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Natalia Zdanowska, Céline Rozenblat, Denise Pumain

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Evolution of urban hierarchies under globalization in Western and Eastern Europe

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Abstract:

European cities can be conceived as forming a system of well interconnected cities since many centuries. The peculiarities of their hierarchical functional organization and territorial patterns have been the subject of numerous analyzes. The purpose of this paper is to detail a few contributions from the science of complex systems to formalize this knowledge. This includes representing the metropolization process occurring within a system of cities with the help of scaling laws and network analysis. We define here the metropolization process, not at the local level of one metropolitan area, but at a macro-geographical level, as the ability of larger cities to capture at first the activities related to innovation waves and being the first to benefit from them in terms of population growth. A series of relevant urban attributes are used for quantifying through scaling laws exponents the differentiated behavior of urban hierarchies when opening to the global networks that characterize the most recent wave of innovation. Network analysis brings another type of formalism that helps constructing a better understanding of how the globalization processes, especially described with the spread of multinational firms, have diffused in the Eastern part of the European urban system.

Keywords: systems of cities; urban hierarchies; metropolization; scaling laws; firm networks; Europe

Introduction

This paper includes a new elaboration in a set of investigations about the evolution of European cities. We define a system of cities as a set of intensely connected cities whose evolutions become interdependent and co-evolve through their connections by multiple networks (Pumain 1997, Peiris et al.2018). We shall not here propose an entire review of that question which is already well documented by statisticians, demographers, geographers and historians from Western Europe (as for instance de Vries 1984; Hohenberg and Lees 1995; Hall and Pain 2006; ESPON 2010) and specialists from Eastern Europe (Dziewoński 1953 ; Korcelli 1977 ; Musil 1977 ; Eneydi 1996). We have summarized earlier how European cities could be considered as forming a system of cities over a very long period of many centuries due to the multiple networks that where developing between them (Cattan *et al.* 1984; Pumain & Saint-Julien 1996; Bretagnolle *et al.* 2000). This hypothesis has been revisited many times, emphasizing the diversity of urban spatial patterns (Rozenblat 1995 and 2009), the diversity and complementarity of urban attributes and functional trajectories (Rozenblat & Cicille 2003) and the polycentric structure of the system (Rozenblat & Pumain 2018). We propose here to focus on the more recent transformations of the European system of cities linked with globalization, especially since the opening to market economy of the Eastern part of Europe after 1990.

Most authors who analyze globalization processes focus on larger cities only. Europe is one of the most developed regions of the world, it has been urbanized for a very long time, but the ancient fragmentation of its territory in many states explains that it does not have very big cities, if we compare it to large Asian countries twice as populated (China and India), or even to less populous countries like the United States, Brazil or Japan. It therefore seems opportune to ask the question of how the effects of globalization spread in European urban hierarchy not only by studying a few large cities, but by considering the system of cities as a whole, including small and medium-sized cities. Following an evolutionary theory of urban systems (Pumain 1997, 2018), our major hypothesis is that the globalization trend can be analyzed as an innovation wave that challenges cities for adaptation. Usually this adaptive urban co-evolution reinforces the hierarchical inequalities within systems of cities, resulting in a metropolization trend (Robson 1973; Pred 1977; Pumain & Moriconi-Ebrard 1997; Pumain *et al.* 2015).

In this paper we shall recall first the peculiarities of the hierarchical structure of the system of cities in Europe including its geographical variations. In a second step, we examine how the recent literature on scaling laws may help in detecting a metropolization process in urban hierarchies and link them to the hierarchical diffusion of innovation in urban systems and led us to observe a West-East divide can be observed in the metropolization trend linked to the recent diffusion of global networks within the European urban system (Rozenblat & Pumain 2019). Finally, a third section enable deepening the interpretation of this last trend, by operating a zoom analysis of how multinational networks selected cities in the Central and Eastern parts of Europe after 1990 (Zdanowska 2018). The conclusion is that path dependence effects are important in urban evolution and sustain a strong explanation of the persistency of hierarchical and geographical peculiarities within systems of cities.

1. Hierarchical and geographical structuration of the European system of cities

The urban transition that massively moved populations from rural to urban areas starting with the demographic transition and industrial revolution in Europe at about the end of 18th century (Zelinsky 1971) has spread in all parts of the world, and the economic, technical and social constraints that are now exerted on urban development seem to prevail globally for all cities (World Bank 2009). This trend towards making urban issues more global is now amplified through the requirements and concerns associated with climatic changes and the mitigating transitional policies, aiming towards renewable energies and more broadly the environmental protection. However, the spatial structures in cities and between cities are still quite dependent on the long history of settlement systems. Traces of ancient spatial organization still differentiate the European urban system from others in the world and to a lesser extent mark a difference between Western and Eastern parts of Europe (Bretagnolle et al. 2000; Rozenblat and Pumain 2018). This is a very good example of “historical chaining” or “path dependence” in complex systems. Such a dynamic feature is very important because it determines the solutions that can be adopted to achieve the future adaptation of cities to ongoing socio-economic and technological transformation processes (UN-Habitat 2016).

1.1 Europe is a continent of small and middle size towns

Due to an old settlement system, in which cities have developed relatively continuously with modes of spatial interaction governed by slow speeds and thus under strong proximity constraints, Europe is in the world, a region of small towns, spaced an average of fifteen km only when urban agglomerations larger than 10,000 inhabitants are considered. As a result, almost half of the population lives in agglomerations of less than 500,000 inhabitants, and Europe differs markedly from other continents (Tab.1). Conversely, the share of the population living in the cities larger than 5 million inhabitants is rather small, lower than 5%, whereas it reaches 10 to 15% in the parts of the world having similar high rates of urbanization, i.e. where at least three quarters of the population is urban - a proportions that will probably be reached quickly in the next two or three decades by countries in Asia or Africa that are undergoing accelerated urbanization.

Table 1: Distribution of total population in size classes of cities* (%)

Size of cities	<500 000	500 000 -5 millions	> 5 millions	Rural population	Total
Latin America	36	22	15	27	100
North America	30	35	12	23	100
Europe	**47**	22	**4**	27	100
Asia	19	13	6	59	100
Africa	23	11	3	63	100

*Source: United Nations, 2014 (*cities delineated as urban agglomerations)*

As a consequence, Europe has two megacities (cities larger than 10 million inhabitants) only, Paris and London, and the continent has not to manage gigantic human concentrations such as those already developed in the megalopolises of Northeast America between Boston and Washington, or in Japan from Tokyo to Osaka, or those developing within the large Chinese deltas, each grouping now from 40 to more than 100 million inhabitants. Besides, in Asia are generated unprecedented forms of mixing and nesting urban habitat and manufacturing activities with rural ones, generating a specific pattern between cities and countryside that was coined "desakota" by McGee (2009). Until now such "desakota" forms are hardly found in the peri-urban areas of major European agglomerations.

1.2 A continent of moderately dense cities yet highly structured in systems of cities

Europe is apart from other continents not only by the distribution of its cities in the territory but also by its average urban densities. The average urban density levels are clearly intermediate between the extreme dilution of North American cities, and the high concentrations of Asiatic cities. The urban planner Alain Bertaud (2004) has calculated average densities for about fifty millionaire cities in the world by dividing their populations by the built-up surfaces measured on satellite images (these measurements thus define "urban morphological agglomerations"). The order of magnitude of these average densities is about 2,000 inhabitants per km^2 for the cities of North America, 10,000 to 40,000 for the Asian cities, and 4,000 for the European cities.

The built-up space of cities is organized with a more or less regular decrease in the intensity of land use from their center to their periphery. This is due to the high social value of their centers, which are places of maximum accessibility and greater identity prestige for businesses and residents. This form of "urban field" is observed everywhere in the world but with large variations in intensity: the center-periphery contrasts are more accentuated in Asia and very weak in North America, while the European cities are in intermediate position. The strong urban density gradients very often correspond in Europe to radio-concentric organizational plans, drawn by the access routes to the attractive centers in several directions combined with ring roads installed on the ancient fortifications that were periodically enlarged.

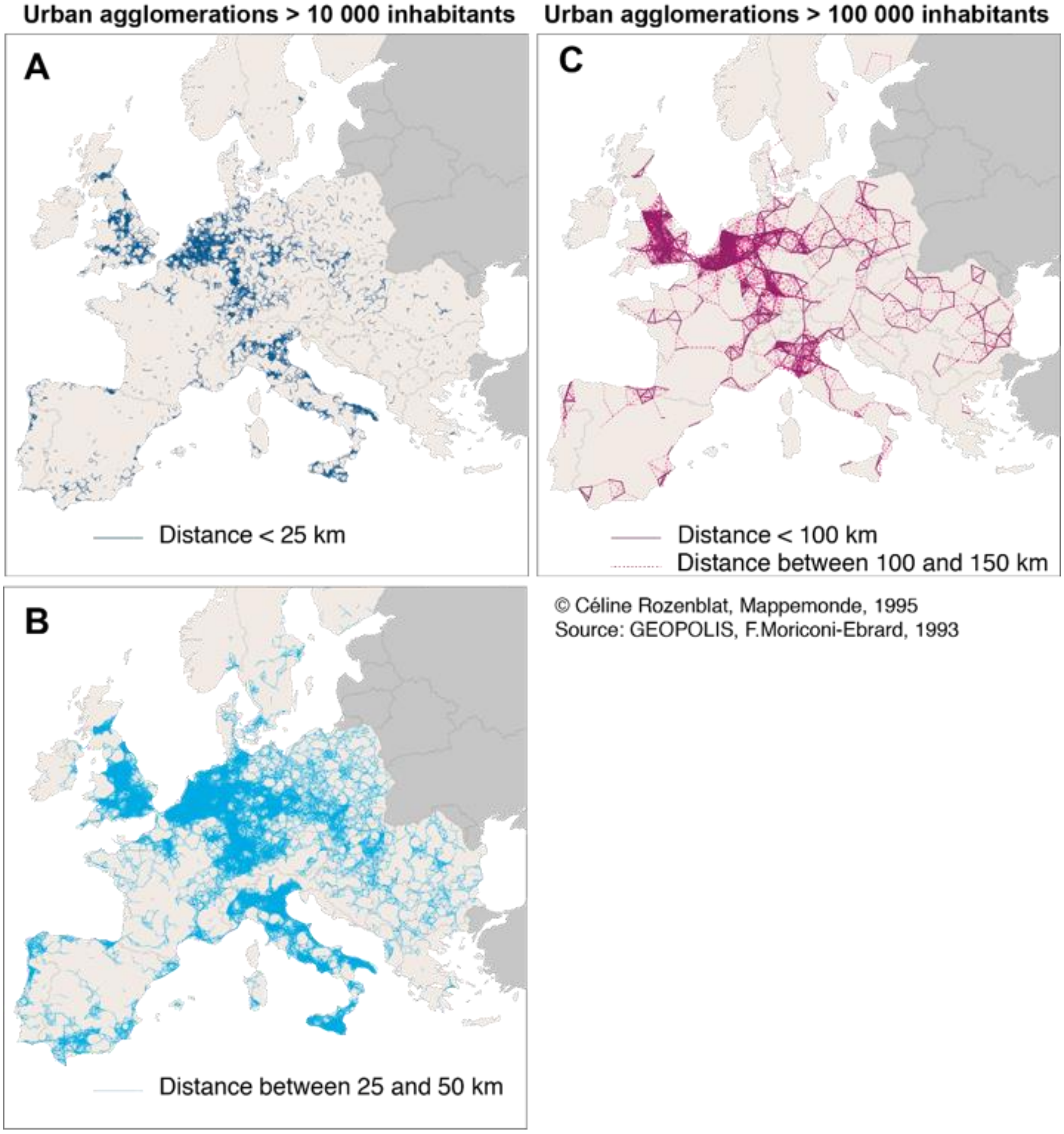
This long-recognized form of spatial organization (Bleicher 1892; Clark 1951) has more recently been formalized in terms of fractality (Batty & Longley 1994; Frankhauser 1994). The use of CORINE Land Cover images has made it possible to highlight the wide generality of a European model for the organization of built-up areas around urban agglomerations (Guérois 2003). While population densities, and especially urban land prices, draw out forms of center-periphery decay modeled by negative power laws or exponential functions, the intensity of physical land occupation is rather distributed according to a double linear gradient as a function of distance to the center of cities. Built-up areas decrease regularly, not only in the densest parts built in continuity within the core of the agglomerations, but also, according to a lower gradient, in peri-urban areas located in radii of 40 to 100 km depending on the size. Fractal measurements reveal dimensions whose values are between 1 and 2 for the central zones of built-up urban areas, while the peripheries of large urban areas have fractal dimensions very often comprised between 0 and 1, according to scattered forms similar to the mathematical model of Cantor dust (Guérois & Pumain 2008).

Is the dual urban building gradient observed from the CORINE Land Cover data predicting the emergence of a new urbanization model on the outskirts of cities, or the gradual incorporation of these peripheries into the urbanized perimeter? The recent evolution of these gradients would rather conclude in favor of the second hypothesis: whatever the size of cities, the highest growth rates of built-up areas are observed at the boundaries of urban agglomerations. In Europe, urban sprawl therefore takes place much more on the periphery of the zones already built in continuity, than it colonizes more distant peripheries (Guérois and Pumain 2008; Denis 2020).

1.3 Regional variations of urban hierarchies

Whereas at local scale European cities exhibit rather comparable spatial structures, there are internal variations in the statistical shape and spatial distribution of urban hierarchies that differentiate roughly three large urban settlement styles from the West to the East. Figure 1 gives a simple but striking image, both of the persistence of the spatial organization of the systems of cities and of the coherence of these forms across the scales of geographical space. Céline Rozenblat (1995) has linked European cities larger than 10,000 inhabitants (delimited according to a harmonized definition of morphological agglomerations) by a segment of varying length, less than 25 km on a first map (Fig.1A), then 25 to 50 km (Fig.1B), and between 150 and 200 km for only the cities ten times larger (more than 100,000 inhabitants) (Fig.1C). The result, which is spectacular, shows on each of the maps the same large territorial areas: to the West, France and Spain, whose territories where early centralized in large kingdoms, exhibit a few high urban concentrations and very contrasted spatial distributions; in the center, a dense wrap of closer cities characterizes the states (Germany and Italy) whose national unity, which occurred much later, allowed rival cities, capitals of principalities or bishoprics, to develop in competition for a long time. (England, although centralized early on, belongs to this diagonal because of the intensity of its industrial revolution, which in the 19th century filled the urban void in the center of the country by creating fairly large cities); in the East, cities are spaced much more evenly, these regions having been urbanized later but quite systematically colonized between the 13th and 17th centuries, most of time by religious congregations. This simple representation is testimony to the strength and durability of the spatial integration of the socio-political structures established in urban interactions and the solid coherence of the resulting multi-scalar spatial organizations.

Figure 1: Three settlement styles of urban hierarchies in Europe



1.4 Trends in the recent urban expansion

We use here a restricted concept of *metropolization* for describing a fundamental trend in the evolution of every system of cities (Pumain and Moriconi-Ebrard 1997). That systematic trend consists in growing contrasts in city sizes over time that lead to sharper inequalities in urban hierarchies. It is theoretically explained by two major processes: i) the hierarchical diffusion of innovations and ii) the space-time contraction (Janelle 1969). The first process leads to a concentration "from the top" of the hierarchy because of the strongest economic and often demographic growth associated with the first stages of development of new products and services that are captured by largest cities. The second process induces a "bottom-up simplification" of urban hierarchies, insofar as the smaller cities, statistically, are penalized for growth, first in relative terms and then in absolute terms, because their catchment areas are bypassed by the expanding range of larger cities linked to faster and more efficient transportation means (Bretagnolle *et al*. 1998). This "simplification from below" of urban hierarchies becomes even more visible when urban growth slows down. Inequalities in size and functional skills are widening between cities, leading to new concerns for the fate of small towns, as well as those left behind by more or less "obsolete" specialized activities. This process of devitalization begins statistically in small towns, and in different European places the support for shrinking cities is beginning to be the subject of remediation policies (Martinez-Fernandez *et al.,* 2012).

The expansion of cities in European space now continues according to two contradictory processes depending on the *geographical scale* of observation. At the level of the national territories, the movement of metropolization summarizes the relative concentration of the innovative social and productive forms in the largest cities. At the local level, the dominant for at least several decades is a trend towards urban de-concentration and sprawl. This process has a long history starting earlier in the largest cities for urbanistic purposes or hygienist reasons (for instance as early as the end of the 18^{th} century in certain Parisian districts), but has accelerated considerably because of the multiplication of motorized journeys, which allow arbitration in favor of lengthening access distances to the jobs and central services of cities at the cost of maintaining travel times.

The two contradictory spatial trends in the evolution of the cities (metropolization at national scale and urban sprawl at local scale), must be reconsidered in the future after the completion of the demographic and urban transitions. Both transitions occurred in the developed countries and especially Europe and Japan since the 19^{th} century, before they reach mainly from 1950 on the developing countries currently undergoing rapid urbanization. One may wonder if, after the completion of urban transition, there is a continuation of the metropolization trend or if a stabilization or even a reversal of that trend is possible. The technical instruments provided by the recent development of studies in urban scaling laws can help in measuring more precisely the components of the metropolization effects according to the way various urban attributes are changing all along the urban hierarchies.

2. Scaling laws for measuring metropolization effects and the European West-East divide

Scaling laws have been the subject of many publications, when physicists have successfully used this formalism to characterize the metabolism of living species (West *et al.* 1997), then more recently when they tried to apply it to cities (Bettencourt & West 2010; West 2017). A recent special issue of the journal Environment and Planning B (vo. 46, issue 9, November 2019) illustrate many examples of applications to urban analysis. We summarize here the results of an experiment conducted on European cities, which develops a theoretical interpretation adapted to these objects that are submitted to evolutionary processes that are not biological, but social and historical.

2.1 An evolutionary interpretation of scaling laws

Scaling laws are systematic relationships whose mathematical models are power functions between the size of entities and some of their functional attributes –as already coined by the biologist d'Arcy Thompson naming them allometry (1952). According to physicists, scaling laws reveal physical constraints on the structure and evolution of complex systems: in the case of biology, they identified systematic sub-linear relationships between the metabolism of species and their size, which reveals economy of scale in the construction of biological organisms over the long time of evolution. They were able to explain this from the spatial distribution of energy within organisms through fractal networks (West *et al*. 1997).

Applied to cities, scaling laws describe the variation of an attribute according to the size of cities generally measured by its number of inhabitants (Lane *et al.* 1999). The surprise to physicists was to discover that some exponents could be larger than 1, especially when considering attributes measuring the urban productive outputs or concentrations of income and skills. Thus instead of always testifying economies of scale (which can be observed in the case of urban technical networks for instance), urban scaling laws can represent increasing returns with scale, when large cities have developed the attribute more than small ones. Such a growing concentration of some attributes with city sizes testifying to a process of metropolization is already well known in urban science, at least since the first formulations of central place theory explaining the increase in number, status and diversity of urban functions with city size (Reynaud 1841; Robic 1982; Christaller 1933). Physicists translate this in a universal interpretation: "*cities are approximately scaled versions of one another*" (Bettencourt & West 2010) and suggest an explanation in terms of "*increasing pace of life*" with city size. Moreover, they infer a longitudinal relationship from transversal data, when pretending that "*on average, as city size increases, per capita socio-economic quantities such as wages, GDP, number of patents produced and number of educational and research institutions all increase by approximately 15% more than the expected linear growth*". Such extrapolations are contested because ergodicity is not a property of urban dynamics, which is an historical process (Pumain 2012) and because there are no universal values for the empirically observed relationships that are highly depending on urban ontologies, measurement contexts and methods (Arcaute *et al.* 2015).

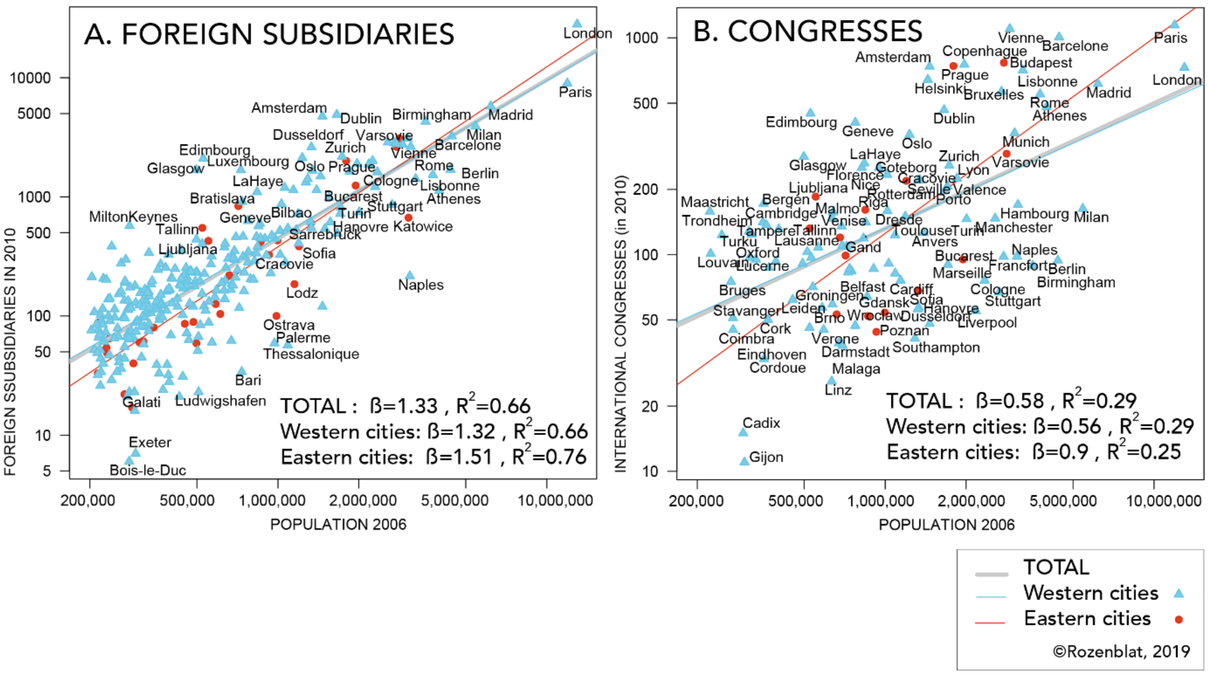
An alternative explanation to urban scaling laws is better related to former urban theories when linking them with the processes of urban growth, inter-urban interactions and the spatial diffusion of innovations throughout systems of cities (Pumain *et al*. 2006). The theory of hierarchical diffusion of innovation (Hägerstrand 1952; Pred 1973; 1977) explains how new activities and social practices are captured at first by large cities having the right information level, financial support, productive structures and employment skills to adopt them at an early stage of their development. Although these innovations tend to percolate afterwards down the urban hierarchies, they leave slightly higher benefits in terms of economic returns and social capabilities in the cities that took the initial advantage of the adaptation, comforting the historical metropolization trend that reinforces urban hierarchies. This process was recently accentuated by the acceleration of globalization as revealed by experiments on the distribution of economic activities of cities using scaling laws (Paulus 2004; Pumain *et al*. 2006; Finance 2016). Indeed, the exponents of urban scaling laws vary over time according to the stage of diffusion of the novelty in the system of cities: at the beginning of a new innovation wave, exponents are raising above 1 until a maximum, then they stabilize around 1 when the new activity or social practice becomes common, and they diminish below 1 when the mature activities or the residual practices are almost found in the smallest towns only. Thus, we decided that the scaling laws exponents could be used as reasonable proxies for detecting the stage of diffusion of an innovation within a system of cities.

2.2 Dual process of innovation diffusion: the West-East divide of Europe

Previous studies of innovation diffusion in systems of cities had demonstrated that the process is different according to the type of urban hierarchies. Sophie Baudet-Michel (2001) observed how business services have percolated in three different systems of cities since the end of 19th century. She demonstrated that in a first stage the concentration of the activity was higher in the systems having a primate city, as France and UK, whereas eight German metropolises had captured each a significant amount of the novelty. But in a second stage, the spatial expansion down the urban hierarchy was much broader in the French than in the German system of cities. Thus, the hierarchical diffusion is not an even process according to city size but an adaptation of the whole system of cities that keep in the process the originality of its structural features.

We assume that a variety of globalization processes integrating European cities in multiple networks can be analyzed as an 'innovation wave' that diffuse hierarchically in urban systems. Thus we decided to analyze which stage had reached the diffusion of globalization in the European system of cities as a whole and in its parts, using scaling laws as providing a measurement of the intensity of metropolization for a series of urban attributes. Regarding the globalization process and its effects on European cities, we gathered a number of attributes that were comparable and available around 2010 for as many cities as possible and estimated by many scholars as revealing the potential or realized participation of them to the global networks. These attributes were indicators of productive capacity, accessibility, attractiveness, centrality in investment networks and centrality in European research space, cultural influence and access to European institutions. We shall not list here again the 25 indicators measured for 356 largest functional urban areas (in European Union plus Switzerland and Norway) that are detailed at length in a recent publication (Pumain & Rozenblat 2019). We provide an illustration of how scaling parameters are estimated in Figure 2 for two among these 25 variables. These two are opposite examples of the different types of qualitative scaling relationships.

Figure 2: Scaling relationships for two attributes measured on European cities



The distribution of foreign subsidiaries among European cities is clearly an example resulting from a hierarchical diffusion process at its initial stage: the exponent of 1.33 marks an overconcentration of this connection to the networks of multinational firms that favors in a first stage the largest cities of the system. Conversely, the number of international congresses scales sub-linearly with city sizes with an exponent of 0.58 that measures a relative overconcentration in smaller towns. It may partly reflect the location of many universities and research centers in smaller towns as Oxford, Cambridge, Bergen, Lund, Turku, or Heidelberg. Congress activity also is sustained by international networks who may search for locations that are not so prestigious and expensive because of their economic power and that offer other amenities for hosting meetings, as environmental resources or heritage landmarks.

Our study including the 25 indicators of metropolization has confirmed the intensity of penetration of global networks among the whole European urban system (Pumain and Rozenblat 2019). Most of these variables scale super-linearly with city size when adjusted as a power function of the population. This form of super-linear relationship demonstrates a greater ability of the largest cities to capture the benefits of the innovation. In a second step this study revealed two different stages in the metropolization process due to the recent globalization, according to the location of cities in the Western or Eastern part of Europe. While the hierarchical diffusion is already almost completed in Western Europe and reaching many medium size cities, the diffusion of global networks is clearly in an earlier stage in the Eastern part, still concentrated in the largest cities, as attested by much larger values of scaling exponents for this region of the system. Thus scaling laws reveal a major difference between the Western and Eastern European process of hierarchical diffusion of globalization that had not been detected before (Pumain & Rozenblat 2019). We try now a deeper investigation in the evolution process among the cities of the Eastern part.

3. Differentiation within Central and Eastern Europe

A specific zoom will now be made on the Eastern part of the European Union, where metropolization and globalization processes have been delayed, first through the more equalitarian urban policies during the socialist period, second because of the later opening of boundaries to market economy. From now on the term of Central and Eastern Europe (CEE)[1] will be used, to distinguish it from Eastern Europe – sometimes referring to Belarus, Ukraine or Russia in the literature.

3.1 Internal West-East gradient in the recent growth impulses probably given by adaptation to globalisation

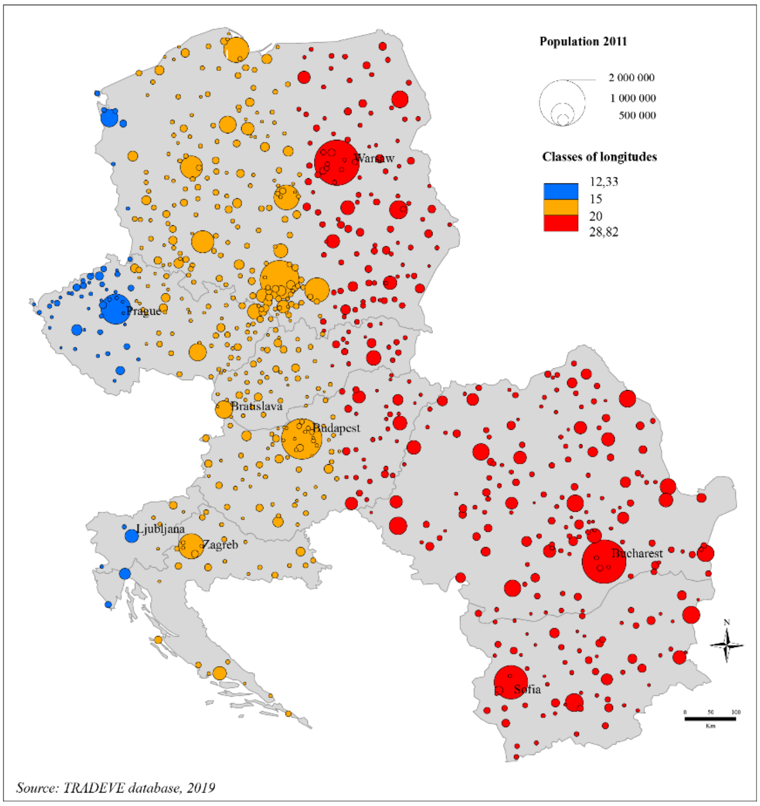
To complete the vision of a purely hierarchical diffusion process that could be suggested by the high scaling exponents of globalization indicators in the Eastern part of Europe, we test in this sub-section the hypothesis of a possible uneven development of cities according to their location. Our hypothesis is that the participation to globalization of CEE cities has been enhanced or facilitated by their proximity with other UE countries.

We thus have estimated this proximity by computing for each city its closest distance in km to the border with Germany, Austria and Italy[2]. All CEE cities were then classified into three classes of geographical longitudes denominated for the purpose of the analysis “Western”, “Central” and “Eastern” facades. The average distance of cities to German, Austrian and Italian borders in each class are 33, 157 and 537 km. (Fig.3). If our hypothesis of an influence of geographical proximity on the level of participation to globalisation is correct, we expect a higher urban growth in the Western class compared to Central and Eastern ones.

[1] Understood as eight post-communist countries, members of the European Union (Bulgaria, Croatia, Czechia, Hungary, Poland, Romania, Slovakia, Slovenia).

[2] In technical terms, under ArcMap software, this corresponds to the shortest distance from a point to a borderline – here defined as the shape of the CEE border with Germany, Austria and Italy.

Figure 3: CEE cities' division into three zones of longitude according to their distance from the German, Austrian and Italian border



We find that up to 1991 the cities located the furthest away from these German, Austrian and Italian borders, had the highest growth rates (Tab. 2). That situation can be explained by the former wave of the demographic transition, i.e. changes in cultural and familial behaviour, whose spatial diffusion was roughly oriented from the West to the East. After 1991 and the major political change, these cities of the Eastern part exhibit the most negative growth rates compared to the Western facade. This reversal in their growth trajectory clearly underlines to what extent the opening of CEE cities to the market economy and globalisation trends has created a West-East oriented gradient of urban growth, according to the growth-recovery logics (Tab.2). The political change instituted a complete reversal in the demographic behaviour of Western and Eastern cities of the CEE region. This new innovation wave may also have widely deepened the pre-existing contrast between Western regions that were sooner involved in the general post-war demographic transition trend, which was delayed in the Eastern part of the socialist countries.

Table 2 Average annual growth rates (%) of cities' population in Central-Eastern Europe per 10 years period from 1971 to 2011 according to their distance to the border with Germany, Austria and Italy[3]

CLASSES	1971–1981	1981–1991	1991–2001	2001–2011
1. 'Western' facade	1,57	0,71	0,02	0,05
2. 'Central' facade	1,82	0,99	-0,01	0,12
3. 'East' facade	2,19	1,26	-0,23	-0,11

Source: Zdanowska 2018

In contrast, the Czech, Slovak and Slovenian Class 1 cities nearest to the German, Austrian and Italian borders had lower average growth rates up to 1991. These cities crossed the period of the 1990s without going through negative growth rates, unlike the cities of classes 2 and 3. The respective rates of the cities of the Eastern facade remained negative, even until 2011. This would confirm the hypothesis of a West-East division of this space in terms of demographic behavior. The demographic trends of the cities of the "West" facade are more similar to those of the old settlement systems in Western Europe, characterized by the end of the urban transition, while the cities of the East facade are still pursuing catch-up logics.

The 2000s are marked by recovering slightly positive growth rates compared to the previous decade, especially in the Western and Central façades. Some cities, such as Prague, Ljubljana, Varna and many small and medium-sized cities in Poland, were even growing during that period (Zdanowska 2018; Guérois et al. 2019). It seems that they have been able to absorb the external shocks suffered during the 1990s that consisted in demographic displacements, intensive forced migrations to the West (Drbohlav 2003; Korcelli 1992; Kaczmarczyk & Okólski 2005), loss of fertility, ageing of population and high unemployment rates (Kovács 2004). We hypothesize that these cities have experienced new metropolitan opportunities, and have increased their exchanges with other cities. Actually, some cities that suffered from decline of the manufacturing sector in the 1990s (Kiss, 2004) have developed metropolitan potential in the 2000s and reoriented into innovative activities as in the military and air transport sector in Rzeszów in Poland (Noworól et al. 2010).

It would seem, therefore, that the degree of urban development of cities in Central and Eastern Europe is related to the geographical proximity to more economically developed areas such as Germany, Austria and Italy. Indeed, there is no correlation between the size of the Central-Eastern European cities and their growth rate, whatever the period, whereas this is the case in France (Paulus, 2004; Paulus & Pumain 2000) and in Russia (Cottineau 2014) (Tab.3).

[3] The first, second and third classes correspond to an average distance of 33, 157 and 537 km nearest to the border. Thus class 1 includes the most western cities of central-eastern Europe and class 3 the easternmost cities.

Table 3: Correlations between growth rate and city size every 10 years since 1961 for all cities of the CEE region

	Correlation coefficient	R^2
1961–1971	-0,035	0,0012
1971–1981	-0,059	0,0035
1981–1991	-0,067	0,0045
1991–2001	-0,057	0,0033
2001–2011	-0,019	0,0004

Source: Zdanowska 2018

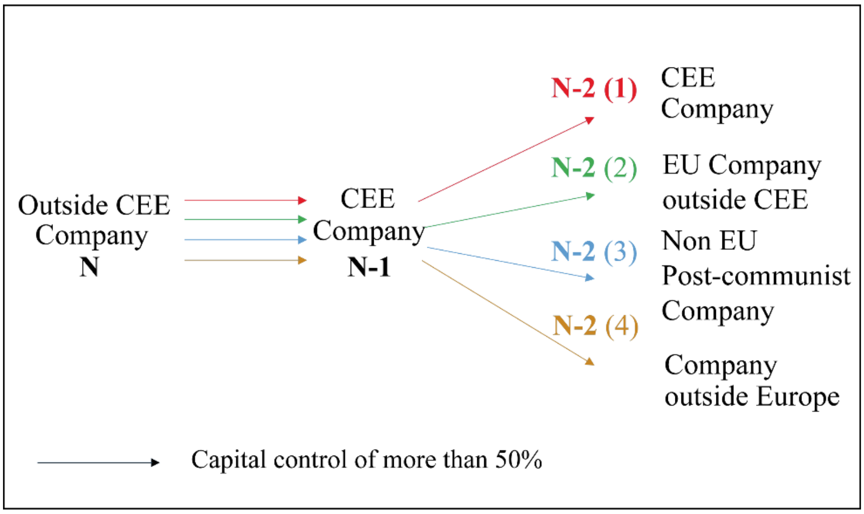
This result confirms our hypothesis that the resistance to political and economic upheavals is rather related to the proximity of economically more developed cities, constituting a source of economic exchange opportunities that stimulates this growth, as well as through processes of metropolization up to today.

3.2 Economic interactions between the present and the past

In the same line of investigation we checked if the population size of the CEE cities is a key factor of their position within multinational firms' networks[4] that are carrying the effects of globalization.

First, a decomposition of the financial ownership linkages led to the identification of capital control chains at three levels, according to the following scheme (Fig.4): a foreign firm (level N) controls the capital of a firm in a city of CEE (level N-1). The latter firm itself owns the capital of another firm (N-2 level). The considered three-level subnetwork of multinational firms and their ownership links in cities of CEE has 2312 firms and 1562 ownership linkages.

Figure 4. Decomposition of the capital control links of companies in CEE into several levels



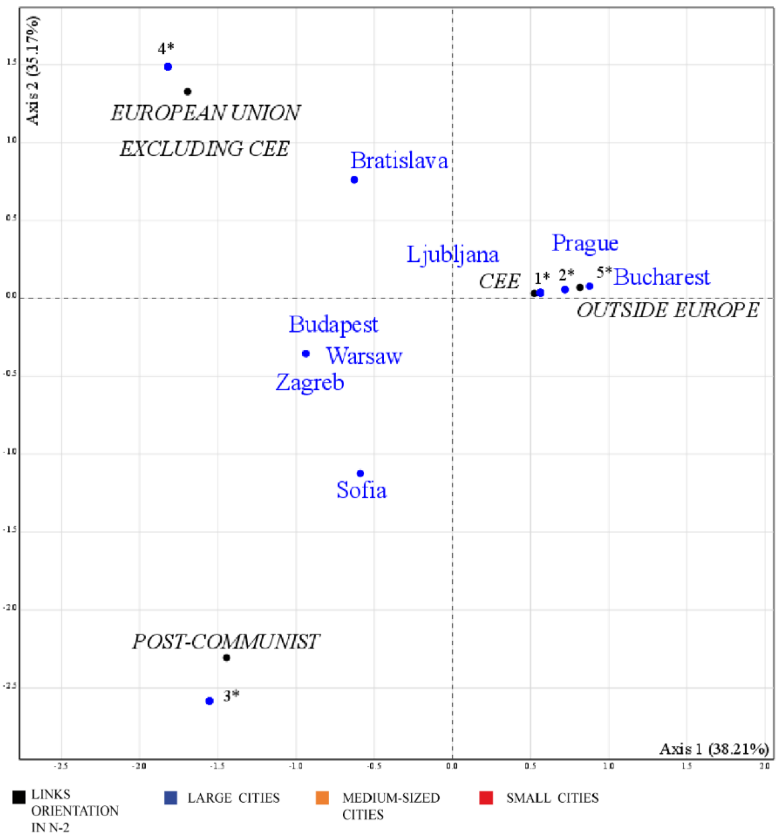
Source: Zdanowska, 2018

Second, a correspondence factor analysis was carried out on a matrix of data, counting the number of times a CEE city in N-1 is involved in the four different orientations of capital control links in N-2: in a city from another CEE country (1), in the European Union outside

[4] Ownership links of firms in 2013 at city level are sourced from the BvD *ORBIS* database listing all the companies, located outside CEE, owning capital of CEE companies in all types of sectors. Additionally, information about CEE companies controlling the capital of other firms in CEE, but also outside CEE, is also available.

CEE (2), in the post-communist space outside the European Union (3) and outside Europe (4) (Fig.4 and 5).

Figure 5: Major implication of the CEE cities in N-1 according to the four types of orientation of the multi-level links in N-2



1* Banska Bystrica, Bolatice, Breclav, Brno, Bourgas, Cesky Tesin, Cherven Bryag, Częstochowa, Debrecen, Decin, Galanta, Gbely, Gheorgheni, Hodonin, Hradec Kralove, Hranice, Jablonec nad Nisou, Jaszfenyszaru, Jihlava, Kamenice, Karlovy Vary, Katowice, Lazuri, Legnica, Lesce, Letohrad, Logatec, Lublin, Medvode, Mochov, Modrice, Mogosoaia, Nitra, Nyiregyhaza, Ostrava, Petrvald, Piestany, Plzen, Połkowice, Poznań, Ptuj, Puchov, Rijeka, Rokietnica, Roznava, Skawina, Split, Stefanestii de Jos, Stefanovo, Stupava, Szczecin, Tirgu Mures, Trnava, Turna nad Budvou, Usti nad Labem, Vrable Wolica, Zatec, Zlin

2* Łódź

3* Belisce, Cracow, Koper, Liberec, Skofja Vas

4* Kędzierzyn Koźle, Krusovice, Majohaza, Medias, Pilisszentiva, Rohoznik, Rzeszów, Sumperk, Tarnów, Velenje,Wrocław

5* Świebodzin

Source: Zdanowska, 2018; BvD ORBIS 2013

On figure 5 are displayed the major geographical orientation of linkages between firms and their subsidiaries for all CEE cities. Some cities have a limited participation to globalization because their firms own links only towards other CEE cities – such as Banska Bystrica, Bolatice, Bralin, Breclav or Cesky Tesin (class 1* on Fig.5) – or post-communist ones – such as Belisce, Koper or Cracow (class 3* on Fig.5). These are mainly small or medium cities. Conversely, large cities, such as Budapest, Zagreb and Warsaw, have links both to European Union areas outside the CEE, CEE and post-communist areas (Fig.5). This is not the case, however, for all capitals. Ljubljana, for example, is positioned among links towards other CEE cities and Sofia is present only in post-communist and CEE configurations (Fig.5). Bucharest, is characterized essentially by non-European implications – which can be explained by its geographical position at the outskirts of European Union.

Small towns (10,000 to 50,000 inhabitants) develop mainly linkages with post-communist, Central Eastern and European Union. Medium-sized cities (50,000 to 250,000 inhabitants) are most present in the CEE orientations (Tab.4). This demonstrates that large cities (above 250,000 inhabitants) are not the only ones attracting capital links from abroad: small and medium-sized cities, often considered as set aside by globalization (Escach, Vaudor, 2014), are also present in these international networks.

Table 4: Implication of small, medium and large CEE cities according to the orientation of their firm linkages (expressed as a percentage of total localized linkages)

	Towards cities localized in :			
From cities :	EU*	CEE	POST-COM**	OE***
SMALL	47	56	50	14
MEDIUM-SIZED	24	29	10	0
LARGE	29	15	40	86
TOTAL	100	100	100	100

** European Union outside CEE; ** Post-communist; *** Outside Europe*
Source: Zdanowska, 2018, BvD ORBIS, 2013

Finally, we computed the betweenness centrality for cities in N-1 (= number of shortest paths passing through a node (Albert & Barabasi 2002)). This determines the number of times that a CEE city in N-1 is a crossing point relaying capital control links towards N-2. The higher this centrality is for a node, the greater its importance in terms of passage and role of gateway between chain levels. We have then checked if the population size is a decisive variable for relaying capital control links towards the four orientations of links in N-2 (Tab. 5).

Table 5: Characteristics of cities in N-1, according to the different orientations of links in N-2

	Among links oriented in N-2 towards cities located in:			
R^2 in N-1 between	EU	CEE	POST-COM	OE
POP & BETWEENNESS	0,75	0,41	0,15	0,24

Source: Zdanowska, 2018; BvD ORBIS 2013

In the case of links oriented towards the European Union outside the CEE countries in N-2, the relationship between the population and the betweenness centrality is significant from a statistical perspective ($R^2=0.75$). This relationship is, on the other hand, much less significant in the framework of the Central Eastern and non-European orientations (0.41 and 0.24) – or practically not in the post-communist case ($R^2=0.15$) (Tab.5).

It can be inferred that the role of small and medium-sized cities is important in all orientations, excepted for those towards the rest of European Union - which shows the importance of considering these links and including small and medium-sized cities in globalized networks.

Conclusion

In this paper, the confrontation of several complex system processes leads to a deeper understanding of the actual trends in progress within the Central and Eastern European system of cities. Between integration and diffusion, the urban system faces both rapid changes and path dependence forces.

Despite not including very large cities, the Central and Eastern European urban system is hierarchized by international functions in a stronger way than the Western European urban system, with a growing concentration of metropolitan functions with city size. Metropolization forces are strong because they are in an early stage of the global integration process compared to the Western cities. However, besides the size effect, the participation of Eastern cities to the networks of globalization also depend on their distance to the Western border. In addition, historical specializations confer to some small and medium-sized cities a more important role than expected in the network of multinational firms, which confirms the necessity of considering small and medium-sized cities in globalized networks analysis. The capital investments generated from multinational firms between largest cities and small and medium-sized cities inside the CEE territory, are key factors of integration to the globalization. This stepwise integration is strongly influenced by the remaining historical linkages between CEE and post-communist cities, and much less intensively to other countries outside Europe. It takes a long time for the Central and Eastern European urban system to recompose inside the capitalist system, and the emerging complexity is mostly based on long term spatial, cultural and political proximities, including a strong importance of Western Europe through EU integration. This ongoing process of EU integration inside the general globalization trend of the CEE urban economies demonstrates how far changes can also be relatively fast in a period of thirty years of intense policies that were undertaken by the EU commission. A wide gap still differentiates Western and Eastern cities regarding the development of metropolization processes. This gap results both from a time lag of the urban system adaptive cycle, and from a structural difference (or path dependence of the dynamics) that will probably further maintain the singular development of the Central and Eastern European urban system. The relaunch of European cohesion policies in the new program after 2020 considers that issue and will probably reduce the gap and enhance further integration.

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