the pump handle was removed suggests it may not have been that pump. The fact that he decided to put the pump at the centre of the map before he started drawing in the data suggests that Dr Snow had some premonition that it might be important. It probably was not that particular pump, but it did turn out to be a water born disease.

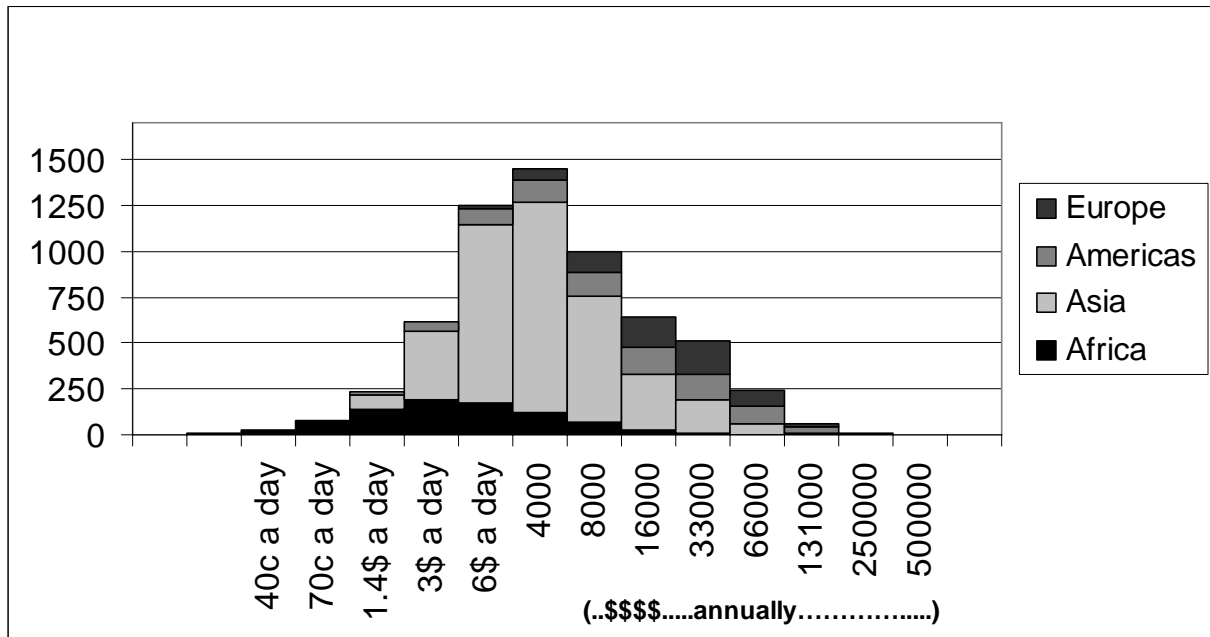
Figure 5 ⁵



Some distributions are normal, but it is not normal that they should be so. Take the world distribution of income drawn using a log scale on the X axis and shown in Figure 6. It appears normal. It partly appears normal because I drew it by adding up log normal curves. I knew the mean and medians of incomes in almost every country in the world and also information on the range and hence standard deviation. That is all you need, if incomes are log normally distributed, to fit a log normal curve for each country. Add those curves up to continents and then the world and you get figure 6. In a few countries inequalities are so great that the actual distribution is bimodal, in others equalities are unusually large and the log normal distribution is too spread out. When summed, these errors tend to cancel each other out (with, including the sum of errors, a little ‘natural normal’ variation maybe for once). What Figure 6 does not tell you, however, is that we have not always lived like this. In the very recent past incomes tended to be much more equitable for most people in most places in the world.

⁵ Source: Magnello, E. and B. V. Loon (2009). *Introducing Statistics*. London, Icon Books. (Page 123)

Figure 6: Distribution of income showing inequality (US\$), worldwide, 2000 ⁶



Notes: X-axis shows a continuous log scale of annual income in comparable dollars, Y-axis shows millions of people living in families supported by such incomes.

Derivation shown below:

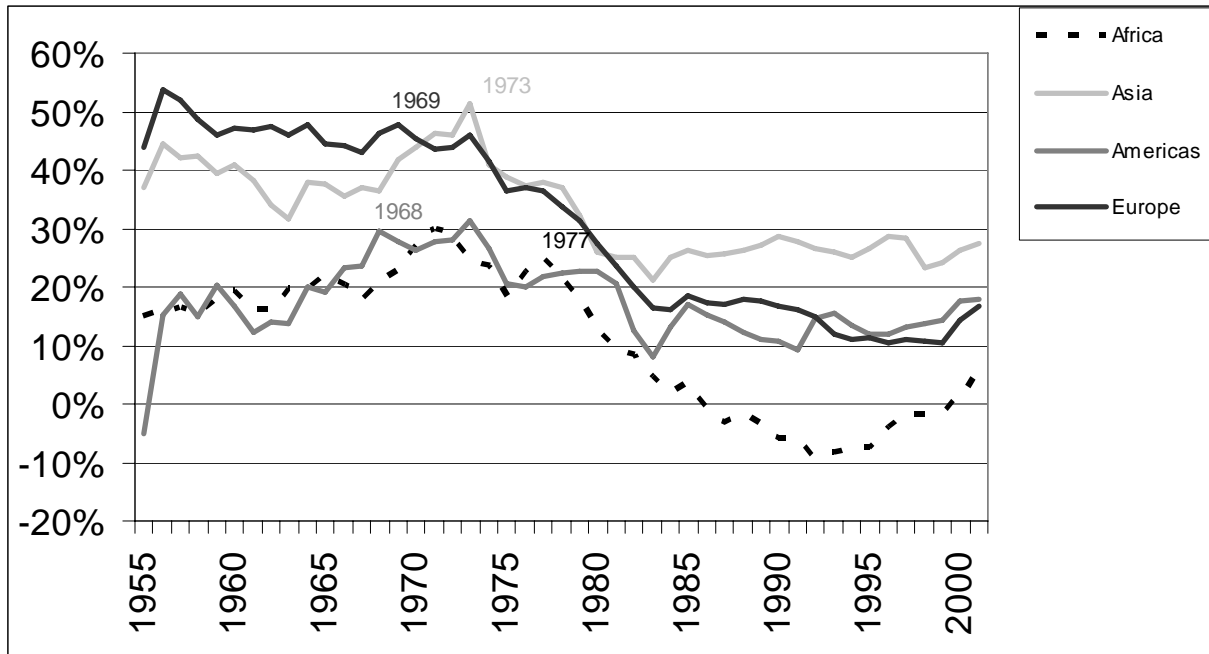
The distributions shown in Figure 6 are log normal partly because the world has become very much more unequal in the last forty years. Between 1968 and 1973 economic growth rates were converging and growth was high in all the continents of the world (see Figure 7). In hindsight such growth is also clearly unsustainable. Growth of such magnitude, of up to nearer 50% increases in national wealth for entire continents in a decade, would require resources beyond the capability of the planet to supply. The first resource to run scarce was oil, but much else also did shortly afterwards. And the result?

By the 1980s it was the poorest continent which was seeing its peoples' incomes fall in real terms; partly because the most expensive continents managed to maintain growth of between 1 and 2% a year by these figures (which are interestingly very different to those many other economists use – but these are from Angus Maddison, so they are especially good ☺). Growth across Asia was higher, but from a much lower base, and across the whole world growth rates were much lower than they had been before and were diverging. In the late 1990s economic growth across Africa, as conventionally measured, finally stopped being negative, but then, and not shown on this series

⁶ Source: Figures (in purchase power parity, US\$) derived from estimates by Angus Maddison, from a version produced in spreadsheets given in ww.worldmapper.org, based in turn on UNDP income inequality estimates for each country.

because it is so recent – came the worldwide economic crash, and rising rates of hunger and starvation in the poorest of countries worldwide. Who will win and lose from this is still all up for grabs.

Figure 7: Real growth per decade in GDP (%), per person, by continent, 1955–2001 ⁷

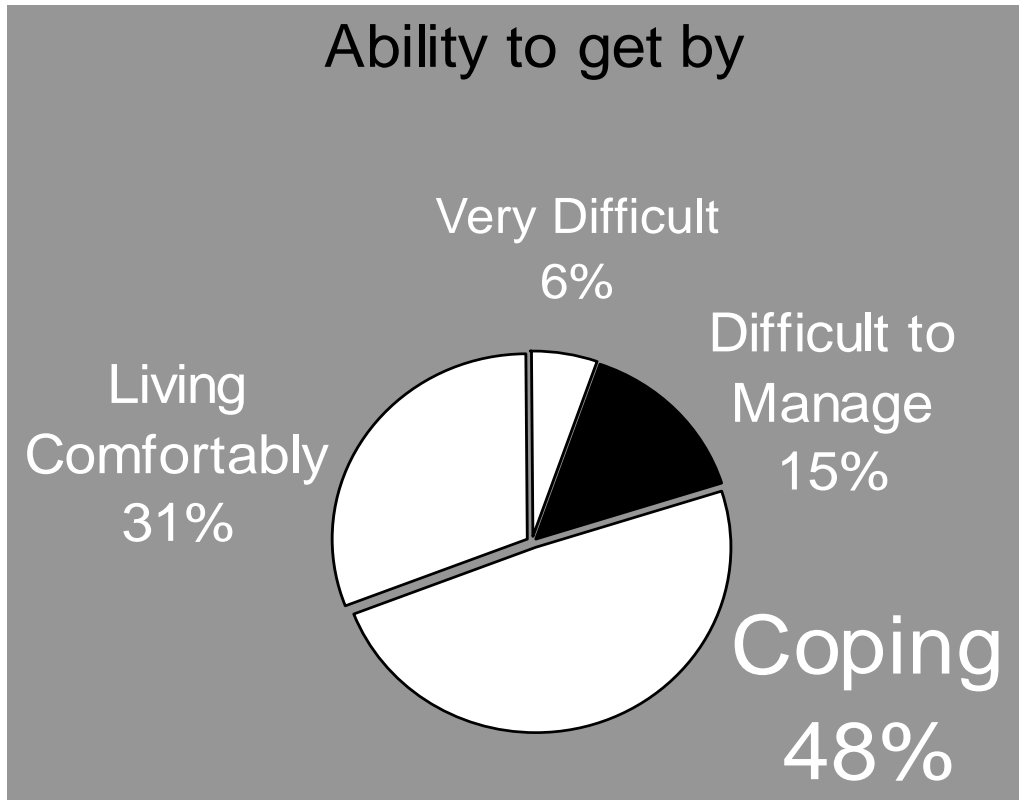


What about back at home? What was happening in Britain? I don't think the picture was good in the 1980s, 1990s and 2000s although Members of Parliament used the figures shown below in Figure 8, and especially those included in the table beneath it to try to argue that people had never had it so good. Look at how few are finding it very difficult to manage they said when the 2004 data was released (a couple of years later). Look at how many are only 'coping' I replied at the time⁸. Since then and with massive cuts on the very near horizon none of this now looks to be very relevant, but please look at Figure 8 and at the table of numbers beneath it and remember that there was both a time when 44% thought they were living comfortably, as the debts funding their comfort grew ever larger.

⁷ Source: Figures (growth in the decade to year shown) derived from estimates by Angus Maddison, from versions provided in spreadsheets given in www.worldmapper.org (constant 1990 \$ used here).

⁸ Dorling, D. (2007). The Soul Searching Within New Labour. *Local Economy*, 22(4), 317-324.

Figure 8: Households' ability to get by on their income in Britain, 1984–2004 ⁹



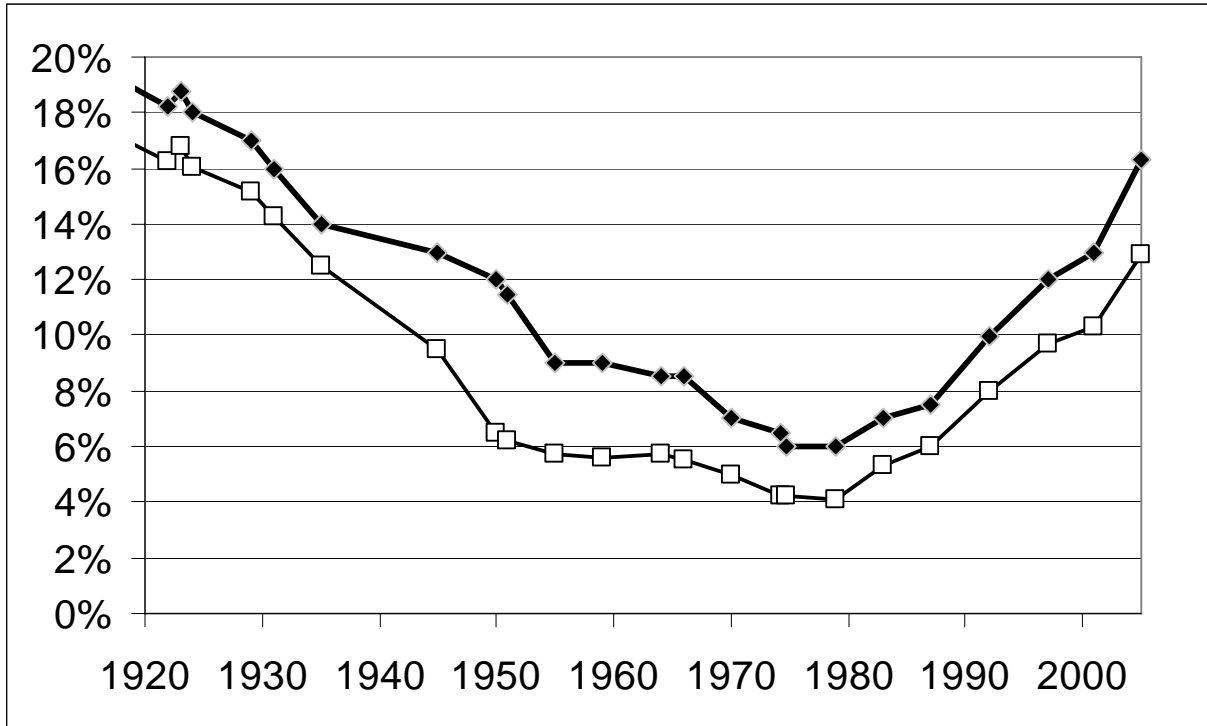
	Mean Average %	1986	1994	2002	2003	2004
Very Difficult	6	8	6	3	3	3
Difficult to Manage	15	18	15	13	10	11
Coping	48	50	49	45	43	46
Living Comfortably	31	24	29	39	44	40

People in Britain were creating their own local versions of reality that could be seen worldwide in terms of unfair income shares becoming ever more unfairly distributed. Figure 9 shows what the best-off 1% have received each year from 1918 to 2005. This paper began with the story of how, in 2010, the Sunday Times rich list reported that the wealth of the richest 1,000 people in Britain had increased by 29.9% in just one year, to stand at £335.5bn. Although they are just a tiny fraction of even the richest 1% of people that huge increase in the wealth alone and the interest they will earn on it is enough to send the final line in Figure 9 up above 1918 heights – and this excludes the

⁹ Source: Derived from ONS (2006) Social Trends (No 36), London: Palgrave Macmillan, table 5.15, p 78, mean of 1984, 1994 and 2004 surveys.

continued payment of bonuses to bankers, the greed at the top and the lack of resistance from below.

Figure 9: Share of all income received by the richest 1% in Britain, 1918–2005 ¹⁰



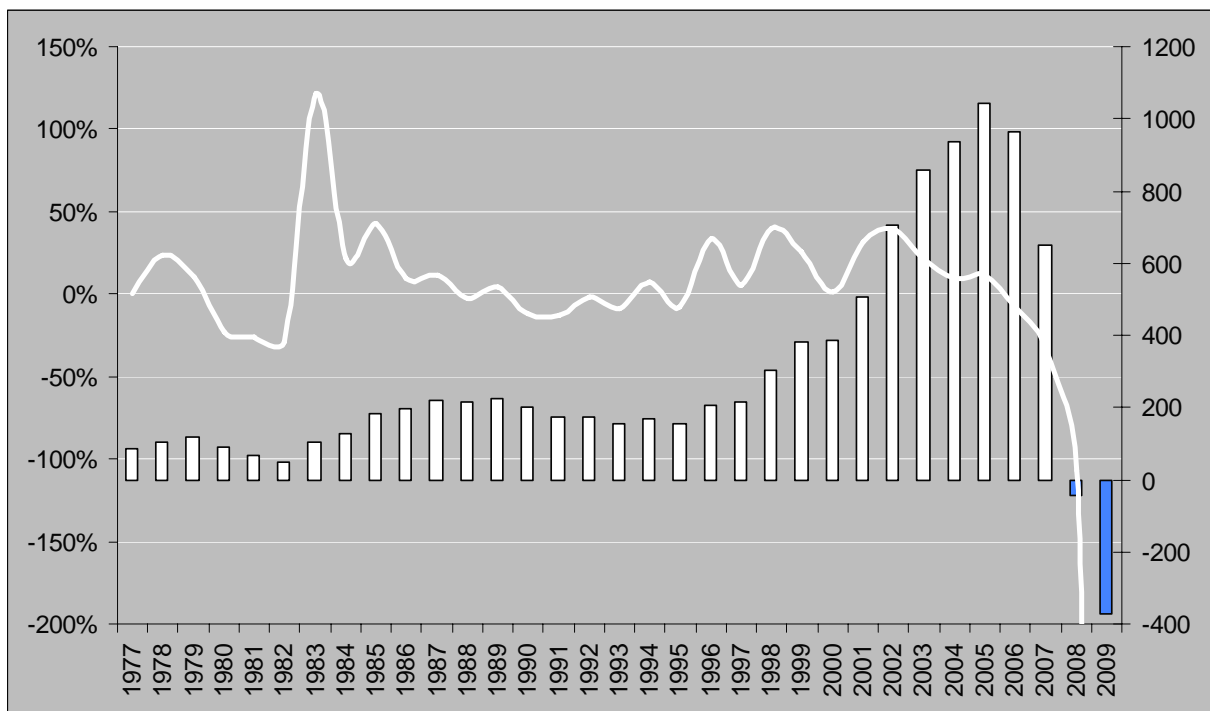
Note: Lower line is post-tax share.

Figure 9 may look bad but look again at what happened when our lives were last this unequal. You'll find few people still alive who can cogently tell you why we progressively became more equal every year from 1918 onwards, but clearly there is still much to play for. We have no idea how the crash will turn out. What we can see, if we draw the graphs, is how very different this crash is from previous ones. The final figure of this paper, Figure 10, shows how – for the first time since figures were collated in the early 1970s – people in the USA are paying their debt back and not taking out more debt. They are curtailing their spending, stopping consuming, on an unprecedented level.

¹⁰ Source: Atkinson, A.B. (2003) 'Top incomes in the United Kingdom over the twentieth century', Nuffield College Working Papers, Oxford (http://ideas.repec.org/p/nuf/esohwp/_043.html), figures 2 and 3; from 1922 to 1935 the 0.1% rate was used to estimate the 1% when the 1% rate was missing, and for 2005 the data source was Brewer, M., Sibieta, L. and Wren-Lewis, L. (2008) *Racing away? Income inequality and the evolution of high incomes*, London: Institute for Fiscal Studies, p 11; the final post-tax rate of 12.9% is derived from 8.6%+4.3%, the pre-tax rate scaled from 2001.

What will happen? Nobody knows. But you can update the graph every quarter using the link to the Federal Reserve given as the source. You can get access almost as quickly as any finance minister. This may not be the televising of a revolution but it is the making public of a change in times. The numbers are made public because the people releasing them do not imagine that there is anyone out there, numerate and with a different view of the world. How could there be, they'll think. People exist along a normal curve of ability, they believe. At the top are us economists who know that there is no alternative.

Figure 10: The crash: US mortgage debt, 1977-2009 (% change and US\$ billion) ¹¹



Notes: Right-hand axis, net US\$ billion additional borrowed in year shown by the bars in the graph.

Left-hand axis: percentage change in that amount. Final percentage change unknown but to be based on a denominator of 'just' -46 US\$ billion (the only negative bar). It is shown plummeting down off the scale.

As of February 2010 third quarter mortgage debt flow was US\$-370 billion, consumer credit US\$-82 billion, total debt increase had fallen under a trillion dollars for the first time since 2000 excluding the financial sectors. Including these sectors, total US debt fell to the third quarter by US\$276 billion. It has never fallen in this series before, and has fallen in every quarter of 2009 so far reported. Business total debt fell for the first time since 1992 and the fall was much greater: some

¹¹ Source: US Federal Reserve: Debt growth, borrowing and debt outstanding tables (www.federalreserve.gov/releases/Z1/Current/)

US\$284 billion by the third quarter of 2009. Only local, state and federal governments kept up borrowing levels to try to deal with the crisis.

Data for Figure 10

Year	Household debt	change (%)	Year	Household debt	change (%)
			1993	157	-9%
1977	86	-	1994	167	7%
1978	106	23%	1995	154	-8%
1979	117	10%	1996	206	33%
1980	90	-23%	1997	216	5%
1981	67	-26%	1998	302	40%
1982	47	-29%	1999	380	26%
1983	105	122%	2000	386	2%
1984	127	21%	2001	507	31%
1985	182	43%	2002	706	39%
1986	199	10%	2003	860	22%
1987	222	11%	2004	938	9%
1988	216	-3%	2005	1041	11%
1989	225	4%	2006	964	-7%
1990	199	-11%	2007	652	-32%
1991	174	-13%	2008	-46	-107%
1992	171	-1%	2009	-370	-801%

These have been just a few graphs and tables taken from many others and all provided here, for free and with the formula and assumption, links and equations put in. There'll be errors too. That's why it's good to share:

<http://www.sasi.group.shef.ac.uk/injustice/>

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Appendix: The OECD descriptions from the PISA study report from which I derived the labels used in Figures 1 and 2 and in the accompanying text.

Source: page 14 of OECD 2007 Executive Summary PISA 2006: Science Competencies for Tomorrow's World.

Note: I have used **bold** for the words I use to summarise what I think (subjectively) each level implies. I have added one word in square brackets and the proportions unable to pass each test. I have also made up the level 0 description as that is missing from the original table. My additions are in italics and enclosed by square brackets. The most subjective thing I think I've done here is to call one category "barely adequate" when they say "adequate" (and then just use 'barely') as I think that is the sense they imply for the above – you read and make up your own mind. Everything we do is of course subjective - a better term for objectivity is inter-subjectivity - when a group of people's subjectivities agree. Eugenics was an example of a set of subjective judgements being in agreement.

Student proficiency in science

What students can typically do at each level on the science scale

Level 6 Must score: 707.9

1.3% of students across the OECD can answer questions at Level 6.

[98.7% cannot]

At Level 6, students can consistently identify, explain and apply scientific knowledge and *knowledge about science* in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate **advanced** scientific thinking and reasoning, and they demonstrate willingness to use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, socio-economic, or global situations.

Level 5 Must score 633.3

9.0% of students across the OECD can answer questions at least at Level 5. **[91.0% cannot].**

At Level 5, students can identify the scientific components of many complex life situations, apply both scientific concepts and *knowledge about science* to these situations, and can compare, select and evaluate appropriate scientific evidence for responding to life

situations. Students at this level can use well-**developed** inquiry abilities, link knowledge appropriately and bring critical insights to situations. They can construct explanations based on evidence and arguments based on their critical analysis.

Level 4 Must score 558.7

29.3% of students across the OECD can answer questions at least at Level 4. **[70.7% cannot].**

At Level 4, students can work **effectively** with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions and they can communicate decisions using scientific knowledge and evidence.

Level 3 Must score 484.1

56.7% of students across the OECD can answer questions at least at Level 3. **[43.3% cannot].**

At Level 3, students can identify clearly described scientific issues in a range of contexts. They can select facts and knowledge to explain phenomena and apply **simple** models or inquiry strategies. Students at this level can interpret and use scientific concepts from different disciplines and can apply them directly. They can develop short statements using facts and make decisions based on scientific knowledge.

Level 2 Must score 409.5

80.8% of students across the OECD can answer questions at least at Level 2. **[19.2% cannot].**

At Level 2, students have **[barely] adequate** scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving.

Level 1 Must score 334.9

94.8% of students across the OECD can answer questions at least at Level 1. **[5.2% cannot].**

At Level 1, students have such a **limited** scientific knowledge that it can only be applied to a few, familiar situations. They can present scientific explanations that are obvious and follow explicitly from given evidence.

[Level 0 Must score – below 334.9
100.0% of students across the OECD can answer questions at least at
Level 0. **[0.0% cannot].**

At Level 0, students have measurable scientific knowledge in our range 0 to 334.9. We are very precise at the OECD so feel the need for all these decimal points. Children at level 0 don't apply what we think we have taught them as we'd like. They appear unable to present scientific explanations in the way we think is obvious and they do not follow explicit instructions as we would like them to. We put 5.2% in this group amongst rich countries. Perhaps the majority of the world's children and most older adults even in affluent countries would be placed here too if they took our tests. It is not obvious that our tests are objective or fair.]