More Equal Societies Almost Always Do Better
Wilkinson & Pickett 2009

Measuring the Digital Divide

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Those online enjoy an **advantage.**

Digital inclusion provides new opportunities,
in education, employment, health, and social well-being.

The distribution of broadband may strengthen or reduce inequality

How can we quantify the **effects** of broadband access **on inequality**?

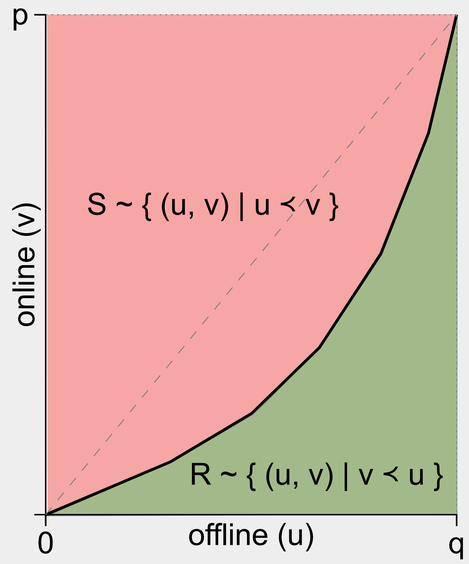
Inequality is a transitive irreflexive relation b < a .

Consider two households,
with b more deprived than a : b < a

If b is online, while a is offline, then b's digital advantage **R**educes existing inequality.

If a is online, while b is offline, then b's digital disadvantage **S**trengthens existing inequality.

A *shuffle graph* plots cumulative households online against cumulative households offline, for each level of deprivation, to give a *Lorenz curve*.



The area **S** above the curve represents the offline-online pairs that **S**trengthen inequality, while the area **R** below represents the **R**eductions

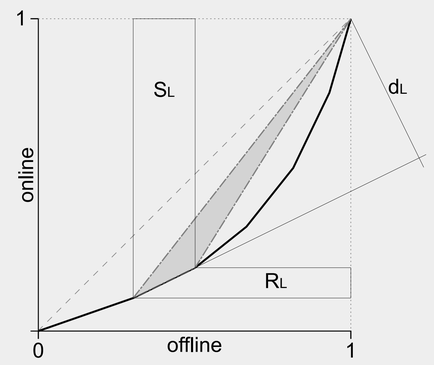
The normalised difference **(S-R) / (S+R)** is the **depth** of the divide.

We interpret the depth of the divide as a measure of the deprivation-related barriers to inclusion. It is normalised to take values in the range [-1,1],

Depth is a **relative measure**:
it quantifies the deprivation of the offline population, relative to those online.

An **absolute measure** of the net contribution of the digital divide to inequality is given by comparing (S - R) to the value $P^2 / 4$ for the extreme case in which the most deprived half of the population is offline, and the rest are online, so that every offline household is more deprived than every online household. We define the **breadth of the divide,** to give range [-1, 1]:

$$4 \times (S-R) / P^2$$



The depth of the divide.

Here, the shuffle graph is scaled to the unit square. (S - R) is twice the area enclosed by the Lorenz curve and the line of perfect equality.

The net effect of the divide on a local population, L, is proportional to the area of the shaded triangle in the diagram, which is equal to

$$(S_L - R_L) / 2 .$$

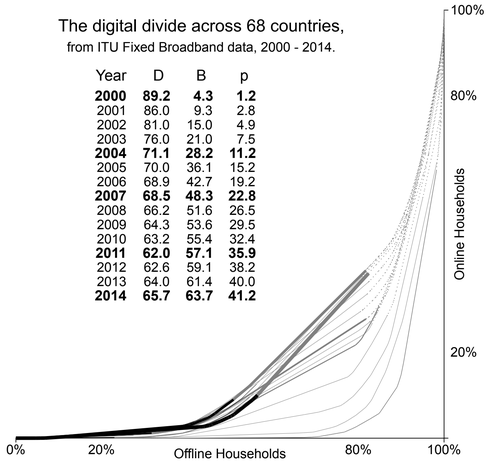
The height of the triangle, d_L, gives a local measure of depth.

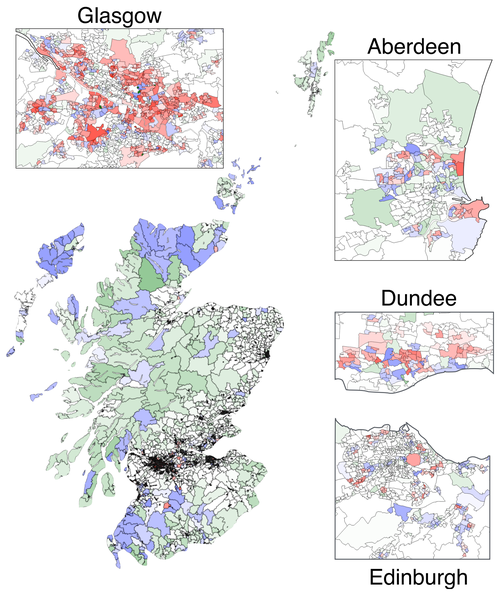
Y	1990	1994	1998	1999	2001	2002
p	15.9%	22.6%	36.6%	42.1%	51.0%	56.5%
C	40%	39%	31%	30%	26%	23%
B	25.4%	35.3%	45.4%	50.5%	53.0%	52.0%
D	47.6%	50.4%	48.9%	51.8%	53.1%	52.9%

USA Home computer uptake

The digital divide across 68 countries,
from ITU Fixed Broadband data, 2000 - 2014.

Year	D	B	p
2000	**89.2**	**4.3**	**1.2**
2001	86.0	9.3	2.8
2002	81.0	15.0	4.9
2003	76.0	21.0	7.5
2004	**71.1**	**28.2**	**11.2**
2005	70.0	36.1	15.2
2006	68.9	42.7	19.2
2007	**68.5**	**48.3**	**22.8**
2008	66.2	51.6	26.5
2009	64.3	53.6	29.5
2010	63.2	55.4	32.4
2011	**62.0**	**57.1**	**35.9**
2012	62.6	59.1	38.2
2013	64.0	61.4	40.0
2014	**65.7**	**63.7**	**41.2**





Results

An early analysis of computer usage 1990-2002, using the Concentration Index, presented a rosy picture of falling inequality, globally and locally. Revisiting the data for home computer usage, we find that the breadth of the divide, which we interpret as its societal impact, grew significantly, The depth of this divide also grew, until 2001.

Analysing more recent ITU data for 68 countries, from 2000-2014 we find that the breath of the global divide is steadily growing, while the depth of the divide, which fell from 2000 until 2011, is now rising.

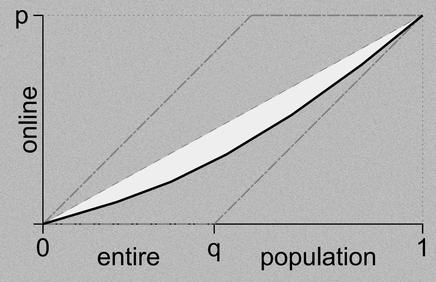
Using fine-grained, postcode-level data, we have examined the distribution of domestic broadband in Scotland, in relation to the Scottish Index of Multiple Deprivation (SIMD). The map shows Scotland's 6505 output areas, the insets focus on Glasgow, Aberdeen Dundee & Edinburgh. **Opacity** represents the local depth of the divide.

Colour indicates the marginal effects of increased inclusion:

- in red areas it would reduce the breadth and depth of the national divide
- in blue areas it would reduce the breadth of the national divide, but increase its depth
- in green areas it would increase both breadth and depth.

To reduce the divide, interventions must focus on the red and blue areas.

The **Gini Index,** or **Concentration Index, C, is** based on a plot of **cumulative income** v. **population ordered by income.**
It is twice the gap between the line of perfect equality and the Lorenz curve, as a proportion of the area, p, of the rectangle. Our depth index measures the same area, relative to the area, pq, of the parallelogram. Wagstaff 2005 suggests a renormalisation for binary outcomes – dividing C by q – which is equivalent to our depth index.



Our breadth index, 4p times C, is Wagstaff's generalised concentration index, which he introduced (in 1991) as an absolute measure of inequality (we scale his index to give a range [-1, 1] for application to a binary variable).