# How large must a population be to accomplish great things?
## A question for social complexity scholars

Brian Castellani and Rajeev Rajaram
Sociology and Complexity Science Blog (17 Sept 2019)

**NOTE: Please cite this blog post as follows: Castellani B., and Rajaram R. (2019) 'How large must a society be to accomplish great things?' *Sociology and Complexity Science Blog*, 5 Sept 2019.**

## THE ROLE OF POPULATION SIZE IN INTELLECTUAL/ARTISTIC TRIUMPHS

How large must a society be to accomplish great things? Or how about even a region or city or town? Is there a certain population size/density required for intellectual or artistic genius or brilliance to emerge? In turn, is there a tipping point past which a population becomes too big, such that only certain types of intellectual or artistic brilliance are recognised? And if so, how and why?

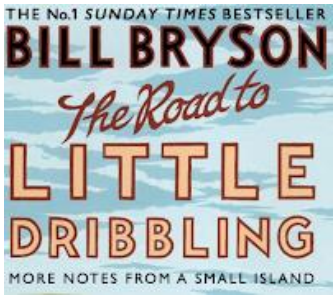
These are the kinds of questions that Rajeev Rajaram and I (Brian Castellani) have been chatting about for the past few years. They come from both a growing list of empirical examples that have intrigued us, as well as from our involvement in a series of interrelated fields of study within the complexity sciences, in particular the study of diversity in complex social systems.

To begin, we will start with our empirical intrigues – each of which sort of gets at or illustrates what we have been thinking about.

## EMPIRICAL INTRIGUES

1. The first comes from a biography of the famous British painter, David Hockney. When asked about the fame he had received for his work, he basically said that, talent aside, it was somewhat all a matter of luck and being in the right circumstances. In terms of luck, he explained that, as he rose in the art scene, he knew lots of hard-working artists who were just as talented as him (if not more) but who never really obtained the success their work deserved. It seemed, he said, like there was some sort of restriction on the number of people who could be artistically famous – most likely, he felt, due to market pressures and the ridiculous prejudices of art critics and the art world. And, in terms of being in the right place, he worked in London and then Los Angeles, which were emerging artistic hubs in the 1960s and 1970s.

2. The second comes from reading thought the 2019 listing of top UK universities in the 2019 Times Higher Education World University Rankings. It is amazing that, for a country of only 66.9 million people, the UK has so many universities in the top 100. Bill Bryson, the famous travel writer, made a similar point in *The Road to Little Dribbling*. "*Britain has 1 per cent of the world's population, but 11 per cent of its best universities, and account for nearly 12 per cent of total academic citations and 16 per cent of the most highly cited studied.... I very much doubt if there is any other realm of human endeavour in the country that produces more world-class benefit with less financial input than higher education. It is possibly the single most outstanding thing in Britain today (p. 357).*" In other words, relative to its rather small population, the UK is an intellectual powerhouse.




3. The third comes from a documentary on the beginnings of *Motown Records* in the States (1952 to 1972). We cannot remember exactly who they were interviewing, but we are pretty sure it was Berry Gordy, the founder. He made an interesting point in response to the massive talent that came from Motown Records, including Diana Ross and the Supremes, Marvin Gaye, Gladys Knight and the Pips, Smokey Robinson and Stevie Wonder to name a few. Gordy explained that, in any given community, as in the case of the music scene that emerged in Detroit Michigan, there is a tremendous amount of talent to be found in small places. The challenge, however, is for someone to recognize this fact and to provide the conduit for it to reach the heights it was born to achieve. And, in the case of Motown records, this also meant specifically overcoming racism and discrimination against African-American musicians in these communities. In other words, a relatively small community can produce genius, but only if certain key social conditions are present!

4. The fourth concerns the tremendous challenges one faces in gaining admission to the top universities in countries like India and China, given the size of their respective populations. India, for example, has over 1.34 billion people. The result is that there are obviously far more talented people than can enter the university system, making competition massively difficult if not impossible for some, particularly for those coming from disadvantaged backgrounds. In other words, it seems that, past a certain tipping point, populations become too large to make the most of their respective talent.

5. The fifth example comes from a very interesting study by Michel Serafinelli (Assistant Professor, Department of Economics, University of Essex), titled, *Creativity and Freedom*. Serafinelli explains the thesis of his project on his blog. He states:

*"Creativity is often highly concentrated in time and space, and across different domains. In the 15th century, Florence was home to an amazing number of ground-breaking innovators in literature, painting, sculpture, philosophy, and science. At the turn of the 19th century, Vienna hosted pioneers in painting, medicine, biology, psychology, philosophy, music, who all interacted with one another. London in the late 16th century, Paris in the early 19th century, and San Francisco and New York in the past few decades are some other examples of clusters of creativity and innovation in a number of seemingly unrelated domains (Banks 1997, Kandel 2012). What explains the formation and decay of such clusters of creativity? Are they driven by wealth, by specific features of local institutions, or by mere chance? More generally, aside from these exceptional clusters, how concentrated are creative activities in time and space? Is there co-agglomeration of creative people from different fields?"*

In terms of an initial answer to these questions, several conclusions were of particular note:

- *"First, births of creative people and famous immigrants are spatially concentrated, generally more so than population"* (See Figure 1).
- Also, the cities where many of these highly talented people were born or immigrated to were not necessarily the largest. However, large cities tend to have a higher level of talent than smaller cities.
- Also, creative cities are often geographically clustered (See Figure 1).
- In turn, many small cities never establish themselves in terms of significant talent. In other words, it seems that the majority of small cities never become intellectual or artistic hubs.
- However, change does take place across time in terms of the most creative cities. Serafinelli states, "*Estimating a transition matrix, we also find that persistence of creativity is higher at the bottom of the distribution than at the top. Most small and uncreative cities remain in that condition. But at the top of the distribution there is more reshuffling in creative clusters than for population – while most large cities keep growing and remain large, creative clusters exhibit more change over the centuries*."

*Figure 1: Spatial distribution of births of famous creatives, 19th century*

Which takes us to Serafinelli next point. Relative to the social forces necessary for such creative accomplishment, he found that:

- *"First, the protection of personal and economic freedoms changed the local culture, making it more receptive to innovations and new ideas."*
- *"Second, the new institutions also changed incentives, through a more meritocratic and inclusive social environment, but also by encouraging works of art and innovations that would enhance the prestige of the city."*
- *"Third, free cities attracted talented and creative individuals who escaped censorship and persecution elsewhere, and this created role models and facilitated social learning, breeding new generations of innovators."*
- *"These channels are not mutually exclusive, and it is likely that they are all relevant, although in our research we cannot discriminate amongst them. But, whatever the mechanism, the historical evidence strongly supports the idea that open and democratic institutions breed innovation and creativity."*

In short, while population size is important and while regional concentration (particularly in cities) is also crucial, the presence of key socio-historical and economic and political factors is vital.

## INTERRELATED FIELDS OF STUDY

In terms of the fields of complexity science that have motivated our interest in the relationship between populations and their creativity, the most important is the study of diversity in systems, which has to do with the role that differences and variety play in the self-organisation of complex social and ecological systems. Through the work of Scott Page and others, for example, a major focus is the role diversity plays in innovation, invention, creativity and advance. And, as developed through our recent work, it has to do with the multiple pathways and trajectories along which complex systems evolve.

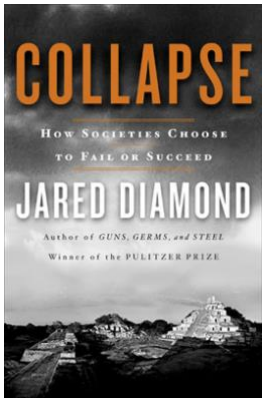
In fact, *pace information theory and the work of* Claude Shannon, we have developed our own approach, which we call $Cc$, **case-based entropy.** (Later in this post we provide a quick introduction. For an in-depth review, click here.)

The measurement of diversity in systems is a rich field of study. For example, do those cities or societies with a greater level of diversity richness and evenness in terms of artistic and intellectual types, accomplish greater things than those that do not? And, if so, could you compute this optimal level or diversity richness and evenness for any given system, particularly for unknown cases or under certain constraints?

The second field is the study of tipping points, which has to do with the thresholds at which complex systems shift from one way of being to another. A related concept, which goes back to the early work of Per Bak and colleagues, is called self-organised criticality. In the case of the current study, for example, we want to know if there are population tipping points that suddenly allow for major artistic and intellectual triumphs?

The third is the study of scale-free networks, which has to do with how the distribution of cases in many complex networks is skewed-right, such that the majority of cases reside within the lower bound of probability types. For us, a similar question emerged: once a certain population threshold is met, if you used $Cc$ to plot the distribution of intellectual and artistic achievements for a city or society, would it be skewed-right, such that the majority of such cases would be reside within its lower-bound? In other words, are most artistic and intellectual accomplishments beholden to some type of restricted diversity in terms of the notoriety and success that they achieve, such that the highest frequencies of cases constitute a minor contribution?

The final area, defined as the study of social systems, has to do with the complex causal factors involved in how societies are formed, evolve and, in many instances, collapse or fall apart. Given that such inquiries are of concern across the social sciences, from sociology and history to anthropology and political science – as well as in such fields as post-structuralism (i.e., Foucault, Lyotard, etc) and globalisation studies (i.e., Giddens, Castells, etc) – the available empirical and theoretical literature upon which one can draw is considerable.




Our focus is fortunately rather specific, as we are interested in the role that population size/density/clustering play in the accomplishments of a city or society. As such, we have spent considerable time exploring the work of Jared Diamond, in particular his two provocative books, Guns, Germs and Steel and Collapse: How Societies Choose to Fail or Succeed. In similar fashion to Diamond, we are interested in what set of population conditions are necessary for a city or society to suddenly tip-over into a situation where it has the capacity to achieve significant intellectual and artistic accomplishments? Also similar to Diamond, we want to know if, sociologically speaking, a population can become too large, such that, relative to artistic and intellectual achievement, negative relations of power emerge that exclude, marginalise, suppress or close-off competition?

## SIX KEY QUESTIONS

So, in summary, we have six key questions, which others may likewise find interesting or worthwhile exploring, as we presently have, at best, a tentative or no answer to them:

1. **POPULATION MINIMUM:** To begin, is there a necessary minimum population concentration/size needed for a complex social system (be it a city or society, etc) to achieve a considerable degree of artistic and intellectual greatness?

2. **POPULATION MAXIMUM:** Conversely, can these complex social systems cross a tipping point where the population is too large for all of its greatest accomplishments to be recognised?

3. **MECHANISMS OF POWER:** Also, due to negative relations of power (i.e., social closure, discrimination, marginalisation, etc) do these complex social systems, once past this tipping point, limit the richness and evenness of their diversity of recognised talent, such that a significant amount of artistic or intellectual ability is missed, excluded, appropriated or oppressed?

4. **PROBABILITY ISTRIBUTION OF ACCOMPLISHMENT:** Also, statistically speaking, once the size of a population meets the minimum threshold for intellectual or artistic greatness, does the distribution of accomplishments (exclusionary or not) form a skewed-right distribution, such that the majority of accomplishments are located in the lower-bound? In other words, are the majority of accomplishments (the highest population frequencies) modestly to minimally recognised or of importance, similar to how most nodes in a complex network have only a small number of links?

5. Also, can this skewed-right distribution be effectively modelled using $Cc$ – our case-based entropy approach – with or without long-tail and whether or not the distribution fits a power-law?

6. And, finally, does this skewed-right distribution fit the 60-40 rule, such that when measured using $Cc$, 60% (or more) of artistic and intellectual accomplishments reside within the first 40% (or less) of the lower bound of equiprobable diversity types— again, with or without long-tail and whether or not the distribution fits a power-law?

## DEFINITIONS

To make better sense of our six research questions, a few quick definitions are in order. First, by '***artistic and intellectual accomplishments***' we mean everything from music and architecture to the plastic arts and literature to sports and theatre to engineering and technology to philosophy and the sciences.

Second, by '***greatness***' we mean accomplishments that inspire people to recognise something as exceptional and distinct from the everyday; something created that inspires people or brings them great joy or improved well-being; in short, the things for which we generally reserve the words 'brilliant,' 'incredibly talented,' 'gifted,' 'genius' or 'remarkable.'

Third, by **'*recognised*,'** we mean that the relevant people (and potentially even a majority) in a society, city, town or community are aware of and acknowledge the greatness of the intellectual or artistic accomplishment and its creator(s).

Fourth, by **'*diversity*'** we mean the **richness** (number of different types of artistic and intellectual endeavours) and the **evenness** (relative abundances of the different types of endeavours) of a complex system.

By **'*diversity type*'** we mean some form of artistic or intellectual endeavour or area of involvement. For example, Italian cooking, abstract art, heavy metal, break dancing, science fiction, or studying social complexity. Also, as we have explained elsewhere, each diversity type in a system constitutes a probability state: one form of complexity possible for the cases in a complex system. As a category of similarity, diversity types function as probability states, around which the cases in a system naturally cluster, given some shared set of characteristics – descriptive, constructive, organizational, scale, etc. This is not, by the way, a new idea: in the case of the classic Maxwell-Boltzmann distribution, for example, mass and temperature determine the probability state (type) for each particle in an ideal gas, thereby determining the natural distribution of the diversity of particle speeds at thermodynamic equilibrium. The same capacity to predict probability seems to be true for the distribution of the diversity of complexity. Be it the population size of a city, the income of a household or the market value of a business, the diversity types for a system constitute its empirically defined range of probability states, along which its cases will distribute themselves, based on similarities in attributes.

**By 'measuring diversity' we mean case-based entropy ($C_c$):** $Cc$ renormalizes the diversity contribution of any probability distribution $P(x)$, by computing the true diversity $D$ of an equiprobable distribution (called the *Shannon-equivalent uniform distribution*) that has the same Shannon entropy $H$ as $P(x)$. In terms of a definition, $Cc$ is precisely the number of equiprobable types in a discrete distribution, or the length, support, or extent of the variable in the case of a continuous distribution, which is required to keep the value of the Shannon entropy the same across the whole or any part of the distribution up to a cumulative probability $c$.

We choose the Shannon-equivalent uniform distribution for two reasons:

- First, it is well known that, on a finite measure space, the uniform distribution maximizes entropy: that is, the uniform distribution has the maximal entropy among all probability distributions on a set of finite Lebesgue measures.
- Second, a Shannon-equivalent uniform distribution will, by definition, count the number of values (or range of values) of $x$ that are required to give the same information as the original distribution $P(x)$ if we assume that all the values (or range of values) are equally probable.

Hence, the uniform distribution renormalizes the effect of varying relative frequencies (or probabilities) of occurrence of the values of $x$ without losing information (or entropy). In other words, if all choices of the random variable are equally likely, the number of values (or

the length, if it is a continuous random variable) needed for the random variable to keep the same amount of information as the given distribution is a measure of diversity. In a sense, each new value (or type) is counted as adding to the diversity, only if the new value has the same probability of occurrence as the existing values.

Diversity necessarily requires the values of the random variable to be equiprobable since lower probability, for example, means that such values occur rarely in the random variable and hence cannot be treated as equally diverse as other values with higher probabilities. Hence, by choosing an equiprobable (or uniform) distribution for normalization, we are counting the true diversity, that is, the number of equiprobable types that are required to match the same amount of Shannon information $H$ as the given distribution.

This calculation (as we have shown elsewhere) can be done for parts of the distribution up to a cumulative probability of $c$. This means that a comparison of $Cc$ for a variety of distributions is actually a comparison of the variation of the fraction of diversity $Cc$ contributed by values of the random variable up to $c$. **In terms of measuring the diversity and complexity of various systems and networks, our approach has two key benefits:**

- $Cc$ provides a scale-free measure to compare distributions without omitting any of the entropy information, but by renormalizing the variable to one that has equiprobable values. It can do so because, regardless of the scale and units of the original distribution, $c$ and $Cc$ both vary from 0 to 1, as such one can plot a curve for $Cc$ versus $c$ for multiple distributions on the same axes.

- What is more, $Cc$ allows researchers to compare different parts of the same distribution, or parts to wholes. That is, one can generate a $Cc$ versus $c$ curve for any part of a distribution (normalizing the probabilities to add up to 1 in that part) and compare the $Cc$ curve of the part to the $Cc$ curve of the whole or another part to see if the functional dependence of $Cc$ on $c$ is the same or different. In essence, $Cc$ has the ability to compare distributions in a “fractal” or self-similar way.

For example, in the case of our interest in the relationship between populations and creativity, $Cc$ provides a useful way to use ‘diversity of information’ as a measure for comparing different population-based distributions of intellectual or artistic talent to one another, as well as to explore different parts of the same population distribution for any one given type of artistic or intellectual endeavor.

By ***'restricted diversity'*** we mean that, when plotted for any given population, as the diversity of complexity $\rightarrow \infty$ (primarily in terms of the number of artistic and intellectual types; but also, secondarily, in terms of the frequency of cases) a limiting law of restricted diversity emerges, constraining the majority of cases to simpler types, which do not achieve as high a level of acclaim or recognition. This restriction appears to be done by constraining the artistic and intellectual **richness** of these systems; that is, limiting the number of highly recognised artistic or intellectual types to a few; and, in turn, by restricting the **evenness** of the intellectual and artistic types in these systems.

In terms of their social mechanics, the restriction of richness and evenness is probably some combination of true talent and ability (one the one hand) and also negative relations of power (on the other hand), which seek to exclude, marginalise, suppress or close-off competition. Examples include racism, sexism, elitism, homophobia, classism, social closure, and the perpetuation of inequality.

By the ***'60/40 rule'*** we mean it appears that, for those complex systems with skewed-right distributions, the clustering of the cases around the lower bound of the diversity of complexity is not arbitrary. Instead, similar to the central limit theorem for mild distributions, there is actually a consistently followed rule hidden in full view within these distributions.

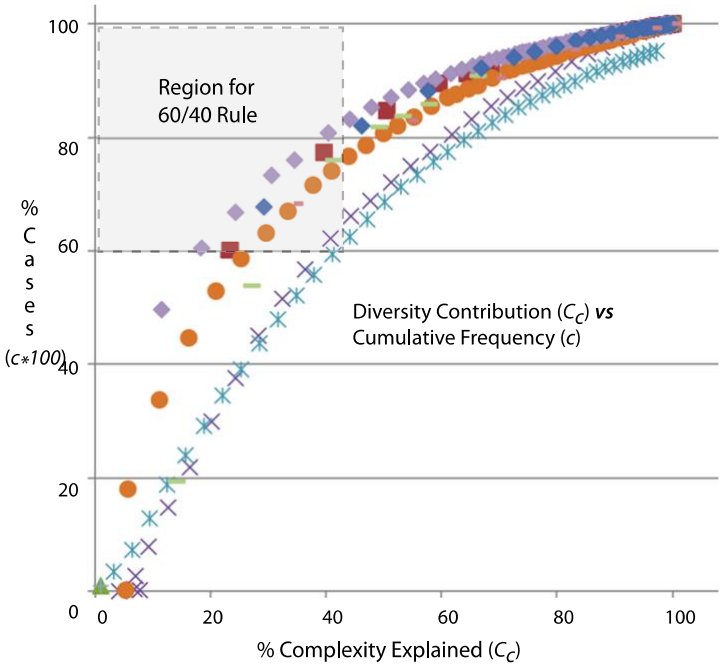



*Figure 2: Graph of 60/40 rule for eight complex systems.*

To make sense of the 60/40 rule see Figure 2, which comes from a study we completed on a series of different complex systems (Click here for more). First, there is the graph. Its purpose is to visualize the diversity contribution $Cc$ of some set of complex probability types relative to the cumulative frequency (c) of cases, for each of the eight systems studied. The diversity contribution for the complex probability types $Cc$ is shown on the x-axis; while the y-axis shows the cumulative percentage of cases (c*100) relative to the x- axis. When examining the curves, we noted that they all passed through the same shaded region on the graph, demonstrating that, for the systems we studied, 60% (or more) of cases consistently resided within the first 40% (or less) of a system's lower bound of complexity.

| Complex System | Coordinates for Each System in the 60/40 Region | | |
|---|---|---|---|
| World Wide Web | *80.86* | *40.16* | 325,729 |
| 2013 USA Household Income | 59.32 | 41.03 | 122,953 |
| Body Mass of Late Quaternary Mammals | 62.30 | 42.56 | 4,916 |
| Human Diseasome Complexity Map | 67.80 | 29.10 | 1,248 |
| Velocity of Galaxies in km/s | *76.10* | *41.18* | 1,000 |
| 2011 USA Cities by Population Size | *77.50* | *39.44* | 715 |
| Financial Times 2014 Biggest 500 Companies | 74.20 | 40.77 | 500 |
| 2012 Prevalence of Mental Disorders | 68.50 | 34.32 | 3,199 |
| | % Cases | % Complexity | N= total cases |

*Figure 3: Table of 60/40 rule for eight complex systems.*

To explore further the specifics of these curves, see Figure 3, which provides the coordinates for a typical point in the shaded region, for each of the systems we examined in our study. The reader can see that, for some systems – as in the case of the world-wide-web, the velocity spin of galaxies, and the city size by population – the cumulative percentage of cases was as high as 80/40. Still, while this insight is useful, the more important point is that all eight systems passed through the same region on the graph, suggesting that the limiting law of restricted diversity follows the 60/40 rule.

**CAVEAT: $Cc$ IS NOT THE POWER LAW!** The 60/40 rule demonstrates that, for a variety of natural and human-made systems, the majority of cases account for a small percentage of the total diversity of complexity. Such an insight, however, is not simply the inverse of the Pareto Principle, otherwise known as the oft misused and misunderstood 80/20 rule.

In other words, the distribution of the diversity of complexity, as measured by $Cc$, is not the same as measuring the decay of a system using the power-law. The Pareto principle only applies to the tail and not to the total distribution of diversity of complexity types in a system. The 60/40 rule, by contrast, concerns the distribution of the lower bound of equiprobable types relative to the cumulative distribution of complexity in the entire system – which is what Figure 2 shows. As such, when the 60/40 rule says that ‘‘the majority of cases account for a small percentage of the total diversity of complexity,’’ it means that, regardless of the distribution studied, 60% of the cases account for only 40% of the equiprobable types necessary to explain the total information in a system.

In the case of 2013 household income in the United States, for example, this translates as follows: 60% of all households constitute only 40% of all equiprobable income types; as such, the majority of households accounted for a small percent of the total diversity of economic complexity. In turn, the top 20% of U.S. households in 2013—which is the same group that the Pareto Principle focuses on; and which amounts to roughly $105,000 dollars or higher—accounted for 34% of the total diversity of equiprobable types.

## TENTATIVE CONCLUSIONS AND CONCERNS

As stated at the beginning of this post, we are in the early stages of investigating our questions. As such, while we have come to some tentative conclusions, we are not entirely sure – and probably wrongheaded about some of it. As such, we are sharing our work for anyone interested in trying to help explore this topic.

### QUESTION 1 & 3: POPULATION MINIMUM & MECHANISMS OF POWER

In regard to the first question, it seems that a population does not need to be very large or concentrated in order for it to draw/achieve a considerable level of artistic and intellectual accomplishment. However, the size of such a population clustering probably does need to be city level.

Also, even for a small population cluster, the necessary socio-economic and cultural and political arrangements need to be in place, sufficient to attract/produce high levels of artistic and intellectual talent. In other words, relative to a particularly large population size/concentration, what seems equally important is the extent/degree of infrastructure support to accomplish various artistic and intellectual achievements. Such support includes not only key societal institutions, but also addressing oppression, marginalisation and discrimination in all of their various forms -- sexism, racism, homophobia, classism, cultural appropriation, etc -- and making sure that inequality and disadvantage (economic, political, geographical) are not negative determinants of success.

**A tentative summary:** if one has a city-level population clustering and the necessary support infrastructure, then high levels of artistic and intellectual accomplishment are likely. We can call such a key combination an **artistic/intellectual population hub**.

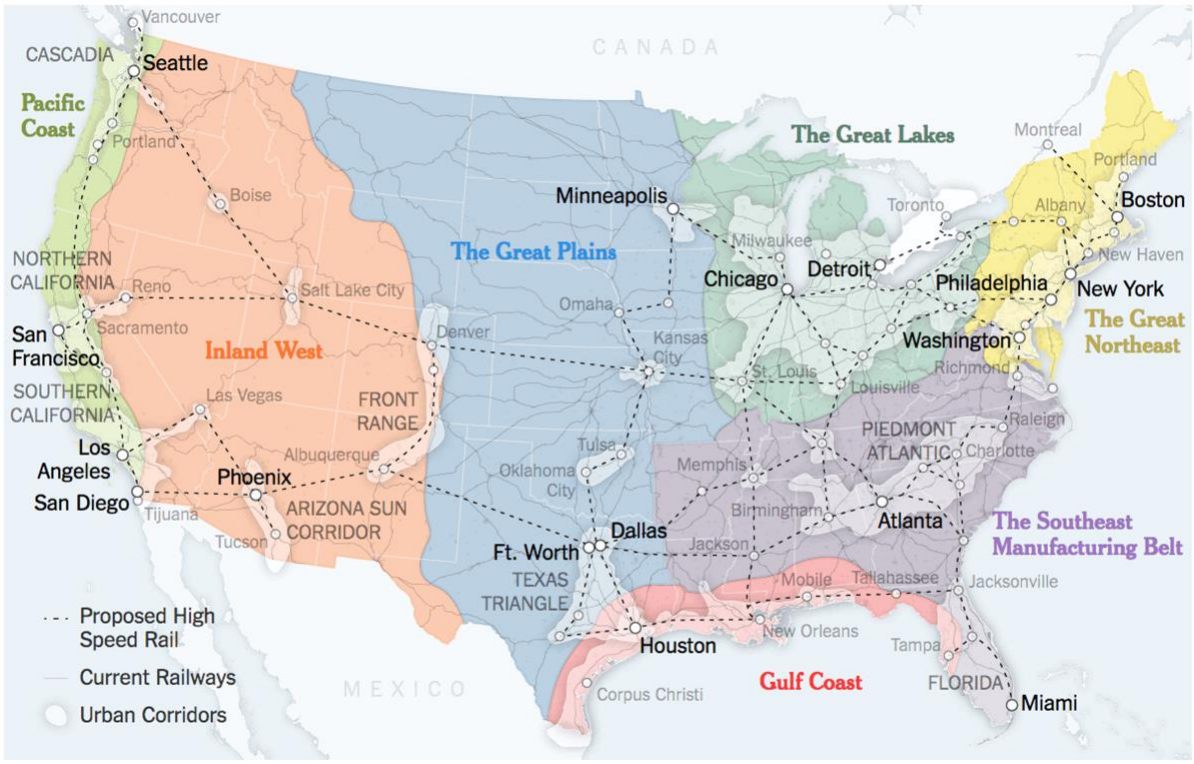
**The unanswered questions:** The question, however, which we have not answered, and which others might seek to explore, is what this minimum necessary population size/ concentration is exactly? And has it changed over time?

**QUESTIONS 2 & 3: POPULATION MAXIMUM AND MECHANISMS OF POWER**

It seems that, in our densely population globalised society, the number of cities with the size/concentration and support infrastructure **necessary** for considerable artistic and intellectual accomplishment far exceeds that of the previous centuries. And, relative to this growth, our global population has likewise grown.

As such, in terms of intellectual and artistic output, these increases in population size, coupled with (a) significant advances in global civil society (e.g., women's rights, educational access, political freedoms, increased economic wellbeing and health, etc), (b) international relations and the global economy, and (c) our globalised cyberinfrastructure (digital social media, the internet, smart devices, global telecommunications, etc) seem to have allowed for a tremendous (almost exponential) growth in artistic and intellectual output the world-over. As such, we have more intellectual and artistic accomplishments to enjoy and benefit from today than ever before. Therefore, in some ways, finding some tipping point past which the population is too large or concentrated to procure the genius within it seems non-existent. In other words, in many ways the world is big enough for it all.

Then again, perhaps not. If one is watching global migration trends, it seems that the world is condensing into major metropolitan regions and mega-cities in response to the growth of our human population. For example, this *New York Times map of the United States* reveals how the country is consolidating into a series of major metropolitan regions.




However, going back to Question 3, not all such regions (either within the United States or throughout the rest of the world) are equal in the provisions they afford people. For example, as the [United Nations Department of Economic and Social Affairs] (UN DESA) explains:

> *"Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050. Projections show that urbanization, the gradual shift in residence of the human population from rural to urban areas, combined with the overall growth of the world's population could add another 2.5 billion people to urban areas by 2050, with close to 90% of this increase taking place in Asia and Africa, according to a new United Nations data set launched today.*
>
> The ***2018 Revision of World Urbanization Prospects*** *produced by the Population Division of the UN DESA notes that future increases in the size of the world's urban population are expected to be highly concentrated in just a few countries. Together, India, China and Nigeria will account for 35% of the projected growth of the world's urban population between 2018 and 2050. By 2050, it is projected that India will have added 416 million urban dwellers, China 255 million and Nigeria 189 million."*

In short, given such a rise in both the world population and globalised levels of urbanisation, the existence of artistic/intellectual population hubs may be a way to restrict complexity into something more manageable. And there appears to be at least three plausible reasons (amongst others we are sure we are missing):

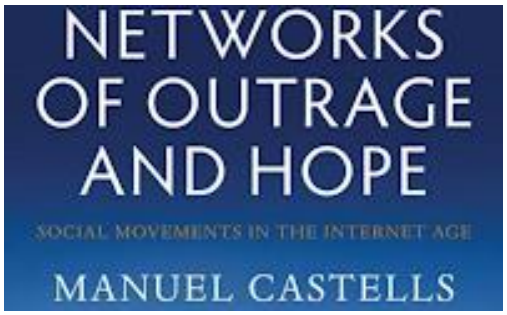
1. First, as the emergence of regional metropolitan areas and megacities suggest, the global population has exceeded (is exceeding) its limits, which is causing the world system to somehow optimise and rebalance its widening intellectual and creative

diversity – which it does by consolidating itself into more concentrated urban environments, which have become the new intellectual and artistic hubs of the world. In other words, the emergence of these urban zones is a way of decreasing the **evenness** but also, in turn, the **richness** of the global population by making the population size/concentration necessary for artistic and intellectual accomplishment larger.

2. Also, all urbanised metropolitan regions are, sociologically speaking, not the same. In other words, due to negative relations of power (i.e., social closure, discrimination, marginalisation, racism, hetero-patriarchy, xenophobia, etc) many urban regions throughout the world limit the richness and evenness of the diversity of recognised talent both within their own populations and the populations of others. This first instance is particularly prevalent amongst those countries where civil liberties and human rights are profoundly limited or largely absent. The second instance is particularly prevalent today amongst the western societies of the global north where many (including their leaders) actively seek to retreat from the global community and from their civil responsibilities to the rest of the world. (For more on this point, see The Defiance of Global Commitment.)

3. As the amount of artistic and intellectual talent grows, so does the challenge of consolidating all of these accomplishments. An easy example are scientific citation networks, which are often limited geographically, with scholars in one country ignoring the work of those in another. (CLICK HERE FOR MORE)

The result from such factors is that a significant amount of artistic or intellectual ability within and across about globalised society is missed, excluded, appropriated or oppressed.




**THE ADJACENT POSSIBLE:** However, due to post-industrialization and globalisation, the above summary might not be exactly the case. The development of the internet and our global socio-cybernetic infrastructure has redefined notions of space and time, making the role that a population size/concentration plays more nuanced and complex. For example, an academic or artist could, to some degree, live just about anywhere as long as they were able to effectively interact with the key socio-cybernetic network involved in their work. Still, as even Manuel Castells and his critics have pointed out, there are limits to how much one can be 'outside' the physical socio-spatial concentrations of the key city hubs of the world and still have significant influence.

**As a tentative summary**: Given what we have so far outlined, it seems that, if there exists the right combination of population size and support infrastructure, then high levels of artistic and intellectual accomplishment are likely. One can call such a key combination an artistic/intellectual hub – which have historically been cities.

However, past a certain tipping point, a population can become too large to consolidate and acknowledge the depth and variety of its intellectual and artistic accomplishments.

In response, the system engages in a form of diversity restriction – which happens both through an increasing size/concentration requirement for a population cluster to be a hub, and through increasing social closure and discrimination, exploitation and so forth. Both of which seek to reduce the richness and evenness of a population by allowing only a small number of artistic and intellectual types (and the frequency of people found within them) to receive the acclaim they deserve. (Remember all three of our plausible mechanisms above!)

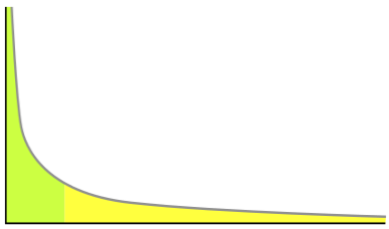
This restriction in diversity, however, is somewhat significantly challenged through the advances of the world-wide-web, digital social media, and the expansion of our global cyberinfrastructure, which have redefined notions of time and place and space.

Still, even with the existence of our global socio-cybernetic world, as the population and opportunity for engaging in artistic and intellectual accomplishment increases, so does the competition for recognition and power and position. Which, to repeat, results in a rather severe restriction of diversity -- both in terms of richness and evenness -- leaving an increasing amount of work (and the people who created it) unrecognised and outside the networks of influence that decide what will be counted as an important contribution.

**The unanswered questions:** The question, however, which we have not answered, and which others might seek to explore, is what this population tipping point is throughout various regions of the world?

**QUESTIONS 4 – 6: PROBABILITY ISTRIBUTION OF ACCOMPLISHMENT**

Of our six questions, the final two require are the most tentative, as such we can only outline what an answer might look like, which we will state here:



Throughout the complexity sciences, one regularly finds the distribution of complex systems and networks taking the shape of a right-skewed distribution – otherwise called, but not entirely synonymous with heavy-tailed or long-tailed distributions. Examples include, as we have mentioned above, studies of intellectual and social influence (as in the case of citation research) and also popularity. Another well-known example is the Pareto distribution and the 80-20 rule (which we also mentioned).

Other examples include network connectivity, which reveal that only a few nodes in, say, a network of online retail companies – as in the case of Amazon.com for example – become widely recognised and therefore the most densely connected nodes in the network. Furthermore, when these massive networks are plotted as a probability distribution, one finds that the majority of cases (retail companies for example) are not as widely popular or recognised.

Barabási and others claim that such distributions (when sufficiently large) meet the criteria of a power-law and therefore are scale-free. However, such claims have been widely

refuted. See, for example, the critical work of Prachter & Bray, Newman, Broido & Clauset and others papers by Clauset and colleagues.

For us, whether such systems are power-law or scale-free really doesn't matter, as all of these studies, supportive or critical, generally agree that a significant percentage of these complex systems are taking a similar skewed-right shape (with or without long-tail), which is of necessary importance, even if the models used to fit them are not sufficient.

Taking these studies into account, it seems that complex social systems, in particular, seem to manage or optimise their diversity by limiting the level of complexity found in the majority of cases to something relatively simple, while allowing for a small set of cases and their corresponding types to dominate.

Translated for the purposes of our discussion here, the consistency of this restricted diversity might suggest that, when it comes to artistic and intellectual accomplishment, such forces as social closure, inequality, discrimination and the consolidation of cities into major metropolitan regions and so forth all amount to producing a right-skewed distribution.

## NEXT STEPS

In addition to trying to answer the unanswered questions posed earlier, our next step is to examine several empirical cases to see if, using $Cc$, a limiting law exists for these distributions, which would obey a 60/40 rule:

- For example, we hypothesize that, if one examined a distribution of cities similar to that explored by Michel Serafinelli in *Creativity and Freedom,* we would find that the majority of cities (vis-à-vis intellectual and artistic creativity) would not have a high number of highly recognised accomplishments, such that 60% (or more) of cities would reside within the first 40% (or less) of the lower bound of equiprobable diversity types, with or without long-tail and whether or not the distribution fits a power-law.
- We also hypothesize that if one explored a distribution of highly accomplished people (relative to a particular type of artistic or intellectual endeavour), 60% (or more) of the highly accomplished artistic and intellectual cases in the distribution would reside within the first 40% (or less) of the lower bound of equiprobable diversity types, again with or without long-tail and again whether or not the distribution fits a power-law.

But, again, these are only conjectures which we (or others) need to explore. For example, we note that, at the end of Serafinelli's post he has the following endnote, which we or others might find useful to explore. He states:

> *[1] A similar historical perspective is taken by a set of studies using microdata on upper tail human capital. In particular Gergaud et al. (2016) analyse a database of more than one million famous individuals and more than seven million places associated with them throughout human history (3000BCE to 2015AD). Relative to this work, we focus more specifically on creative individuals, on spatial patterns*

*(using the city as the unit of analysis), on the flow of ideas, and on the effects of local self-government institutions on the formation of creative clusters.*