The Levels and Scales of Urban Networks

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The urban networks discussed in this volume, and that appear in the literature more broadly, are characterized by significant diversity. This is perhaps no surprise because the study of urban networks is necessarily interdisciplinary, drawing on theoretical foundations from geography, economics, psychology and sociology, and on methodological tools including ethnographic and qualitative methods from sociology and quantitative methods from mathematics and physics. However, although the flexibility of network models to capture a wide range of urban phenomena is a key strength of the approach and source of intellectual diversity, it can also be a source of confusion. Different fields and different research questions require studying different kinds of urban networks, often defined in very different ways, which obscures their commonalities.

In this introductory chapter, we sketch a framework for integrating the diversity of urban networks by situating them along the dimensions of level and scale. These two dimensions define, respectively, the aggregation and spatial scope of the nodes, and therefore provide critical parameters for defining an urban network. In some cases, a network's level and scale are defined implicitly by the research question, but we contend there is still value in being explicit about level and scale. Likewise, although much past research on urban networks has explored only specific intersections of level and scale (e.g. networks of people at the local scale, or networks of cities at the global scale), we contend that exploring urban networks with different combinations of levels and scales offers opportunities for new insights that the reader will find in this volume. We begin by describing the level/scale framework in general, then discuss the case of economic urban networks as an extended example, and use the framework to explore commonalities among the diverse urban networks in this volume. We conclude by discussing ways that levels and scales can be made more explicit in urban networks, and the potential benefits for studying urban networks at multiple levels and scales.

1. Defining urban networks

Networks are distinguished from other types of data by their focus not on individual cases, but on relationships. Therefore, defining any network, including urban networks, begins by specifying the relationship that the network is intended to capture. That is, in network terms, *what are the edges*? The relationships or edges that serve as the building blocks of an urban network, giving it a particular structure, might include physical flows such as the movement of people in a transportation network, intangible flows such as the movement of information in communication networks, or the physical infrastructures that facilitate such flows (e.g a street network). But, they can also include affective relationships (e.g. friendship), biological relationships (e.g. kinship), relationships of similarity (e.g. co-location). Clearly, defining the relationship that the network is intended to capture, already defines to a significant extent what kind of network it is. Therefore, and because there are so many types of relationships that an urban network might aim to capture, clarity and precision about the specific relationship an urban network does capture is critical for clearly defining the network.

1.1 Levels of aggregation

Once the relationships or edges of an urban network have been defined, next the nodes – that is, the objects participating in these relationships and between which the edges exist (or not) – must be defined. Butts (2009) recommends that "nodes should be defined so as to include all distinct entities that are capable of participating in the relationship under study" (p. 414). Following this recommendation, avoiding any aggregation of distinct entities, defines nodes at what we call the *micro-level*. However, nodes can be aggregated and defined at the higher *meso-level* or *macro-level* also. Such aggregations of smaller nodes into larger nodes is sometimes essential because, as Pavé (2006) explains, "properties of processes having no significance at lower levels appear at each level [through a process known as] emergence" (p. 45). It is in this perspective that Berry proposed in 1964 his seminal paper "Cities as Systems within Systems of Cities", that several levels of systems characterize cities: cities are themselves some spaces of interactions of actors and institutions (cities as systems) and are positioned into spaces of other cities with which they interact (systems of cities).

Thus, the *level* of an urban network characterizes the extent to which the nodes represent aggregations of the smallest distinct entities capable of participating in the relationship under study to larger systems (parts of cities, cities or systems of cities) that transform their individual actions and interactions. There are many ways that micro-level nodes might be aggregated, for example, individual people can be aggregated into groups with common interests or with common demographic characteristics, while individual firms can be aggregated into groups by sector or by value chain. Importantly, the aggregation of low-level nodes (e.g. people) into higher-level nodes (e.g. demographic groups) also implies aggregating their edges (e.g. person-to-person friendships are aggregated as group-to-group friendships). During this aggregation, although the basic definition of the edges themselves remains constant (i.e. friendship), the nature of the relationship does not necessarily keep the same significance after aggregation due to the non-linearity in the aggregation process. Following our example, friendship between persons is not necessarily the same kind of relationship as friendship between groups (i.e., the criteria for measuring friendship and the consequences in behavior are different for individuals and for groups).

The challenge of defining the level of a network mirrors the "modifiable areal unit problem" (MAUP) in geography (Openshaw & Taylor, 1979), where distinct spatial locations can be aggregated into spatial units in different ways (e.g. defining a "city" as a legal municipality vs. a metropolitan area). As Wolf et al. (2020) explain, "Place characteristics are contingent on where place boundaries are drawn" (p.2). Therefore, as is the case with the MAUP, defining an urban network's nodes at different levels can yield very different networks, with different structures, capable of capturing different processes and of answering different research questions. Therefore, clarity and precision about the level of (aggregation of) the nodes in an urban network is critical for clearly defining the network.

1.2 Scales of inclusion

Once the edges and nodes of an urban network have been defined, finally it is necessary to define which of these nodes (and their edges) should be included in or excluded from the network. In the social network literature, the specification of which nodes are part of a network is known as the "boundary specification problem" (Laumann et al., 1989). Because in the context of urban

networks the notion of a network 'boundary' is often specifically spatial one, this becomes a spatial scale specification problem. An urban network may be defined at the local scale to include only the nodes within a local area, or at the global scale to include all nodes regardless of their location, or at any spatial scale between these extremes (e.g., regional, national, etc.). The selection of a particular scale directly defines the size of the network (i.e. the number of nodes and edges it includes), and can significantly impact its structure because it implies the inclusion of some nodes and edges and the exclusion of others. But, still more substantively, as Wolf et al. (2020) explain, "Characteristics of a geographical process are contingent on the scale at which the process is measured" (p.2). That is, for example, trade processes may operate in radically different ways among a local network of cities within a region versus among a global network of cities. Therefore, clarity and precision about the spatial scale of (inclusion of) the nodes in an urban network is critical for clearly defining the network.

2. Economic urban networks: An example

The framework sketched above is intentionally abstract, allowing it to accommodate the diversity of urban networks. However, a concrete example serves to illustrate how edges, levels, and scales might be defined in practice, and how different definitions can yield different urban networks. Here, we focus on the broad case of economic urban networks.

2.1 Defining the relationship

In an urban economic network, the relationship under study is the exchange of capital. Exchanges of capital can take many forms, including exchanges of financial capital (i.e. money), physical capital (i.e. goods), intellectual capital (i.e. information), and human capital (i.e. labor). By defining an urban network in which the edges capture exchanges of capital, before we have provided any other detail about the network, it is already clear that it is an economic network.

2.2 Defining the levels

The smallest distinct entities which can exchange capital are individual people, which serve as the nodes in an economic urban network defined *at the micro-level*. Defining the network at this level may be useful for understanding, for example, how neighbors provide assistance to one another (e.g. borrowing a lawnmower), but for other research questions it is more useful to conceptualize capital exchanges as occurring between aggregations of people. For example, studying the movement of capital between firms (i.e. between people grouped into firms to which they contribute their labor) provides an urban economic network *at the meso-level* that may be useful for understanding supply and production chains. Aggregating further, studying the movement of capital between entire cities (i.e. between firms grouped into cities) provides an urban economic network *at the macro-level* that may be useful for understanding the organization of command and control centers in the world economy.

Notably, although the micro-, meso-, and macro-level definitions of an urban economic network differ in their aggregation of the nodes, they are all defined by the same relationship: the exchange of capital between these nodes. However, the specific nature of the relevant capital exchanges may depend on the level. For example, individual people may exchange their working (human) capital and relatively small amounts of money, while firms exchange large quantities of goods and

services in trade and supplying networks, and cities exchange labor pools and billions of dollars in financial products.

2.3 Defining the scales

An urban economic network might be studied at several different spatial scales, each which involves including different sets of nodes in the network. For example, a micro-level urban economic network in which the nodes are individual people might be studied at the local scale, including all the people in a given neighborhood in the network. In contrast, a macro-level urban economic network in which the nodes are cities might be studied at the global scale, including all the cities in the world.

2.4 Combining levels and scales

Much of the existing research on urban networks has focused on only some potential combinations of level and scale. For example, Neal's (2013) framework combines levels and scales to define micro-, meso-, and macro-urban networks, which correspond to the shaded cells along the diagonal in Table 1. However, each combination of level and scale potentially defines a unique urban economic network, and each of these networks may be useful for understanding different urban economic processes.

Table 1. Combinations of level and scale to define classic urban economic networks.

LEVEL (aggregation of linkages and nodes)		GEOGRAPHICAL SCALE (network boundary)		
		1 – Local	2 – Regional	3 – Global
A – Macro	Cities	City as a whole entity	Central place system (e.g. Christaller, 1933)	World city network (e.g. Friedmann, 1986)
B – Meso	Firms	Clusters (Porter, 2000)	Regional economic integration and functional polycentrism (e.g. Scott, 2001; Boschma, 2005)	Global inter-firm network (e.g. Cohen, 1981)
C – Micro	People	A neighborly economic support network (e.g. Wellman, 1979)	A local labor market (e.g. Granovetter, 1974)	The global economic elite (Sassen, 1991)

A network defined at the micro-level and local-scale (cell C1) may capture a network of exchanges of resources among the neighbors in a particular neighborhood, thereby providing insight into how neighbors provide one another economic assistance. At a larger scale, a micro-level regional-scale network (C2) might capture employer-employee relations in a metropolitan area, and thereby capture the exchanges that constitute a local labor market (Granovetter, 1974). At a still

larger scale, a micro-level global-scale network (C3) would include economic exchanges between all people everywhere, and thus would be simultaneously very detailed but also impractical to actually collect and analyze. A notable exception is Sassen's (1991) study of economic exchanges among a global *sample* of individuals, which provides insight into how economically-influential individuals interact on the global stage.

A network defined at the meso-level and local-scale (B1) could capture the alliances and complementarities among firms in a particular district within a city, which may be useful for understanding industrial clusters that facilitate competitive advantage (e.g. Porter, 2000). At a larger scale, a meso-level regional-scale network (B2) may focus on the inter-firm exchanges of information throughout the region that promote innovation through proximity (e.g. Boschma, 2005) and create locally specialized systems of production (e.g. Scott, 2001). Finally, at a still larger scale, a meso-level global scale network (B3) would include all the supplier-buyer or command-control relations between firms around the world, allowing for exploration of the new international division of labor (e.g. Cohen, 1981).

An urban economic network with nodes defined at the macro-level may not exist at the local-scale (A1) because in such a network the nodes are whole cities, but studies considering the city as a whole entity, without scrutinizing the internal interactions between actors, may be viewed as falling within the scope of this category. A macro-level regional-scale network, capturing the economic relations between cities in a region, lies at the heart of economic base and central place theories (e.g. Christaller, 1933). Finally, a macro-level global-scale network, capturing the specialized economic links of all the world's cities, is the focus of research on the world city network (e.g. Friedmann, 1986).

3. Finding commonalities through scales and levels

The confusion between levels and scales comes from the fact that the space-time scope (scale) usually characterizes nested levels of organization. However, as explained above, levels depend on the size and nature of the relations (links) between individuals (nodes) that are considered in the network, while the scale is the boundary of a set of interacting nodes. Disentangling scales from levels clarifies the diversity of network approaches which attribute different roles and properties to cities in their contribution to network formation.

We explore this two-dimensional perspective through the 28 chapters of this book. The explicit deployment of the levels supporting each chapter will underline *emergence mechanisms* appearing with the combination of multiple and dense interactions (3.1). Once the levels of the study are identified, the definition of scales depends on the network's context; one can adopt one or more scales (3.2). Thus, the comparison and the classification of the levels and scales of the networks presented in this handbook clarifies the diversity of city conceptualizations among these studies, enriching the mutual constitutive relation between cities and networks (3.3).

3.1 Levels

The definition of levels starts with the initial lower level where the basic networks are considered (3.1.1). Upper levels underline these *emergence mechanisms* (bottom up or top down), that are

the core of the different social sciences' contributions to the science of city (3.1.2). Micro/Macro or Micro/meso/macro suppose some nested levels, but non-nested levels are also possible, as well as multi-dimensional levels considering several criteria of aggregation (3.1.3).

3.1.1 Lower micro-level of relations

The lower micro level is the basic frame of urban networks. Nodes can be people, actors, or firms, with more or less specification on their interactions. For many chapter authors (Bettencourt, Metcalf et al., Bartholomew & Jones, Christens & Coope, Cachia & Maya-Jariego), individual persons develop certain connectivity according to their socioeconomic status, which leads to people's activity spaces inside each city. For Janulis, individuals develop their networks according to their sexual preferences, norms, and constraints and their partners, which extend the conditions to define the basic networks. These micro-networks link people and create their social proximity. This social proximity is not the goal *per se* for Batty, but proximity serves to channel opinion influences from a person to another. More implicitly, the city is a set of interacting actors for Hanson, Raimbault, Pumain or van Meeteren, but not studied *per se*. They use the (bounded) rationality of actors to explain the formation of urban processes, but without defining the individual properties and their relationship.

For Bogumil and Chase-Dunn, diverse networks as merchant trade, intermarriage, political-military alliances and conflicts, and more generally communication explain the history of cities' settlements, while Parnreiter focuses on contemporary trade networks between producer service firms and their clients. The networks between firms are privileged in the inter-city networks whether the links would be ownership relations (Rozenblat), greenfield investments (Wall & Kollamparambil), or mergers and acquisitions between firms (Pain & Shi). For O'Clery et al., firms are considered by their activity and linkages rely on co-located activities, so nodes are not the firms, but their activities.

Geographical space as location or movement can also constitute the basic frame at the micro-level of the city. For Barthelemy, interacting position nodes in the city constitute the micro-level framework. At the inter-city level, Ducruet considers maritime traffic as the initial network. Interestingly, other authors mix the movement and the social interaction between actors (Kourtit & al., Freeman Anderson et al., Burtner et al.). Thus, spatial and social movement combine very explicitly to produce urban life. Going a step further, Pieber & Quan-Haase propose that individuals interact with space through digital media. For them, direct social relations disappear and are replaced by the indirect relation of each individual with places. We are here in the classic geographic debate, where one wonders if the basic urban framework is constituted by the social relations in space or by the relations between society and space. It is interesting that this old question rises with the new digital media and their implication for the relation of inhabitants to their cities.

A last category of chapters considers the lower level as an already aggregated collection of individuals (that we could call meso-level). In this category we can distinguish two sub-categories. First, some approaches start at one unique aggregated level (e.g., communities of actors formed by cognitive, institutional, organizational, social distances; Sigler et al.), while others start at an

even more aggregated level of cities as a whole (Mahutga; Raimbault). Second, some approaches are rooted in the mix of two levels because the relations are defined by the belonging to a group. It is in particular the case of the interlocking model which assumes that linkages exist between members of each group. This book presents different examples of the application of this model: inside cities with the bipartite network formed by people and associations in Newcastle city-region in the nineteenth century (Barke & Taylor); Intra or inter-firm networks (Pan et al.; Derudder & Taylor; Pain & Shi for London).

3.1.2 The meso and upper nested levels

Collective properties that define intrinsically the mutual formation of cities and networks emerge from network processes happening in cities at a lower level definition. Most of the studies presented in this book use three levels (micro, meso, macro) or more that are often nested.

A typical example is the set of approaches described by Pumain, where individual interactions (micro-level) create cities or city-regions (meso-level) interacting with other cities in systems of cities (macro-level), but numerous other schemes are possible. Barke & Taylor define the city using two nested meso-levels: The city as a set of associations within which members interact by co-membership, and the city as interacting groups. Thus, these two meso-levels constitute the capacity of Newcastle to specialize in coal exportation and to become an industrial powerhouse in relation to other cities at the macro-level. Similarly, Pain & Shi, and Rozenblat, studying polycentric city regions also consider two meso levels: local centers interacting to form the city region that is itself situated among other cities with which it interacts at the macro level.

Other examples mix social relations and space to define the meso-level: For Kourtit et al., public spaces represent the meso-level where actors interplay; they call them 'platforms of interactions' or the 'microcosmic city.' Thus the 'smart city' (macro-level) is a network of microcosmic constituents. For Burtner & Murray, the meso-level is the aggregation of people by common ethnic and neighborhood. Accordingly, Bettencourt considers cities as groups formed by social transactions and diffusion, or by infrastructure networks. These mixed approaches support the view that social and physical properties interact to form the city.

3.1.3 Non-nested levels

When multiple levels are defined, they are not necessarily nested. Bartholomew & Jones suggest that cities create a double-embeddedness: social relations are embedded in a local structure of other relationships, which in turn is embedded in geographic space. Thus, they define four meso-levels according to different types of ties: "*avocational associations, institutional ties, familiar strangers, eponymous relationships*". These meso-levels are not at all nested, but in a way, they are arranged hierarchically by the intensity of the relations they imply, from closer relations for eponymous relationships to more distant relations for avocational associations.

3.1.4 The city in inter-level interactions

Upper levels in all cases are assumed to create emergent processes between basic initial relations. Direct and indirect collective mechanisms rise from the interacting multiple social networks. Each individual participates in several networks, transforming his or her behavior in a certain way for

future interactions. The change of individual behaviors could transform the cities, because cities, by their dense social networks are strong path of diffusion for new way of life and new practices (Hägerstrand, 1952; Cliff et al., 1992). In turn, the previous cities' structure support or slow down individual actions. Dynamics of multiple networks at micro-levels are embedded in the collective trend they create in a structuration way where individual actions and collective structure are intertwined (Giddens, 1984). Assuming levels is like considering them as regulators of the maintaining of the systems forming cities. In transition stages, individual behaviors and their levels of emergence transform in new ways of regulation and binding of actions.

Levels can be seen as pure 'social' groups or as 'pure' space or a mix of both. In most of the chapters presented in the book, the city is a system constituted by a set of social groups or by a set of places, that are all assumed to have a consistence by the intensity and the nature of the networks building them. Thus, a city represents some evolving structural properties that contribute to shape social practices of networking through these socio-spatial elements, and the city itself is transforming under the effect of the evolution of these networks.

Cities are the resulting macro-level, if one considers only what happens inside the city, or cities are only an intermediate meso-level if one assumes that each city is a part of a system of cities that constitute then the macro-level.

3.2 Scales

By the same diversity with which cities are assumed to constitute a certain level of emergent processes, cities are also situated among various scales depending on the questions addressed. Remember that the scales are considered here as the *extent of nodes and edges included in the network*. Most of the time, scales are geographical ones, but some examples show scales that are not necessarily geographic or that go beyond a simple geographical scope.

3.2.1 Geographical scales

Most of the chapters adopt some nested geographical scales, while varying firstly according to their intra or inter urban perspective. For intra-urban approaches, most of them have the lower scale as "neighborhood" (1) and the larger scale as the whole city (3; Freeman Anderson & Galaskiewicz; Burtner & Murray; Metcalf et al.), with sometimes an intermediate level in between like district (2; Kourtit et al.).

For inter-urban approaches, cities' boundaries constitute the lower scale (1) which are situated inside hinterlands/regions/kingdoms/states/countries (2), which is itself into the Global system space (Pumain; Bogumil & Chase-Dunn; Hanson; Mahutga; Sigler et al.; van Meeteren).

A third set of chapters broaden the scales from intra-urban to inter-urban (Bettencourt; Christen & Coope; Pain & Shi; Rozenblat). Here the lower scale is a part of city (neighborhood or locality) and the city appears at a second embedding scale, itself interacting with other cities at higher scales that could comprise countries, which themselves are interacting in the global space.

3.2.2 Non-nested geographical scales

Geographical scales are not necessarily nested. For example, neighborhoods, third places, venues, and activity spaces formed by the movement of actors (Bartholomew & Jones; Janulis), or sets of locations with amenities (Batty), are distinct ways to qualify different spaces that are not nested spaces. In addition, Bartholomew & Jones propose the scale "Online" which concerns only intra-urban relationships, despite its worldwide dimension. So, the scales are used here to delineate the set of nodes and their relations with a freer range of different meanings. The freedom of these authors is also visible when they address the different levels formed by social proximity, without any space, as a general premise of organization of the cities.

3.2.3 Non-geographical scales

The variety of scales extends outside geographical space by O'Clery et al. when they apply, for each city, three types of distances between their firms, to define the network boundaries, following the evolutionary economy approaches of relatedness: (1) occupations with similar skill requirements using occupational data, (2) shared customers and suppliers using input-output matrix, and (3) research and development proximity using patent citation data. Each city is seen as a whole, and networks according to the three 'proximities' are built between located firms (micro level) forming industrial clusters (meso-level), all together constituting the economy of each city. The unique geographical scale is thus the city (here US Statistical Metropolitan Areas – SMA), while other metrics are used to make varying the scale in non-geographic dimensions.

4. Multi-level and multiscale approaches of cities and networks

The set of chapters underlines the variety of possible definitions of levels and scales of networks when speaking about cities. Disentangling levels and scales permits to going beyond the assumption that larger levels correspond to larger scales.

4.1 Privileging the Diagonal of levels and scales?

As we observed at the beginning of this chapter, it is often assumed in network or system analyses that levels and scales would vary together privileging the diagonal of a table crossing both criteria. While this may often be a useful approach to city networks, many of the chapters in this volume illustrate that more nuanced approaches are possible.

Table 2. Levels and scales of the "City of opportunity" (Kourtit et al.)

LEVEL (aggregation of nodes and linkages)		GEOGRAPHICAL SCALES (network boundary)		
		The city is considered within different geographical scales		
The city is considered as a level of organization		1- Neighborhood	2- District	3- The whole city
A- Macro	"smart city" – network of microcosmic constituents	Identification of critical transitions and vulnerabilities at the local and district scales of urban spaces		XXQ city - city of opportunity': decentralized, interconnected urban areas by network linkages and new information technology / City management
B- Meso	Public spaces where actors interact (platforms of interactions) - 'microcosmic city'	'Active space' ties in a capability approach where is built the 3H-City triangle (happiness, health and home)		Environmental resources: infrastructures and places
C- Micro	Interacting actors	Micro-behavioral, 'opportunity-oriented' and 'bounded rationality' perspective at local and neighborhood level. Physical and virtual proximity		Collection of Big data

The conceptualization proposed by Kourtit et al. illustrates a classical intra-urban approach (Tab. 2). The city's inhabitants are seen as interacting actors (C1) for which the interactions could be intensified in 'active spaces' that are defined very locally and that emerge at a meso-level (B1) in the "3H-city triangle" (Happiness, Health and Home). This emergence is evaluated thanks to the collection of big data at the scale of the whole city (C3). What Kourtit et al. call the 'city of opportunity' (XXQ city) or 'smart city', is the network of these platforms of interactions emerging at the macro level of the whole city scale (A3). The city management of this process is based on resources situated in the active spaces of the whole city at the meso-level (B3), while the identification of critical transitions and vulnerabilities is conducted by the whole city's government at the local and district scales of urban spaces (A2). Thus, the district scale does not seem active at the meso-level of 'active spaces' (B2), because the district scale only participates to the general evaluation of their contribution to the whole XXQ city (A3). Then the diagonal is not complete, which is the case for most of the chapters presented on intra-urban approaches.

***Table 3**. Levels and scales of the "settlement networks and sociocultural evolution" (Bogumil & Chase-Dunn)*

LEVEL (aggregation of nodes and linkages)		GEOGRAPHICAL SCALES (network boundary)		
		The city is considered within different geographical scales		
The city is considered as a level of organization		1- Local	2- Regions/States	3- International/Global
A- Macro	Settlements in Core / semi-peripheral / peripheral hierarchies		- Rise of networks that emerged to link settlements => early instance of semi-peripheral development/ hilly flanks /chiefdoms	Global hierarchy of cities => multicentric political structure of interstate networks
B- Meso	Settlements and institutions	First sedentary villages	- Effect on cities' size and differentiation - Cities-States	Large city-regions
C- Micro	Merchants trades intermarriage, political-military alliances and conflicts, and communication		Camps and migration circuits	

Shifting now to an inter-urban approach, Bogumil & Chase-Dunn's chapter on the "settlement networks and sociocultural evolution" is an exemplary construction on levels and scales (Tab.3). Bogumil & Chase-Dunn define the basic linkages as the trade between merchants, intermarriage, political-military alliances and conflicts, and communication, all often implying institutions' political power or control. Before settlements became sedentary, every interaction remained isolated and fragmented in camps and migration circuits (C2) that occupied a larger regional space than cities. A meso-level emerged from the aggregation of relations created in sedentary settlements (B1). Interestingly, the portion of space is reduced in local spaces during this transition. Then an early instance of core/periphery relations emerged from the interactions between settlements at the region/state scale (A2), in limited areas because there were not long-distance interactions. It favored certain cities and not others, making the size of cities grows unevenly and attributing functions of capitals and city-states (B2). At the global scale, the encounters of several systems having uneven development, increased the sociocultural complexity of the core/periphery model creating a "multi-centric political structure of interstate" networks (A3). At the meso-level, some few cities benefitted from this global integration creating large city regions (B3). Bogumil & Chase-Dunn specify that "higher levels of complexity cannot emerge directly out of low levels", because scale expansion from local to regional and from regional/state to Global participated together with levels, to this emergence. But this "scaling-up" and "levelling-up" shift was not necessarily in the diagonal of 3*3 matrix of levels and scales.

Table 4. Levels and scales of the "Ties through place: socio-material network analyses in urban studies" (Bartholomew and Jones)

TYPES OF TIES to form communities	TYPES OF PROXIMITIES to define spaces of interaction			
	The city is considered within different spaces			
	Neighborhood	Third Places	Activity Spaces	Online relationship
Avocational associations	Socializing frequency is distance dependent			
Institutional ties		It is the interactions that occur in institutional settings, such as schools, that lead to greater tie generation		
Familiar Strangers		Frequency of meeting others with similar interests increases with the density of locations serving that interest in a given area	Friends are more likely to share urban space than random user pairs, and they also share more locations	
Eponymous Relationships				

Finally, Bartholomew and Jones' chapter on "Ties through place: socio-material network analyses in urban studies," where both social (levels) and spatial (scales) contribute in different ways to identity formation and social cohesion, offers an example that has neither nested levels nor nested scales (Tab.4). The complementary scales and levels are described as multiple ways that intersections may occur across spaces and between the different types of ties, where "unplanned encounters" would happen. They have no hierarchy, but act as complementary social and spatial dimensions. Not all the cells of the table are described because many social forms of community operate regardless of the kinds of space, and types of spaces create platforms of interactions whatever the type of ties. Online relationships are a particular form of social tie, which is not spatial, but still also contributes to the cohesion of the city or of parts of the city.

4.2 The city as a level or a scale?

These three examples serve to enlighten the general model sketched at the beginning of this chapter and to disentangle how scales and levels operate together, thereby illustrating, that the relation between cities and networks takes numerous aspects of levels and scales. Cities form different kinds of communities with uneven contents, multiple natures of relationship, creating cohesions and communities by social, economic, cognitive, political, spatial, digital, and other forms of proximity.

To the question: "Is the city a level or a scale?", one can answer that the city is both a level and a scale: it represents a social / economic / cognitive process that emerges in specific spaces, and the city can eventually be considered as emerging from its relations with other cities that constitute a system of cities. It is both a top-down and bottom up complex process evolving in relation with the transformation of social relations and of global trends. The urban space is strongly dependent

on what is considered as the basic constituent of this emergence, namely the nodes and linkages of the networks. This is surely why cities' boundaries are so difficult to delineate in a universal way: rooted in sociocultural evolving relations, it reflects the specific places of the organization of the society. As with every evolving system, cities' boundaries continuously move according to the transformation of its components, of its levels and of its scales. Scales of cities depend on the networks' scope of each one, leading some authors following Lefevre (1970), to argue that urbanization would be generalized over the planet in a "planetary urbanization" (Katsikis, 2018).

4.3 Role of digital networks in cities (levels, scales)?

With the increasing role of digital networks, the city continues to evolve but also to reinvent social relations in space. Several chapters deal with this new 'scale' and how levels and spatial urban scales transform under the effects of these new communication modes that occupy more and more aspects of citizens' life. Digital networks both create a new space but also new communities, renewing the basic constitution of cities. Cities are not disappearing with these digital communications, but instead will gain new strength and new imaginary symbols. Technology, culture and identity have new ways to convey citizen expressions and claims, mixing online social networks, locational digital tools for meeting or repulsion, reviving traditional human feelings with new tools. Democracy, climate change and global issues of human development, health and well-being are some of the main issues that must be solved by networks and cities for the future.

5. Presentation of the structure of the volume

This book explores the state of the art of the intertwining of cities and network relations. The individual chapters represent an interdisciplinary set of collaborations introducing a large variety of approaches, in terms of levels and scales of networks, often going outside the traditional co-variations of levels and scales we discussed above. These chapters are grouped in five parts:

I. Theoretical conceptions of cities and networks
II. Cities and networks in the history
III. Methods & models of cities-networks interactions
IV. Network processes within cities
V. Network processes between cities

This clean grouping belies the diversity and depth of these chapters as each chapter often addresses multiple issues (e.g. theory *and* method, or intra *and* inter-urban) and could have appeared in multiple parts. However, each chapter contributes to some understanding of the relations between cities and networks, constituting a kaleidoscopic contribution which reflects the complexity of these relations. We hope that the volume will be useful for scholars of all disciplines that would like to go deeper in one or several dimensions of cities and networks mutual constitution, and that this plurality of approaches will open large avenues for further multidisciplinary studies.

Acknowledgement: We thank all the cited chapters' authors who reviewed this chapter, helping to make this introduction more consistent with their own chapters. But of course, the responsibility of the content developed in this introduction chapter, remains with the authors.

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