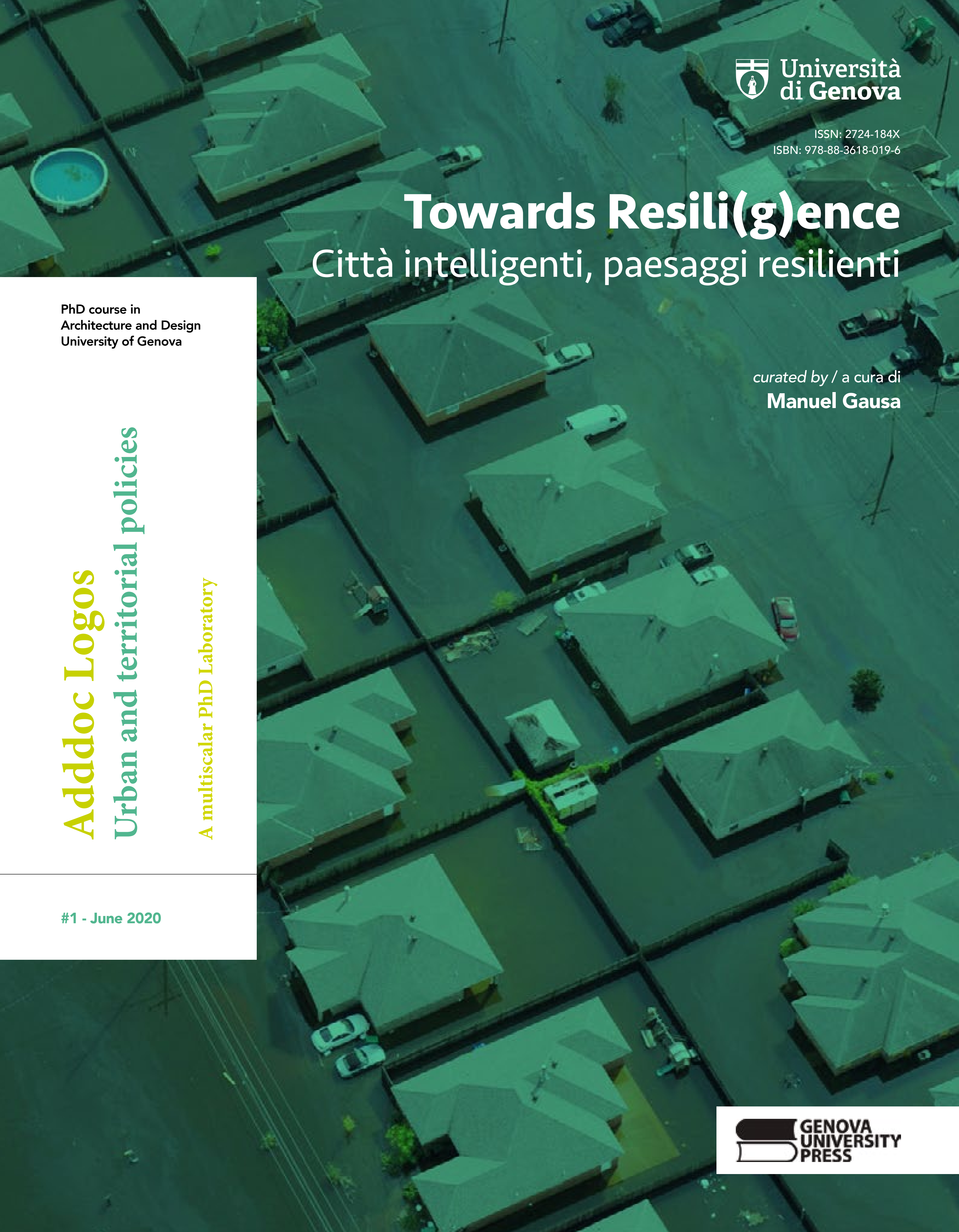

Università di Genova

ISSN: 2724-184X
ISBN: 978-88-3618-019-6

Towards Resili(g)ence

Città intelligenti, paesaggi resilienti

PhD course in
Architecture and Design
University of Genova

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Urban and territorial policies
A multiscalar PhD Laboratory

#1 - June 2020

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#1 | *Towards Resili(g)ence. Città intelligenti, paesaggi resilienti*

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Giugno 2020 / June 2020

Collana / *Collection*
ADDDOC LOGOS - Monografie di Dottorato

pubblicazione semestrale / biannual magazine
ISSN: 2724-184X (versione e-Book)
ISSN: 2724-1831 (versione stampa)

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www.addgenova.org

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UPI UNIVERSITY PRESS ITALIANE

This book has been object of a double blinded peer-review according with UPI rules.

Realizzazione Editoriale
GENOVA UNIVERSITY PRESS
Via Balbi, 6 - 16126 Genova
Tel. 010 20951558 - Fax 010 20951552
e-mail: gup@unige.it
http://gup.unige.it

ISBN: 978-88-3618-018-9 (versione a stampa)
ISBN: 978-88-3618-019-6 (versione eBook)

Finito di stampare nel mese di giugno 2020

Stampato presso
Grafiche G7
Via G. Marconi, 18 A - 16010 Savignone (GE)
e-mail: graficheg7@graficheg7.it

summary

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BETWEEN BLACK SWANS AND DRAGON-KINGS: THE NARROW PATH TO THE RESILIENCE OF URBAN REGIONS

On and on the rain will fall
like tears from a star, like tears from a star
on and on the rain will say
how fragile we are, how fragile we are
Sting

• From the city to urban systems and urban regions •

The human settlement on Earth has evolved in the contemporary age in a wide range of inhabited centers, from the smallest village (which still constitutes the prevalent form of collective living in many regions of the planet) to those that today we call "megalopolis", where we can observe a concentration of tens of millions of people.

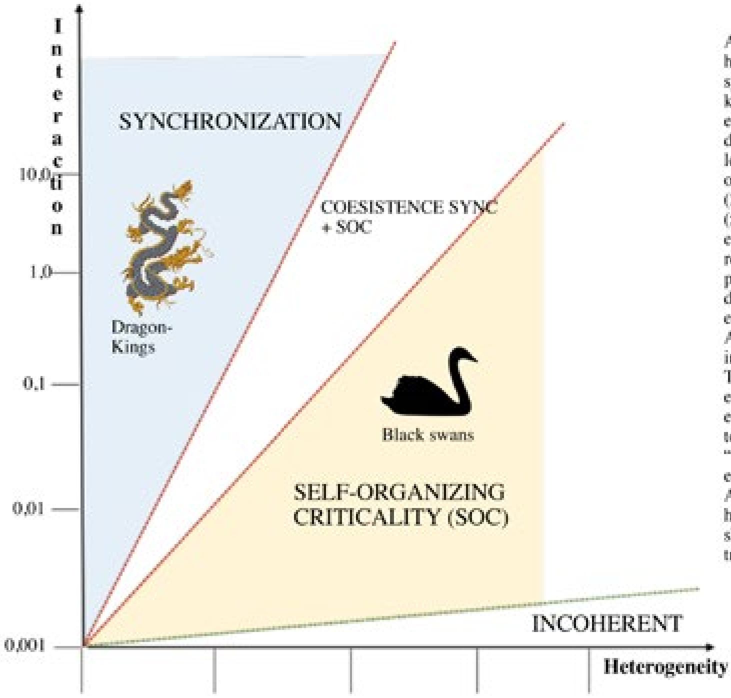
The history of humanity has never reached not only such a large number of individuals, but also such a diversified variety (quantitative and qualitative) of settlement forms.
What emerges clearly from studies of urban geography is however a common trait to all these different forms of settlement: their existence, development and – sometimes – even perish, in

reticular forms. The relationships between the different urban centers mean that we can no longer speak of the city as an isolated phenomenon, a spatial fact of population concentration which corresponds to an equally evident relationship of domination over an "external" space to the city itself. The cities, if we can still call with this word them (and recognize them), in this period dominated by the urban realm (Choay, 1994), live and change only as elements of a complex network system, which in turn tends to configure in the space clusters of connected centers, which we can define "urban regions". And the urban region is the true protagonist of contemporary economic and social events, perhaps more than nation-states.
In contemporary urban regions, which link urban forms that are very different from each other, the built-up space intersects with ecological networks, green spaces, agriculture space, often in contradictory and problematic but often (at least potentially) virtuous form (Douglas, 2013; Grimm N. et al., 2008). The open space is a fundamental part of contemporary urban agglomerations and through it, its use (or often: over-use), its relationships with the built space, generate those problems that go under the name of sustainability and urban resilience. The artificialization of contemporary living, which first involved the cities and then progressively wider spaces around them, passed in the space of a few decades from the process of industrialization and urbanization of the first Industrial Revolution to contemporary urban forms. In today's urban regions, the cities of the atom were superimposed over the cities of bits and they are dominated, in economic and social terms, by the platform economy (Srnicek, 2017; Kenney and Zysman, 2016) which characterizes the so-called fourth industrial revolution (Schwab, 2016). The exponential dynamics of control over the environment through the artificial have been accompanied by the processes of environmental change that today constitute one of the elements of crisis in our societies. The emergence of the Anthropocene (Crutzen and Stoermer, 2000) is one of the fundamental elements of the transition that humanity is experiencing, accompanied by the other two equally impressive in dimensions: the demographic and the technological ones. And there seems to be no doubt that the processes of environmental modification have undergone a strong acceleration, at a global level, starting from 1945 (McNeill and Engelke, 2014).

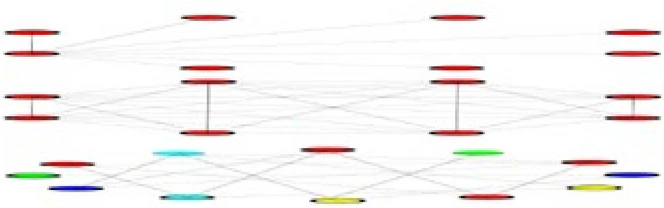
• The differentiation of urban settlement forms •

Cities originate and develop from the bottom up. They are generated when some individuals begin to put together their respective skills in a way that they can take advantage of physical proximity and thus begin to achieve economies of scale. According to Jane Jacobs (1970), the concept of city is intrinsically anthropological, even existing in nomadic societies at the time when packages of innovation are generated thanks to the advantage deriving from coming together, sharing and dividing work. In this sense, the city, in the forms it has assumed in the West, is not the only possible form of human settlement, as recently demonstrated by J. Scott (2017) in his work on the birth of urban civilizations. The cities born with the great agrarian grain civilizations are the result of a systematic process of production control and of economic and social reproduction mechanisms. Other forms of settlement are possible and have been practiced throughout history in various regions and times over the planet. However, the cities developed according to the Western model and which today characterize the contemporary settlement landscape (which is a predominantly urban landscape) are, together with the process that generates them (the post-metropolis process: Soja, 2000), the most clearly pervasive fact on a planetary level.

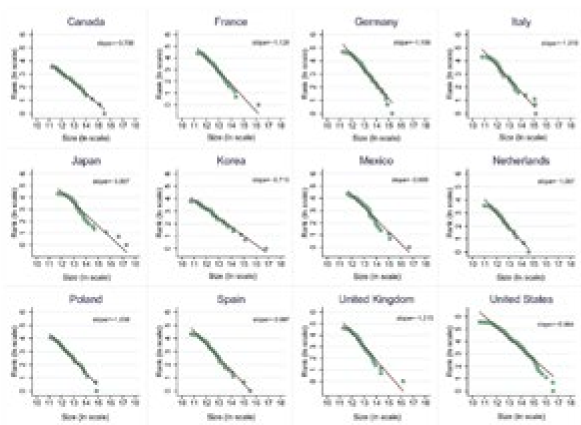
In a world in which the global population is entering a phase of demographic transition that will probably lead to its stabilization at the end of this century, the population itself is urbanizing at an ever increasing rate. This does not mean that we will all live in one big city in the future, but rather in a world made up of cities of all sizes, with an overall distribution among different settlement dimension similar to the current one (Batty, 2015). What we are living in this period is a radical transition (a tipping-point) from a rural world to an urban world that takes place 5,000 years after the emergence of the first cities and the start of stable agriculture. This means passing from a world of strongly localized interactions to a world of global connections, from a world based on physical technologies to a world based instead on those of computers, from a world of atoms to a bit world (Negroponte, 1995). While the world urban population has exceeded the 50% threshold in 2008, by 2050 this percentage will reach 66%, to reach at least 75% at the end of this century. All this presupposes that a high percentage of the population lives and will live in some kind of settlement that we call “city” or in any case in an environment that we call “urban” (although the debate on what today can be understood with this term is strong: Brenner, 2014). At the statistical level, the definition of urban of the United Nations, which is the one mainly used (Dijkstra, 2014; U.N., 2018), is closely connected to the concept of concentration or density of interconnected populations. In a panorama made of so many different urban centers (different in size and function), if the urbanization process until a few years ago was determined by a strong migration from rural to urban, in a world of zero growth (which is what let us stretch and that it is already present in some regional realities, such as Europe for example), migratory waves will tend to shift from a rural-urban dynamic to an urban-urban one. Thus, some cities will grow enormously and others will be subjected to equally dramatic phenomena of decline.



A system with a low level of diversity (or heterogeneity) but a high level of interaction can be considered a system in a synchronized phase. In this phase emerge rarely a Dragon-king. Dragon kings form special kinds of events leading to extreme risks (which can also be opportunities). Natural disasters provide many examples (e.g., asteroid impacts leading to extinction). Some statistical examples of the impact of extremes are that: the largest nuclear power plant accident (2011 Fukushima disaster) caused more damage than all (>200) other historical accidents together, the largest 5 epidemics since 1900 caused 20 times the fatalities of the remaining 1363, etc. In general such statistics arrive in the presence of heavy tailed distributions, and the presence of dragon kings will augment the already oversized impact of extreme events.
A system with a high level of heterogeneity and a high level of interaction is a system in a phase of self-organizing criticality. The system possesses excellent ability to respond to external events (robustness) thanks to its self-organization, however, extremely rare and unpredictable events may appear, unrelated to any internal variable. Black swans encourage one to "prepare rather than predict", and limit one's exposure to extreme fluctuations.
A system with a low level of interaction and a high level of heterogeneity is a system within a phase of incoherence (a shock event is extremely probable). It has a structure like a tree (following C. Alexander…).

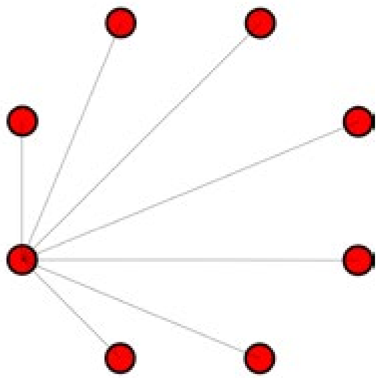


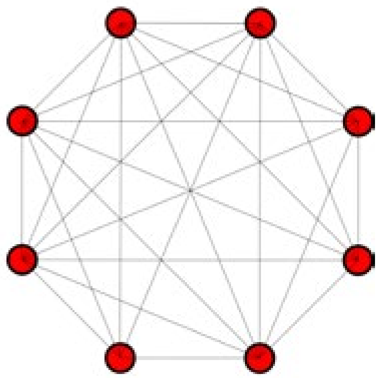
Systems with different degrees of internal connectivity and different levels of heterogeneity

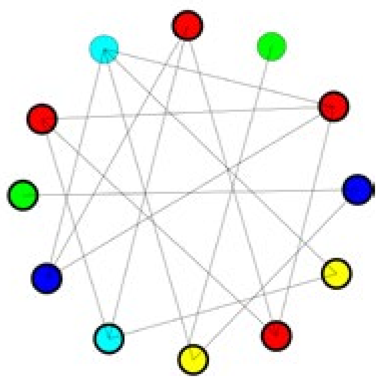


The rank size rule of the urban systems of some OECD countries. In several of them emerges the presence of primate cities that represent exceptions to the allometric rule represented by the power law. These are real dragon kings (in some cases we witness the phenomenon of double primate cities) that are repeated at different scales and that cause strong regional and urban imbalances. A challenge for urban and regional resilience.

• The evolution of urban systems: the size of cities and the rank-size rule •



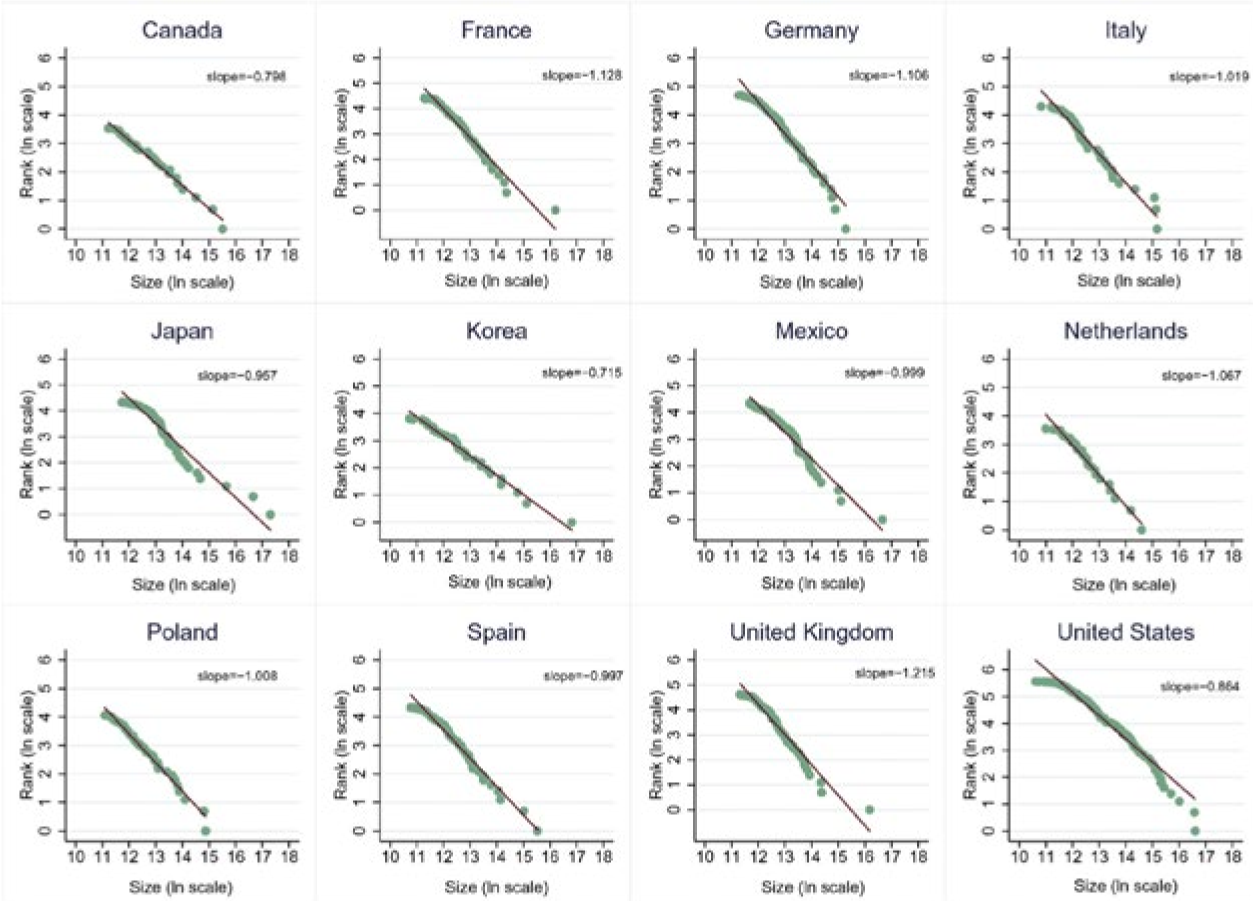




If we consider the historical trend of the 50 largest cities in the world, we can see how their growth exceeds the growth rate of the world population in percentage terms only since the Industrial Revolution. The total population of the 50 largest cities was in fact about 2.5% of the world population at the time of the Roman Empire, while in the following thousand years, this ratio collapsed to 1.7% and then fell again to 1,3% in 1825. Since that time its growth has been very substantial, reaching around 10% around 2000, while now it seems to suffer a further decline (Reba M. et al., 2016). The distribution of the city size has remained rather stable over the last two centuries (those of the great urbanization) and perhaps even earlier and is characterized by a small number of large cities and a large number of small cities: a configuration, that is, that seems like follow the well-known Zipf-rank rule. This distribution seems to reflect in some respects a competitive equilibrium (Krugman, 1996) where, despite the constancy over time of the overall relationship between larger cities and smaller towns, in cities of different sizes the struggle for resources, wealth and power prevails. The larger cities of the distribution seem to follow a power law (with an overall log-normal frequency). Even a completely (or almost) urbanized world will involve a rank-size distribution of cities similar to that which has been continuously recorded for several millennia until today: there will therefore be many small cities and a much smaller number of larger cities and a small amount of mega-cities. Using the Nordpil data set and constructing the rank-size chart for cities with over 750,000 inhabitants for 5-year intervals from 1950 to 2015, we can see how the distribution curves (represented in a log-log graph) can be approximated for good part of their length to a power law (Cristelli et al., 2012) and how this distribution can be approximated to a line. Within this hierarchy, cities move rather quickly (Batty, 2006), although total distribution tends to remain stable over the years. The distribution is represented by a series of lines that decrease their angular value over time. This means that larger cities tend to be, on the whole, less important than smaller cities. The consequence of this projection is that most of the world's population will live in small and medium cities rather than in large or very large cities in the near future. The urban systems (or urban regions) formed by so many small and medium-sized centers and a few large cities will be the prevailing ones globally. The majority of the population will live in this type of urban region and the future of global sustainability will be played in these areas.

Population differences between cities are decreasing over time. The explanation of this phenomenon may be due to the impact of new technologies (especially ICT) and how these increasingly connect cities to each other.

The distribution of the city-size seems to take the typical form of the Gibrat's law (EeckhoutT, 2004) and finds an interesting parallel with what happens in the business world, where we observe



Rank Size of Urban Contemporary Urban Systems in a Set of Urbanized Countries

the presence, in almost all sectors, of many small and medium companies and a few large companies. Both processes (cities and companies) follow a particular form of statistical distribution which is characterized by a higher localized concentration, in the frequency graph, towards the left, in correspondence with the medium and small size units and which becomes normal if observed at one logarithmic scale. If the process continues for a sufficiently long time, the distribution of the variable reaches an equilibrium, or steady state, from which it remains unchanged, taking the name of stationary distribution. Just as the development of production units is not affected by systematic factors connected to the productive dimension, so urban systems tend to be stable over time along a given distribution law. For companies, this means that the opportunities on the markets for goods, labor, money and technology are independent of size. Similarly, for cities, the chances of success (or failure) are to a large extent independent of their size, but actually lie in other factors such as, for example, their degree of connection with territorial networks and other cities, the rate of innovation, the relationship with the environment (and therefore with the use of resources).

• The size of the city and the emergence of Dragon-Kings phenomena •

To define what a city is and what distinguishes it from a minor settlement (village or hamlet) there is today a certain sharing in considering the minimum demographic dimension equal to 1,000 individuals grouped in a stable manner. In the course of the history of thought, on this subject, the first to express a formal idea was Plato, who had arrived, on the basis of a complex demographic and geometric argument, to define a settlement with 5,040 inhabitants as the optimal dimension of the city (Batty and Ferguson, 2011 ; Batty, 2015). In modern times the theme of the optimal dimension has crossed the whole history of urbanism, passing through Mumford, Howard, Le Corbusier, Jacobs, Saaty in urban planning and Alonso, Richardson, Mirelles in the economic field. The fact is that if the cities could exceed just one million inhabitants at the beginning of the great transition represented by the Industrial Revolution, it was precisely technological development to break down this barrier. But despite the technological advances, however, there continue to exist physical limits to the spatial dimension of the city (or urban region): we can suppose, for example, that it is difficult to think a city as an entity in which transport time is greater than one hour of travel in each direction for daily journeys. Although there are no stable rules on how long a daily shift can be (over time), it is difficult to imagine cities dispersed over a radius of more than 100 km from their center. Beyond this limit, it is unlikely to still consider a city an unitary organism. Thus, while the limits imposed by density and transport technologies will continue to limit the city in its maximum dimensions, a complete decentralization of the population in small and very small clusters is highly unlikely.

Linked to the phenomenon of the urban dimension is the distribution of large cities within urban systems and their role within these. Just as, on an urban level scale, there is the question of the supremacy that certain urban poles can assume within the spatial configuration of the urban region. On a global level, if we look at the ranking of the world cities ordered according to the rank-size rule, we note that there is no "primatial" city (i.e. no city is much larger than the one that follows it in the ranking). There is no global effect of a primate city (primatial city, according to the term coined for the first time by Jefferson in 1939). At the regional level instead (and even more at an infra-urban level) we can observe the emergence of a primatial effect in many States and regions and in many cities or urban regions. Emblematic cases of primatial cities are London and Paris, in the sense that they are urban entities much more populous than the second respective cities (Liverpool the second most populated city in Great Britain is 7 times smaller and Lyon, in France, 5 times smaller). These deviations from the power law are the result of a phenomenon called "Dragon-King" (D-K), observed in many scientific fields.

Primatial type events have been observed within phenomena characterized by a normal power law distribution in a wide vari-

ety of systems. While in a probability distribution that is configured as a power law, the dependence as a function of the size of the event or object seems to be omnipresent in a wide variety of statistics of natural phenomena and social systems (ie of complex systems) and is considered the confirmation of the presence of self-organizing mechanisms; the appearance of exceptional cases, real black swans, also seems to be configured as a phenomenon with based on different rules. The appearance of these extreme cases in functions which are otherwise quite predictable, has been observed in several examples (Sornette, 2009; Pisarenko and Sornette, 2012): the rank-size distribution of cities, the distribution of particular acoustic emissions associated with material failures, the distribution of speed increases in hydrodynamic turbulence, the distribution of anomalies in financial markets, the distribution of energy during epileptic seizures, the distribution of energy peaks during an earthquake. Although not predictable over time and / or in space, such events are in any case foreseeable in the fact that they will nevertheless occur with high probability rates. For contemporary urban systems, characterized by high levels of interconnection and complex hierarchies, this means that the appearance of king-dragons will be systematic and increasingly present.

If we think of urban systems and cities as network constellations, they take on more the form of a set of interconnected networks. The best definition of hierarchy within an urban reticular region can be represented as a set of geographical units or communities that are gradually smaller and grouped within larger geographical areas. At the level of the overall urban system, this configuration corresponds to a structure in which neighborhood services grow in specialization (decreasing in number) as the size of the neighborhood itself increases. If we suppose that each neighborhood remains rather separated from all others, a perfect hierarchy will emerge. This structure represents the model of a theoretically resilient system: a set of strongly interconnected groups of elements, but with weaker relations with each other. Systems where the basic units are grouped into sets with a dense internal structure, but a lower level interconnection between groups are very resilient at the level of the single base unit.

The connections within an urban region are not only geographical (physically determined: roads, telecommunications, maritime routes, etc.) but they also have a social, aesthetic and cultural nature. With modern information technologies the "real" city gets to cover a much larger extension than the physical city, since its inhabitants live on much more extensive connections than this. We are often led to think that an urban system is more resilient if it's strongly connected. In reality, if the connectivity and redundancy of connections in many situations helps the system to deal with crises, in many situations excessive connectivity can instead cause excessive and exponential damage propagation (similarly to what has been demonstrated in epidemiology and in the error propagation theory). Cluster configurations internally strongly connected but more weakly related to each other, responds better to those needs of resilient performance required today in our urban regions. Likewise, similarly, a strongly diversified environment within it, but with parts and functions connected at various levels, is a guarantee of better responses in terms of resilience. Although the resilience depends, in addition to the internal variety of a system and its degree and distribution of connectivity, on the typically self-organizing ability to adapt and learn from mistakes.

The large size (with its large number of connections and therefore, apparently, opportunities) is not synonymous with resilience. In the study by Briguglio et al. (2009), for example, the so-called Singapore paradox stands out. More than a nation, this Asian dragon is a city-state, whose small size seems to make it terribly vulnerable: too dependent on exports, therefore defenseless in the face of external shocks that come from the global economy. Yet Singapore has become a resilience laboratory. As well as, in other respects, Switzerland. The formula of their success lies in the extraordinary ability to adapt and to maintain a constant balance between external needs and external solicitations. Here the black swan (Taleb, 2010) is not represented so much by the unexpected and in some

ways unpredictable ability to survive by entities that we would expect extremely weak, but by the extraordinary resilience capabilities, based on a "creative" self-organization. Following the thought of Taleb (2013), therefore, uncertainty and unpredictability is not only a source of dangers to defend oneself from: we can take advantage of volatility and disorder, even from errors, and therefore be antifragile. The robust bears shocks and remains the same, the antifragile wants them, and feeds them to grow and improve. In terms of anti-fragility, city-states work better than nation-states, the spontaneous confusion of souks is preferable to the formal elegance of regulated markets, large corporations are a threat for society (examples of Dragon-Kings), as much as small entrepreneurs represent their strength.
What is "antifragile", that is able to thrive thanks to chaos and uncertainty, stress and disorder is what characterizes the organic systems, which are strengthened if exposed to environmental stresses. It is a characteristic of life, which is antifragile because through chance it conquers its variety. And it is also a characteristic of creative thinking, antifragile because it manifests itself in the presence of obstacles to overcome, and problems to be solved. The characteristics that can make cities resilient are therefore a strong sense of identity, the ability to adapt to historical and social change, the courage to invest in different sectors even at the risk of some failure, being permeable to the outside world, capacity to learn, the ability to reinvent oneself.

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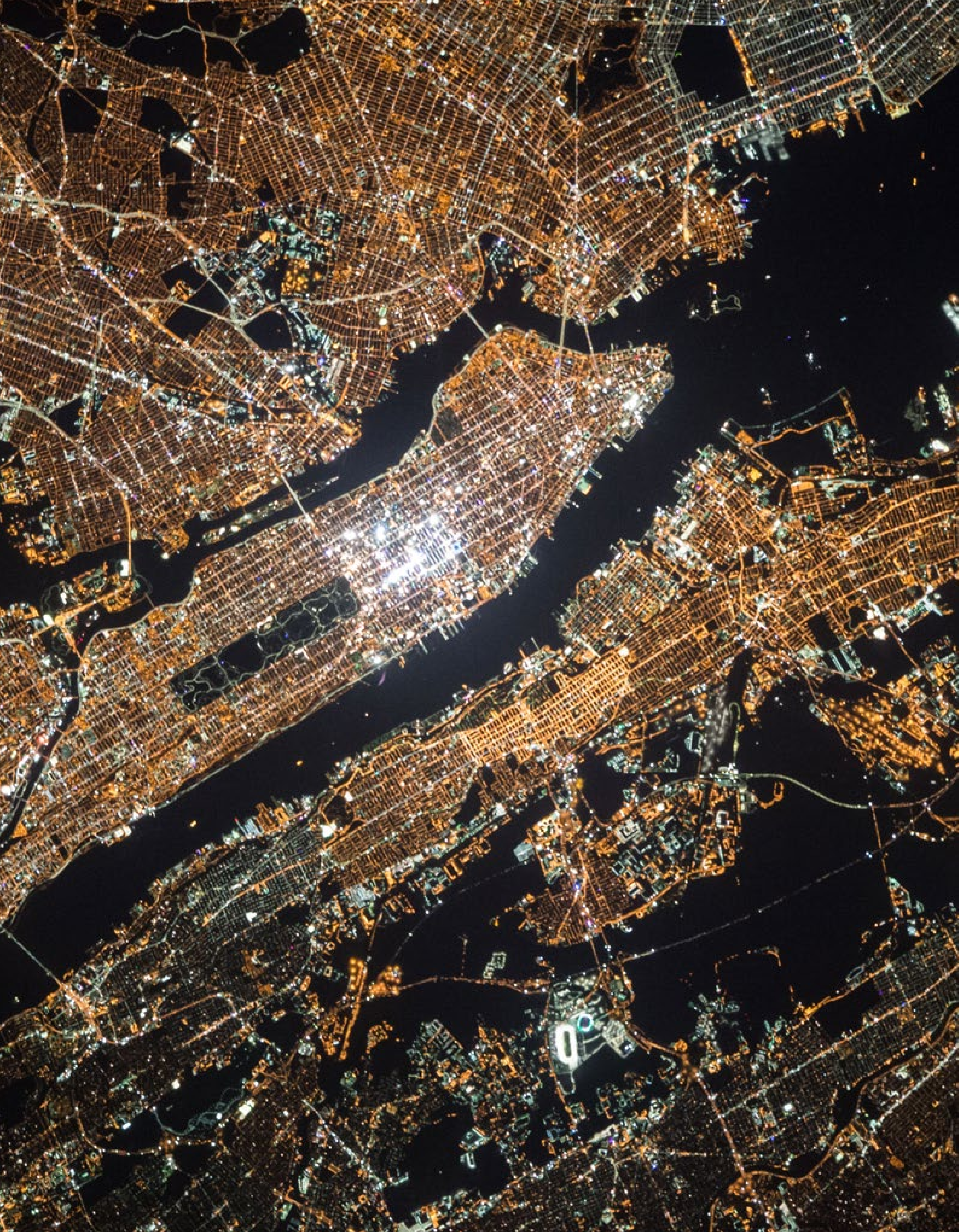

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