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Editorial

Cities in a completely urbanised world

Stimulated by recent projections that world population was likely to flatten out at around 9 billion this century but with urbanisation continuing inexorably, I wrote a Commentary in 2011 in our sister journal *Environment and Planning A* (Batty, 2011) which sketched out the prospect of a world where all but a tiny fraction of the population were urbanised and where the dominant patterns of growth and decline would be generated by migration. This prospect, of course, conjures up the notion that everybody will live in large cities, which is unlikely to ever be the case, or of a world where everybody is spread out much more thinly across the planet but connected using all the instruments of transport and communications that we now have at our disposal. This too is unlikely, for it would require a very dramatic loosening of the effects of geometry and distance. In fact since my Commentary, it appears that world population is flattening out somewhat less quickly than assumed and recent projections suggest that this demographic transition for global population may not be as strong as was then implied. Gerland et al (2014) report that by the year 2100, the world's population will range between 9.6 and 12.3 billion, estimates much narrower than the UN's previous figures where the highest was some 16 billion but not as small as the 6.7 billion low variant which implied a decline in population from 7.3 billion after it had peaked somewhere around 8.3 billion in the mid-21st century (http://esa.un.org/unpd/wpp/unpp/panel_population.htm).

What, however, is changing at a much faster rate than population itself is its urbanisation. The famous milestone in 2008 when half the world's population was deemed to be urban will increase to 66% by 2050. The trend associated with the ten-yearly increase in the percentage urbanised is strongly linear with this proportion increasing at around 10% per decade at present but predicted to fall to about 5% by the end of the century when some 85% of the total population will be urbanised. Projections suggests that the entire population will be urbanised by 2140. All of this of course begs the question as to what we mean by 'urbanised'. In fact, the term is rarely defined, being used very loosely in many contexts to imply populations and their infrastructure that are living in towns and cities where the density of population implies more or less continuously built-up structures. Even this frays a little on the edge for in suburban or exurban areas—terms also used to refer to types of urbanisation—structures may be far apart but usually within sight of one another, although this is hardly a rigorous definition. If you Google the word urbanisation, then invariably you get many definitions that refer to populations as living in town and cities. Indeed the word 'city' appears in most definitions. The English edition of Wikipedia defines urbanisation (http://en.wikipedia.org/wiki/Urbanization) as a process of "population shift from rural to urban areas" which in turn pushes the focus onto what a rural or urban area is. Drilling down further in Wikipedia, an urban area is defined (http://en.wikipedia.org/wiki/Urban_area) as "a location characterized by high human population density and vast human-built features in comparison to the areas surrounding it. Urban areas may be cities, towns or conurbations, but the term is not commonly extended to rural settlements such as villages and hamlets."

So a completely urbanised world is a world where everywhere is a town or a city. One of the scenarios this kind of prediction conjures up is of a world where everything looks like a big city. But the evidence suggests otherwise. Although there is some sense in which world cities are getting bigger and more polarised, it appears that their densities are still falling. As far as I know, there is no good source of data on the density of towns and cities worldwide

from which we could test this speculation, but casual evidence suggests that this is the case. We are however able to examine the size distribution of cities, the structure of which has remained stable for at least two centuries, probably much longer. This distribution is formed from a small number of large cities all the way to a large number of small cities. In its crudest form—although a gross simplification—the largest cities in the distribution appear to follow a power law but the frequency is probably lognormal. This means that at the lowest end of the distribution, where towns and cities are the smallest, there are fewer of these than there are of slightly larger places: in fact, at the lowest end, these might be hamlets and villages with some debate as to whether or not these qualify as urban areas as the Wikipedia definition also implies. Nevertheless, the lognormal can be approximated in its heavy tail by a power law, notwithstanding the fact that one has to be particularly careful in defining a system of cities that in some sense is integral to the efficacy of these forms of law (Cristelli et al, 2012).

What all this implies in a completely urbanised world is that the distribution of cities will remain roughly the same as it has been for millennia: there will be many small towns, a lesser number of larger cities, and a tiny number of really large ones—megacities. A completely urbanised world implies that most of us will be living in small towns rather than big cities. To get a sense of this, we can examine the distribution of the largest cities—those over 750 000 in 2010. We do this for the last sixty years where the smallest city in the 2010 set of 590 cities in 1950 was just 10 000. This is to an extent a relative analysis because we are not taking just the cities over 750 000 in 1950 and comparing these over time, we are excluding cities that were greater than 10 000 in 1950 but had not reached 750 000 in 2010. However, these are the best data we can get for the distribution of world cities over the last half century (derived from the UN Population Division by Norphil, https://nordpil.com/resources/world-database-of-large-cities/). These distributions are shown in figure 1 and it is very clear that, although the cities in the set move up and down this hierarchy, the distribution is quite stable but with a significant trend in terms of the relative positioning of cities. In short, the distribution 'tends' to be getting a little flatter through time and this implies that the larger cities are becoming somewhat less significant than the smaller.

In fact, there is considerable evidence from individual city systems, often organised by countries, that the rank-size or Zipf plot which is what figure 1 shows falls in its slope over time. We can of course measure this fall in slope if we fit regression lines to the data in figure 1 but, because the implication is that these data are lognormally distributed, we will approximate the dataset by taking only the first 100 cities at each time period. The regressions show good fits with $r^2 = 0.991$ for 1950 and $r^2 = 0.963$ for 2010, with the slope falling from 0.656 to 0.567 over the sixty-year period. Explanations of this decline probably relate to the impact of new technologies on how cities increase in size with lower densities and also the impact of globalisation and information technologies on how cities connect to one another. What this really shows is that in an entirely urbanised world, the majority of cities will be small rather than large.

A good way of demonstrating the relative importance of large and small cities from this dataset is to form indices of primacy. In many systems of cities, the largest city often dominates the set more than proportionately or rather more than the pure form of Zipf's Law suggests (which means that the second sized city is half the size of the first, etc). If the largest city is more than twice the size of the second largest, this ratio of sizes can be regarded as a measure of primacy, as first discussed by Jefferson (1939). In some cases, it is called the 'king' effect, with Pisarenko and Sornette (2012) referring to it as a 'dragon king' where it is particularly strong. In fact in the data we have, the ratio is less than 2 for the earlier time periods and only reaches 2 in 1990 to fall back over the last twenty years to about 1.82. This data does not show primacy in any sense, and if we take the ratio of the first to the sum of the next four cities, this value falls from 0.54 to 0.47 over the period. If we take the ratio of

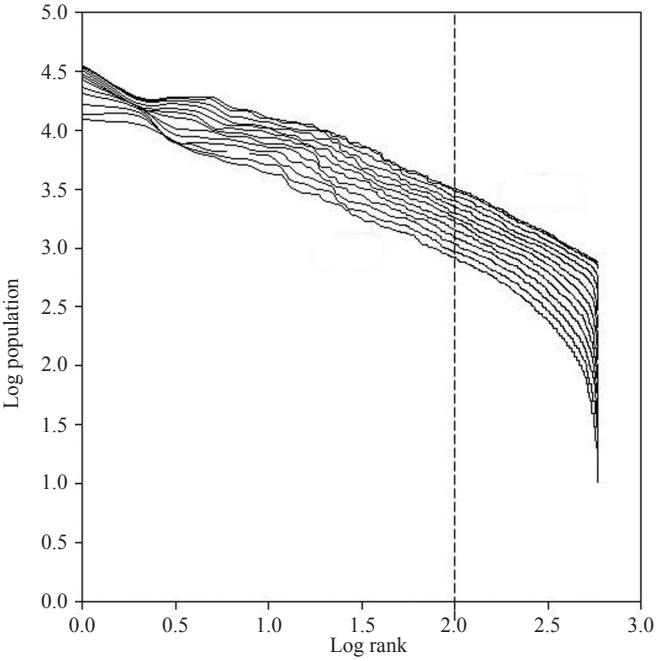

Figure 1. Rank-size distributions of all cities greater than 750 000 population in 2010 from 1950.

the first to the next nine, this falls even further from 0.31 to 0.26, evidence that at the top of the hierarchy of cities, the biggest ones are losing their supremacy. All this is consistent with the notion that, as the proportion of population living in cities (urbanisation) increases, the domination of the urban hierarchy by large cities will continuously weaken.

What we now need to explore this kind of future is an integrated database that defines the largest set of cities as possible across the globe. The first problem with defining city size distributions is that they are invariably incomplete. The second issue is that defining cities spatially is problematic especially as cities grow into one another and there are no standard definitions. The third issue is that we need to link city size distributions to their densities and, although this might seem trivial, it is rarely done. The fourth issue is that systems that grow from the simplest origins. As new cities enter the set, this changes the nature of the distribution, and makes it hard to generate stable estimates. This is a classic problem in the data we have used here where cities in 2010 which are significant, need to be present in 1950 for the city size distributions in the intervening years to be comparable. But there are cities that are much larger in 1950 that do not meet the cutoff in 2010 of 750 000 and are thus absent, thus limiting the analysis. My hunch is that the distributions we have used here to speculate on an entirely urban future go some way to making sense of what this future will be like but we need to resolve these methodological problems before we are able to produce a more complete picture.

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