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Urban Resilience Discourse Analysis: Towards a Multi-Level Approach to Cities

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Abstract: This study aims to understand the current state of research in urban resilience, its relations to urban sustainability and to integrate several distinct approaches into a multi-level perspective of cities comprising micro, meso and macro levels and their interactions. In fact, based on the meta-analysis of nearly 800 papers from Scopus from 1973 to 2018, we show that urban resilience discourses address micro and meso levels, considering shocks of bottom-up origin such as natural disasters. In contrast, the regional resilience approach addresses meso and macro levels (regional and global scales), considering shocks of top-down origin such as world economic crises. We find these approaches complementary and argue that in order to expand the urban resilience theory and overcome its limitations, they should be combined. For that purpose we propose a multi-level perspective that integrates both top-down and bottom-up dynamic processes. We argue that urban resilience is shaped by the synchronicity of adaptive cycles on three levels: micro, meso and macro. To build the multi-level approach of dynamics of adaptive cycles we use the panarchy framework.

Keywords: urban resilience; regional resilience; sustainability; cities; multi-level approach; complex systems; panarchy; adaptive cycles

1. Introduction

Today the concept of urban resilience has a growing interest among both scholars and practitioners. One explanation is the fact that the notion of resilience raised the demand for further clarification, both for theoretical analyses and for implementation in urban policies. Indeed, in the wake of UN Habitat's Urban Agenda 2030, based on the City Resilience Profiling Program (CRPP) (UN Habitat, 2015), non-governmental organizations (such as ICLEI, Cities Alliance, The Ecological Sequestration Trust, 100 Resilient Cities etc.) expressed more concern with this concept [1].

However, the notion appears very polysemic and its measures and operationalization remain unclear, especially when resilience is applied for the analyses of socio-political, economical or socio-ecological systems, such as cities [2]. Besides this, it is unclear whether "resilience" is an inner property of a system, or it must be understood as an interaction between a system and its context [3]. When Martin [4] considers regional resilience as a process corresponding to certain stages of economic system's reaction to shocks, does he limit the resilience mechanism to the regional system itself, or does he take into account both this system and its national or international environment producing the shock? More extensively, the question is to which extent urban resilience processes or/and properties appear either inside cities, or between cities and their environment, or between cities in a system of cities? In other words, we wonder how the city level behaves regarding individual actors, composing them and their interactions on one hand, and influence from other cities, with which they strongly interact on the other hand? If we deal with economic resilience, can we assume that "economic environment" for a city is a system of cities to which a city belongs?

Based on a meta-analysis of urban resilience discourses, we found that scholars mainly consider resilience of cities towards local problems such as natural disasters, domestic consequences of climate change and/or resilience of communication networks inside a city. In other words, they focus on the local scale with shocks of a bottom-up origin. Contrary to this approach, studies in regional resilience highlight a link between meso and macro levels processes, considering shocks of top-down origin such as economic recessions, international trade restrictions, world crises etc. Since the regional resilience approach considers shocks on the global scale as main stress factors, a region is studied as an embedded system into macro processes, unlike the urban resilience approach, where external cities' interactions are not taken into account. Thus, we consider that urban and regional resilience discourses must be integrated into a single approach.

In fact, we assume that cities, similarly to regions, are parts of global socioeconomic processes through numerous exchanges with other cities that create, therefore, a system of cities. To address these inter-city processes, we propose to integrate urban and regional resilience approaches into a multi-level perspective that would address both types of shocks: local bottom-up, coming from intra-urban interactions, and top-down, which are external shocks coming from national or international scales. In this paper, we consider a city as a connector between micro processes that unfold at the level of actors inside a city (intra-urban), and macro processes that unfold on the level of systems of cities (inter-urban), where a city itself constitutes an emerging meso-level [5,6]. Therefore, we propose to approach cities' resilience as a result of this multi-level dynamics that is stressed in a panarchy framework. Particularly, we argue that every level of a city, namely, micro, meso, and macro, operate within its own adaptive cycle and urban resilience depends on the interactions and synchronicity between them. To illustrate this multi-level framework, we consider urban resilience in an economic dimension.

The multi-level perspective is built in four steps: in the beginning, we describe the evolution of resilience research and a current delineation of the urban resilience discourse (Section 2). Having noticed a confusion between the terms resilience and sustainability on the conceptual level and its particular importance for urban context, we compared them highlighting the link of resilience approach with time scales of adaptive cycles (Section 3.1). Then we conducted a systematic literature review, both for urban and regional resilience discourses to specify adaptive cycles, at the two levels of application (meso and macro) (Sections 3.2 and 3.3). In the last section, we propose to combine them in a multi-level framework that integrates both urban and regional resilience perspectives and includes internal and external processes to cities. Furthermore, in this section, we wonder how far the panarchy perspective could formalize interactions between different city levels (Section 4).

2. Evolution of the Resilience Concept

In 1973, C.S. Holling introduced the notion of resilience into the ecological discourse defining it as "*a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables*" ([7], p. 14). He conceptualized it based on the distinction between stability and resilience. Stability was considered as the ability of a system to return to an equilibrium state after a temporary disturbance: the more rapidly it returns and the less it fluctuates, the more stable it would be [8].

With time, the notion of resilience became an influencing theoretical framework that diffused in different fields outside ecology such as engineering [9], ecological economics [10], socio-ecological systems [11], psychology [12], identified by Folke [13] in a historical context. Today, the resilience notion has been adopted by numerous scientific domains: for example, Quinlan et al. (2016) [14] classified eight domain-specific definitions of resilience, and Xu and Kajikawa (2018) [15], based on a citation network analysis identified ten clusters inside resilience research. Moreover, there are papers of literature review type, addressing a particular domain of resilience: for example, recently a special paper was published on a current status in resilience engineering research, where the authors applied an original technique, namely factor analysis and multi-dimensional scaling [16]. We are not going to

repeat an extensive historical study on resilience; however, it is meaningful to pay attention to certain milestones in resilience emergence to support our reflection on urban resilience.

Initially, resilience was considered as a property of only ecological systems; however, later it was expanded in a broader context. In 1998 Levin et al. [17] argued that resilience is a "*property of any complex, non-linear systems, whether ecological or socioeconomic, do not lend themselves to management protocols based on assumptions of linear, globally stable, single equilibrium systems*" (citation from [18], p. 259). As a consequence, the concept became multidisciplinary and some other quite similar, but still distinct notions from different scientific domains, have been introduced into the resilience discourse such as vulnerability [2,19], adaptability and transformability [20–22]. Partially, this is linked to a disciplinary origin of the researchers who study resilience: for example, in the complex system approach scholars tend to use more sophisticated vocabulary that relate resilience with adaptability, and sustainability with transformability [20]. This supplement of other notions adds confusion to the already existing tensions between sustainability and resilience [22,23] that needs further comprehension (Section 3.1).

This multidisciplinary nature of the concept also influenced the formation of the urban resilience discourse and resulted in a delineation of several resilience notions. On the one hand, urban (meso level) and community (micro level) resilience can be combined into one discourse, because they consider similar types of shocks (local bottom-up) and analyze them on the micro to the meso levels [24]. They are often based on a layer-oriented resilience, considering a certain layer on a given territory and that is why operationalization can be extended from one layer to another with certain limitations (We consider a layer as a network system on a given territory, e.g., water supply system or metro system). Resilience engineering consider them as different intertwined systems [25] often applying the resilience analysis grid as a conceptual framework [26]. On the other hand, regional resilience constitutes its own discourse, very different from all the previous ones with a very strong domination of the economic context and with top-down shocks that come from macro level (national and international). Thus, urban, and regional resilience seem to be applied at two distinct levels: urban resilience is mostly applied at micro/meso levels privileging bottom up processes, while regional resilience is mostly applied at macro/meso levels privileging top-down processes. Each of these two groups of approaches needs to be further discussed to better understand their fundamental theoretical bases (Sections 3.2 and 3.3).

Since scholars opened a discussion about resilience application in any complex systems, the following question appears: how to measure urban resilience in such different applications? Along with local resilience measurement in ecological systems [11,14], some papers about resilience measurement of local economies have been published lately [27–31]. However, are there more general measurements integrating micro levels inside larger ones and both bottom up and top-down processes? Some authors apply a framework of adaptive cycles from ecology [32] to explain local economic resilience [28,30] that seems relevant and lead us to try to reconceptualize urban resilience in a multi-level approach combining the two levels approaches addressed by urban resilience and regional resilience discourses (Section 4).

3. Systematic Mapping of the Literature

To better understand the conceptual differences between urban resilience and urban sustainability (Section 3.1), and specify, on the one hand, the urban resilience applications (Section 3.2) and the regional resilience ones (Section 3.3), we conducted a systematic mapping of the literature. Considering the huge amount of literature from 1973 to May 2018, we constructed several corpuses to synthesize them. Many of the recent reviews on sustainability and resilience used co-citation analysis and explored the relationship between different scientific communities and domains of research [15,33,34]; however, systematic mapping of conceptual keywords was not yet applied.

Despite that most of the recent systematic literature reviews on sustainability and resilience used Web of Science as the only source [33–36], we choose the Scopus database because it is the largest multidisciplinary scientific database of peer-review literature that exists today. Naturally, this database

is also far from being perfect [37], but it has been shown that the omitted citation rate is lower in Scopus (about 4%) than in Web of Science (about 6%) [38]. We consider that Scopus, Web of Science and Google Scholar are complementary sources [35], while Scopus is the largest and the most representative, which is the reason that guided our choice.

Based on the Scopus database, we implemented the analyses with *four steps*:

I. Search for the papers in Scopus where some focused terms are present in the title of the papers. We made the selection according to three key expressions:

   a. Resilience and sustainability (242 articles)
   b. Urban resilience (596 articles)
   c. Regional resilience (174 articles)

II. Then we extracted words (terms or expressions) from each of the selected papers, considering the entire abstracts of the papers. We removed meaningless words, grammatical forms and syntactic structures, trying to keep specific expressions. Then, we built the networks of terms appearing in the same sentences: Nodes are terms, links are co-occurrences between them. We then calculated the conditional distance between terms (We used Gargantext that is an open access software of the Institute of Complex Systems in Paris (URL: https://gargantext.org/)), which is an absolute measure that reflects the highest co-occurrences between two terms in the corpus. It highlights words' centrality among other words, that is a complementary measure to the simple "occurrences" that means how many times each word appears in the texts.

III. Selection of the words occurring more than five times;

IV. Application of clustering analysis detecting words that are more connected to each other (We used the Louvain cluster technique [39] with the Gephi open access software (URL: https://gephi.org/). The Louvain clustering technic is one of the most popular clustering technics applicable on weighted networks and is much faster than others (see [40])).

With this method, we will stress the conceptual maps for each group of discourses, keeping in mind the following limitations: (1) literature sample is limited to the sources only from Scopus; however, this database is more complete than other ones; (2) as the first stage searching key, we used the presence of certain words only in titles, in order to limit our corpus only to papers that focus exclusively on the issue; (3) the conceptual maps were constructed only based on the analysis of abstracts and titles because abstracts concentrate the main ideas and key terms of papers. In addition, despite these limitations, our review seems representative of the whole picture of urban resilience research, since one can find most of the similar keywords in other meta-analyses of the literature on the same thematic [33,41]. With this approach, we will manage to better determine common points and differences between resilience and sustainability (Section 3.1), and to identify the key elements one can use to define a multi-level urban resilience combining existing urban resilience (Section 3.2) and regional resilience discourses (Section 3.3).

3.1. Resilience and Sustainability

In the urban context it is particularly important to distinguish sustainability and resilience. Sustainability primarily concerns the question of equity of resources for further generations meaning that they are not less than for the current generation; resilience, in its turn, focuses on the system behavior before, during and after a shock. These concepts constitute different goals and require different policies and institutional regulation from cities' governments, what makes this distinction crucial first of all for practical purposes. However, conceptually, the relationship between resilience and sustainability still remains unclear [22,33,42]. Sustainability is oriented towards the future, constituting certain objectives for the perspective of a sustainable development of the society. Unlike resilience, which describes systems [43], sustainability is a normative concept that includes assumptions or preferences about which system states are desirable [35]. An example of these states can

be Sustainable Development Goals that were set by United Nations in 2015. Besides, on the literature on social-ecological systems (SES) [35,42,44,45], some scholars argue that resilience may be a new way to conceptualize sustainability [2,11,20,46]. It was noticed that resilience and sustainability concepts have many things in common: firstly, they both concern ecology, economy and society, however, resilience seems to be even wider, because it also deals with psychology and engineering [47,48]; secondly, they can both be applied to different levels such as firms, cities and regions [33,49,50]. Some authors even understand resilience and sustainability as synonyms: "*A system may be said to be Holling-sustainable, if and only if it is Holling-resilient*" ([51], p. 28) or "*A resilient socio-ecological system is synonymous with a region that is ecologically, economically, and socially sustainable*" ([52], p. 1). Nevertheless, most studies conclude that these two concepts are different, although they have both differences and similarities [35,36,43].

With the methodology previously described, a graph of words co-occurrences was created (based on the 242 articles comprising both resilience and sustainability in their title) that supports reflections on the conceptual building of both notions (Figure 1). The main purpose of this graph is to visualize the relationship between resilience and sustainability and to select the elements that are important for the multi-level perspective to urban resilience. The size of the nodes indicates the occurrences of the terms in the abstracts, the thickness of links indicates the number of co-occurrences between terms in the same sentences and the color of terms indicates their belonging to different clusters.

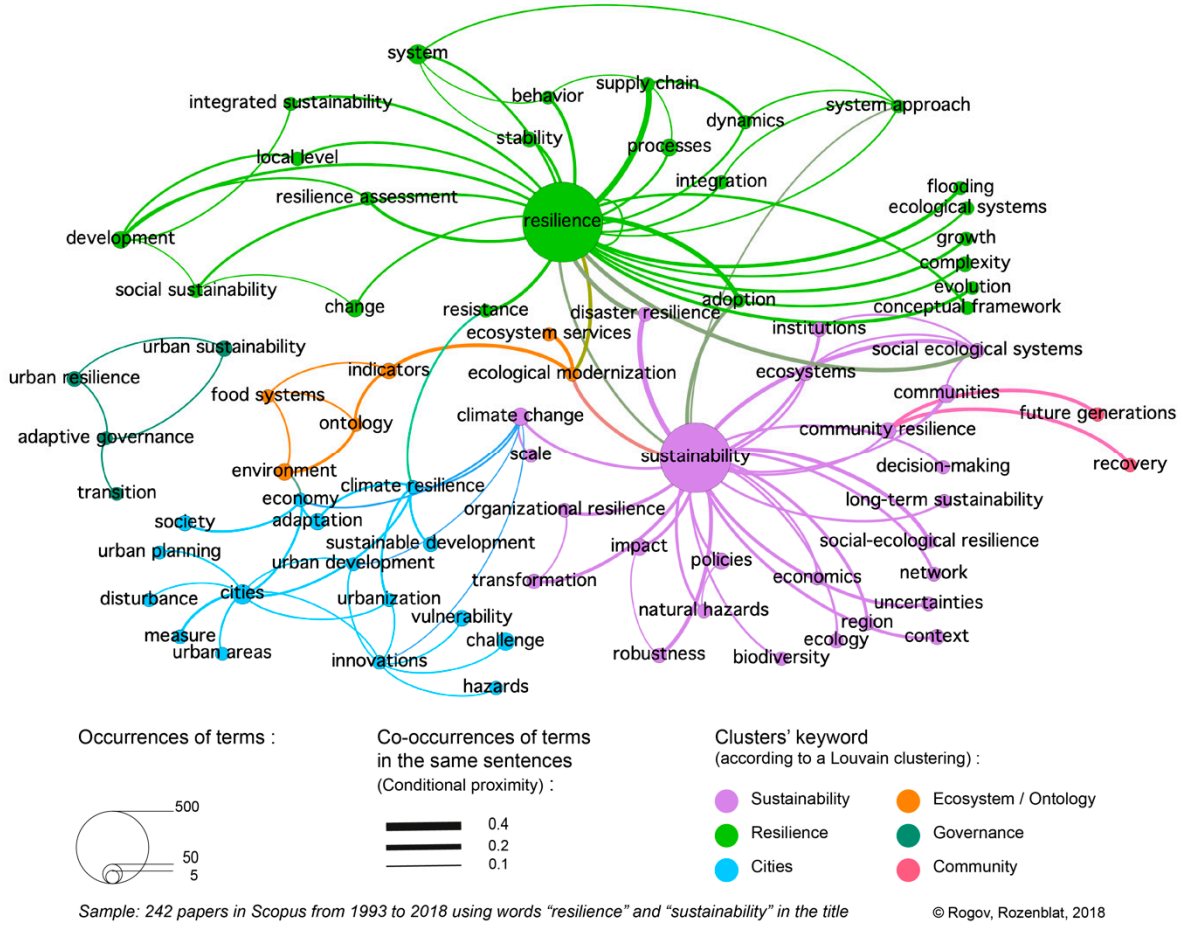

Figure 1. Co-occurrences of terms appearing in the abstracts of papers with "Sustainability & resilience" in their title.

The resulting graph underlines that only four terms appear linked to both resilience and sustainability: ecological modernization, disaster resilience, adoption and social ecological

systems [42,44,45,53]. The papers that create links between these two terms analyze both sustainability and resilience and their interpretation depends on the focus of studies. The fact that definitions of sustainability and resilience are predetermined by the objectives of research was described as a "constructive tension" in resilience studies [54]. Through the qualitative analysis of these papers, we can reveal that papers considering adoption are mostly either about adoption of different sustainable practices, policies or systems in agriculture [55–57], or they address questions of implementation of different sustainability and resilience policies and standards [58]. Studies on disaster resilience often concern a community level from different perspectives: for example, in engineering context [59], from a tourism development [60] or water supply contexts [61]. Despite certain peculiarities such as units of analyses, most of these studies agree that resilience and sustainability have a hierarchical relationship, where resilience is a part of sustainability: it is said that resilience is a "*foundation*" for sustainability [60], resilience is a "*requirement*" for urban system sustainability [62], or resilience is a necessary condition for sustainability [59]. However, going deeper, Marchese et al. [36] identified three possible frameworks for sustainability and resilience: (1) resilience as a component of sustainability; (2) sustainability as a component of resilience; (3) resilience and sustainability as separate objectives, and they argued that the similarities and differences between these two concepts become partially framework-dependent. In the current paper, exploring the relationship between sustainability and resilience for urban context, we share the notion that increasing the resilience of a city makes that city more sustainable, but increasing the sustainability of a city does not necessarily make it more resilient. Also, we acknowledge that sustainability sets objectives for a system, while resilience is used as means to meet those objectives [63].

For our objectives, one of the crucial distinctive features between sustainability and resilience is various cross-scale interactions [22,42,45,64]. Being related to such terms as "*evolution*", "*complexity*", "*process*" and "*change*", resilience implies the process of adaptation as its core characteristic. Adaptation is linked to a system's capacity "*to learn, combine experience and knowledge, and to adjust its responses to changing external drivers and internal processes*" [64]. It relates both to system's self-organization process and to institutional decision-making that adjust a system to future shocks, stresses, or other changing conditions, in a way that maintains essential system functioning [21]. Moreover, adaptive measures are often specific and local (for example, adaptation is often related to climate resilience). Therefore, resilience is focused on the system's dynamics adaptation that can be explained through adaptive cycles. Adaptive cycle is a heuristic model that includes four stages, namely, exploitation, conservation, release and reorganization that explain a behavior of a complex system [32].

In contrast, sustainability is linked to terms such as "*policies*", "*decision-making*", "*institutions*", "*climate change*" that are related to a process of system's transformation. Transformation, unlike adaptation, implies a more pervasive and radical reorganization of the social-ecological system: it is a fundamental alteration of a system once the current ecological, social, or economic conditions become untenable or undesirable [20,21,65]. The difference between adaptation and transformation can also be seen through time and space cross-scale interactions: in any complex system, adaptation at one scale might require transformations at other scales, and building resilience at a certain scale can reduce resilience at other scales [42], which consequently affect sustainability.

To illustrate the relationship between resilience and sustainability, we constructed a schema (Figure 2) that is based on the graph interpretation and conducted a literature review with a focus on the chosen theoretical framework. From the graph of Figure 1 we selected terms that appeared linked only to one concept: sustainability or resilience. They were chosen because of the highest co-occurrences with the central words (sustainability or resilience) and, therefore, they best characterize a distinct character and essence of sustainability and resilience approaches.

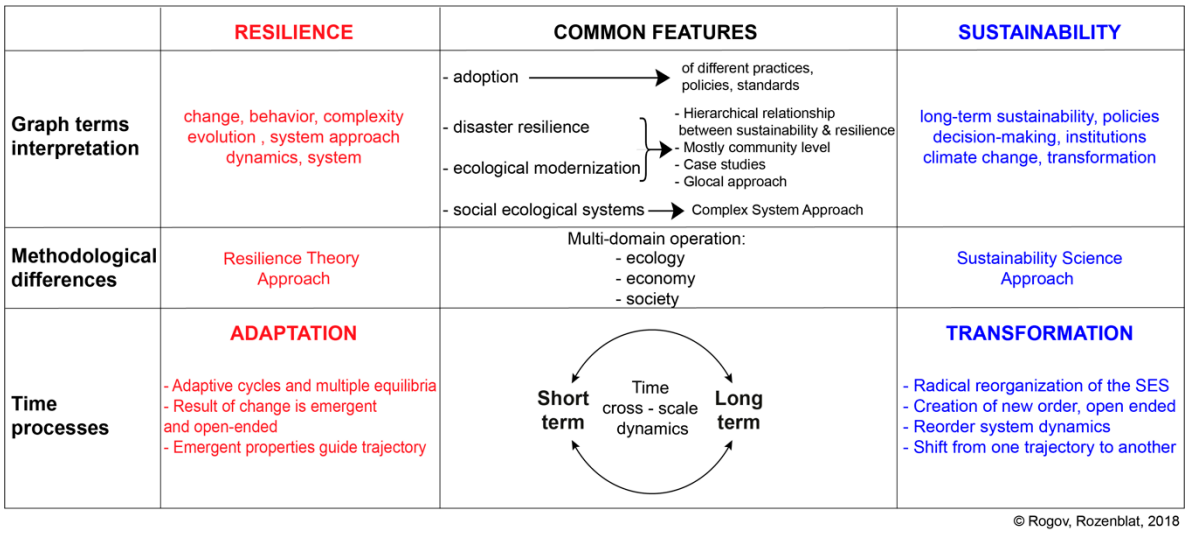

Figure 2. Differences between the concepts of sustainability and resilience.

Resilience operates within adaptive cycles that are initiated by shocks: in other words, it is a short-term characteristic of system behavior before, during and after a change. Being resilient, a system perceives change as a normal, multiple stable state and the result of this change is emergent and open ended.

Unlike resilience, in the sustainability science, shocks are not approached as opportunities for further development. Instead, having its origin in social science, the sustainability approach aims at achieving certain goals (for example, Sustainable Development Goals) where desired results are specified in advance and the focus is on certain human interventions that lead to sustainability: in other words, the outcomes are predefined and can be achieved through transformation of a system [20,22,42]. Sustainability seeks to address the major challenges facing society, understanding the biophysical drivers and constraints on a system's future, but focuses on the measurable change in terms of human decisions, institutional dynamics, and shared attitudes [22]. Consequently, sustainability is revealed within a long-term perspective, and only implicitly includes adaptive cycles partially depending on them. Therefore, sustainable development, as a long-term goal, is based on systems' resilience that, in a short-term, is revealed within sudden shocks and negative stress factors.

However, to say that resilience is simply a short-term reaction of a system would not be true. Indeed, it unfolds in the moment of a shock, but resilience itself is based on the capacity to adapt and change over the long-term. For example, in the context of regional economies, resilience is defined as "*the capacity of a regional economy to maintain an above average long-term economic growth rate by adopting to the shocks arising from the endogenous or exogenous invention, innovation or diffusion of technological innovations*" [29]. The key characteristic of resilience is system's adaptive capacities that evolve over time and based on the relationship between internal system's components. It makes resilience dynamics evolutionary and a path-dependent process that unfolds in the long run. However, in the short run, when a system is impacted by a shock, we observe resilience as a system's property that absorbs shock and transforms it into an opportunity for further development. Resilience, as a process, is mostly approached from an evolutionary perspective in economic geography [28,29,66], while resilience, as a system's property, is more considered in engineering or ecological domains [25,67].

3.2. Urban Resilience Discourse

To better understand the urban resilience discourses, we used the same four steps method as before (on 596 papers from Scopus from 1990 to May 2018 that includes urban resilience in their title). Based on their abstracts, we built networks of term co-occurrences. The constructed graph (Figure 3) illustrates the dominating position of ecological topics in urban resilience: more than 30 terms out of

125 in total are linked in one way or another to ecology (terms such as "*natural disaster*", "*ecosystem services*", "*urban climate resilience*" etc.). For comparison, only nine terms represent the social domain of urban resilience (terms such as "*social resilience*", "*social support*", "*social vulnerability*" etc.) and three belong to the economic domain, namely, "*economy*", "*economic recessions*" and "*economic growth*". Thus, it appears a disbalance in urban resilience research dominated by "ecology" and rarely concern economic shocks.

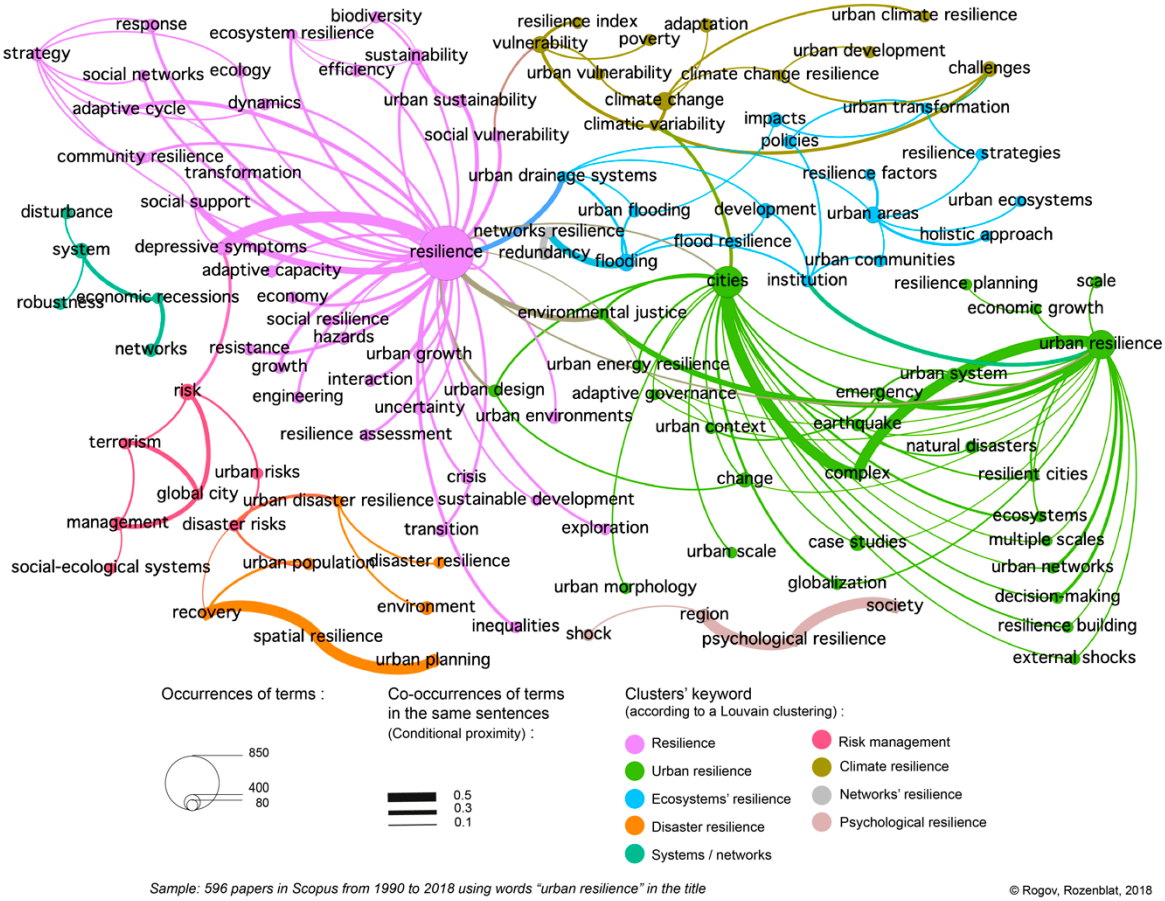

Figure 3. Co-occurrences of terms in the abstracts of papers with "Urban resilience" in their title.

The dominating position of ecological topics in urban resilience can be clearly seen on Figure 3: there are such separate terms as "*urban climate resilience*", "*flood resilience*", "*urban disaster resilience*", "*urban energy resilience*", "*ecosystem resilience*". Moreover, terms from ecology appear in most of the clusters. Even though these terms belong to different clusters, due to the specific problems they address, they are always considered in an urban or community context. Social resilience in this graph is also very often linked to ecology, especially when it concerns consequences of natural disasters for cities and communities [68–70].

In the graph there are terms such as "*economic growth*" that are directly linked to urban resilience, or such as "*economic recessions*" that are in separate clusters. However, in most of the papers, natural disasters are the principal obstacles for economic growth [71], which is approached as a *result of local disaster risk reduction policies* [72]. Economic recessions are also considered on a community level [73], or for particular markets such as the housing market [74]. Probably, this focus on the intra-urban processes explains the existing "lock in" of urban resilience research in the ecology domain. Would it be possible to address urban resilience to economic shocks *per se* if we expand the approach to other levels? Meerow [75], discussing economic consequences of natural disasters, also wonders *how global processes interact with contextual factors*. Even more explicitly, Lee [76] asks how urban resilience can

combine *local and extra-local competences* in order to develop an *inter-city system* that is the major strategy for cities to mitigate and adapt to climate change and economic recessions. Currently these questions remain open, and we must agree with Peyroux [77], who noticed that there is a substantial gap in understanding the relationships between urban resilience and economic growth that, in our opinion, must be addressed through a multi-level perspective.

With this multi-level perspective in mind, we paid special attention to certain terms linking "*urban resilience*" and "*cities*". Papers concerning the term "*multiple scales*" are either about the influence of natural *hazards* to technical networks on different scales [78], or about the influence of natural hazards to diverse urban morphological entities [79], or about the multi-scale approach in ecosystem management [80,81]. However, some papers apply the multi-scale approach directly to a city considering cities as functional nodes in global market networks [82]. Chelleri et al. [82] argue that addressing multi-scale and temporal aspects of urban resilience will allow greater understanding of global sustainability challenges, though they admit that further research is required to understand *urban resilience as a multi-scale process*.

Assuming that on the larger scale a city belongs to a system of cities (also sometimes called urban systems) that is created through different networks between cities, we focused on the papers talking about "*urban networks*" and "*urban systems*". However, this approach did not meet our expectations: All articles using one of these terms either deals with different types of technical networks inside cities [83–85], or internal urban systems that consist of such types of networks that include flows of infrastructure, resources, materials, energy and waste [86–88]. In other words, they consider different networks inside cities, but they do not study systems of cities where cities constitute networks and interdependencies between each other.

Thus, the exploration of "*urban resilience*" discourse illustrated its focus on intra-urban processes on the local level, such as the consequences of natural disasters mostly. However, not only research communities consider urban resilience in this narrow framework: in an official document ISO 37123 "*Sustainable Development Communities—Indicators for Resilience Cities*" (ISO 37123, 2018) [89] issued by United Nations, *shocks* are defined only as natural or man-made event that causes a disaster, namely, floods, earthquakes, hurricanes, wild-fires, chemical spills, power outages ([89], p. 10) and *resilient economy* is considered in the context of disaster losses as a percentage of city GDP ([89], p. 11). Moreover, the biggest international annual event on urban resilience "*Resilient Cities*" (Global Forum on Urban Resilience and Adaptation "Resilient Cities", URL: https://resilientcities2018.iclei.org/) that principally gathers policy makers and few researchers, focuses exclusively on natural disasters and discusses different policies and institutional mechanisms to mitigate their consequences for cities.

All of this shows the central assumption of the urban resilience discourse: most scholars and practitioners consider a city as an isolated entity that creates resilience based on the inner processes in cities, neglecting the top down processes that shape urban resilience from outside of a city through interactions with other cities. We call it a *"lock-in" in research*: when the concept is used only partially and in one direction. If we consider the embeddedness of a city into another system, not necessarily into systems of cities, but into regional systems, for example, the dominating approach in resilience discourse will probably change?

3.3. Regional Resilience Discourse

To address this question, we conducted a third literature review on "regional resilience" in the title and constructed a corpus of literature that includes 174 papers from 1986 to May 2018. Using a similar methodology, we created a graph that shows relationships between terms appearing in the abstracts of these papers (Figure 4).

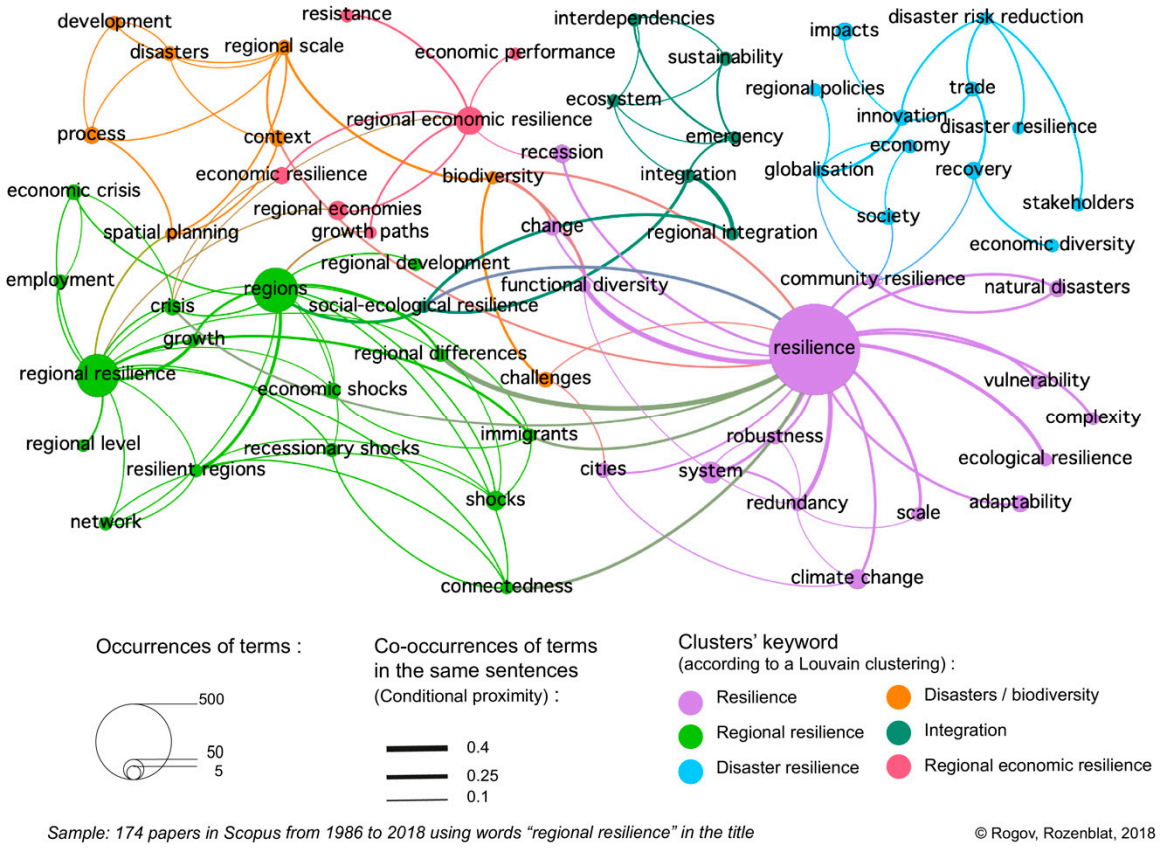

Figure 4. Co-occurrences of terms in the abstracts of papers with "Regional resilience" in the title.

According to Figure 4, the dominating topic in the regional resilience discourse is economy: in every cluster, there are words linked to an economic context. As shocks on a regional scale, scholars mostly perceive economic crises and recession [27,31] and address them decomposing regional resilience into certain stages, such as vulnerability, resistance, robustness and recoverability [28], or resistance, rebound and recuperation [27]. As a measure of regional economic resilience, indicators such as employment [66,90,91], employment growth rate [66,92], or per capita GDP [93] are used. However, the most common indicator is regional employment, because the behavior of the labor market is considered to be one of the main sources of economic resilience on the regional level [66,90].

Since most of economic crises taken for the analysis in regional economic resilience research [27,31] unfold on the global scale—national or international—their initial question is why the systems on the smaller scales (such as regions in this case) react differently to the same stress factor. To explain this uneven economic dynamics, regional resilience researchers highlight the embeddedness of a region into processes on macro scales [28,29].

Besides, we do not exclude that regional resilience does not concern natural disasters at all [94]; however, we highlight that it is not a dominant topic in this discourse contrary to urban resilience research. In fact, specific economic terms in the graph, one can see words such as "*disaster resilience*", "*climate change*" or "*ecological resilience*" which, nevertheless, don't create their own clusters (unlike "*regional resilience*" and "*regional economic resilience*") and are linked to terms such as "*cities*" and "*community resilience*".

Partially, this separation of topics between urban and regional resilience can be explained through a focus on different spatial scales in these two approaches. However, to understand a scale's separation, one must understand the meaning of "regional" and how scholars distinguish one region from another. The most widespread point of view is to consider regions within *administrative boundaries* [66,90]: in terms of empirical analyses it is convenient for longitudinal data acquisition. In fact, urban

economic approaches adopting cities' delineation composed of an aggregation of localities, are restrained by the poverty of urban data to build economic resilience indicators [28,90]. Others argue, that *functional criterion* is much more important when distinguishing regions, particularly considering employment rate, even if the data acquisition is more complicated [95]. In doing so, Faggian [95] proposed the so called "*local labor systems*" that are based on the commuting between residence and workplaces and often cross administrative boundaries. The same issue arises when one talks about cities: how to define their boundaries, administratively, morphologically or functionally [96].

To sum up, in regional resilience research, a city is considered to be embedded into another system (region), even though the effects of this system on city resilience are not investigated. Moreover, scholars, considering a region first of all as an economic system, emphasize that it is connected to economic changes at macro scales such as national or global [97,98]. They argue that each region has its own relative position in national and global markets [99], which means its embeddedness into the processes on a macro level.

4. Discussion of a Multi-Level Perspective to City's Resilience

As it was shown in the previous sections, urban resilience research concerns intra-urban processes that are mostly linked with cities' resilience to natural disasters on the city or community scales. By contrast, the regional resilience approach highlights an embeddedness of regional processes into macro levels, such as national or global. The fundamental difference between urban and regional resilience research is that regional resilience scholars consider a region as an open system, interacting with other systems within national or global scales, and therefore, they take into consideration top down processes that are crucial for economic analyses, which became the main instrument for regional resilience research. Contrary to it, most urban resilience scholars consider a city as an isolated entity and, therefore, analyze only internal shocks that have an origin inside a city and unfold there. Some of them apply a system approach to a city, but they perceive a city only as a system itself, but not as an embedded system into another system—system of cities that constitute a macro level of city's dynamics based on its interactions with other cities [5,100].

We believe, that considering a city as a complex adaptive entity implies an integration of inner processes into macro processes on the level of systems of cities. There were some attempts to address this question through a multi-level perspective to cities: For example, Chirisa & Banbauko [101] and Asprone & Manfredi [62] apply a systems approach to cities and argue that contemporary cities are complex systems with networks of composite relationships among their internal components and inter-laced networks that cities have with one another [62]. Nonetheless, they do not go further to link a multi-level approach to cities and urban resilience and they do not seem very interested in the relationships between these different urban levels and resilience processes.

The relationships between these different urban levels and resilience processes implicitly exist in the urban resilience discourse, although, because of the focus of this discourse only on one level, it is not yet conceptualized in a cities' context, despite general resilience paradigm, where the question of multi-level/multi-scale approach was raised by several authors [42,64,102,103]. For example, Bergström and Dekker [103] link micro (human resilience), meso (resilient organizations) and macro (societal resilience) levels of resilience, arguing that factors of resilience are common across these three levels. They consider resilience as "*fractal, including learning networks across scales and social capital that allow autonomous action, diversity in terms of economics and skills, and leadership*" [103]. The authors propose an interesting idea, arguing that resilience, as a system property, emerges from interactions and relations on local levels, which can be developed further in a multi-level approach to cities. Following the idea of these authors on multi-level interactions, we propose to consider urban and regional resilience as complementary in order to create a multi-level perspective to a city's resilience (Figure 5).

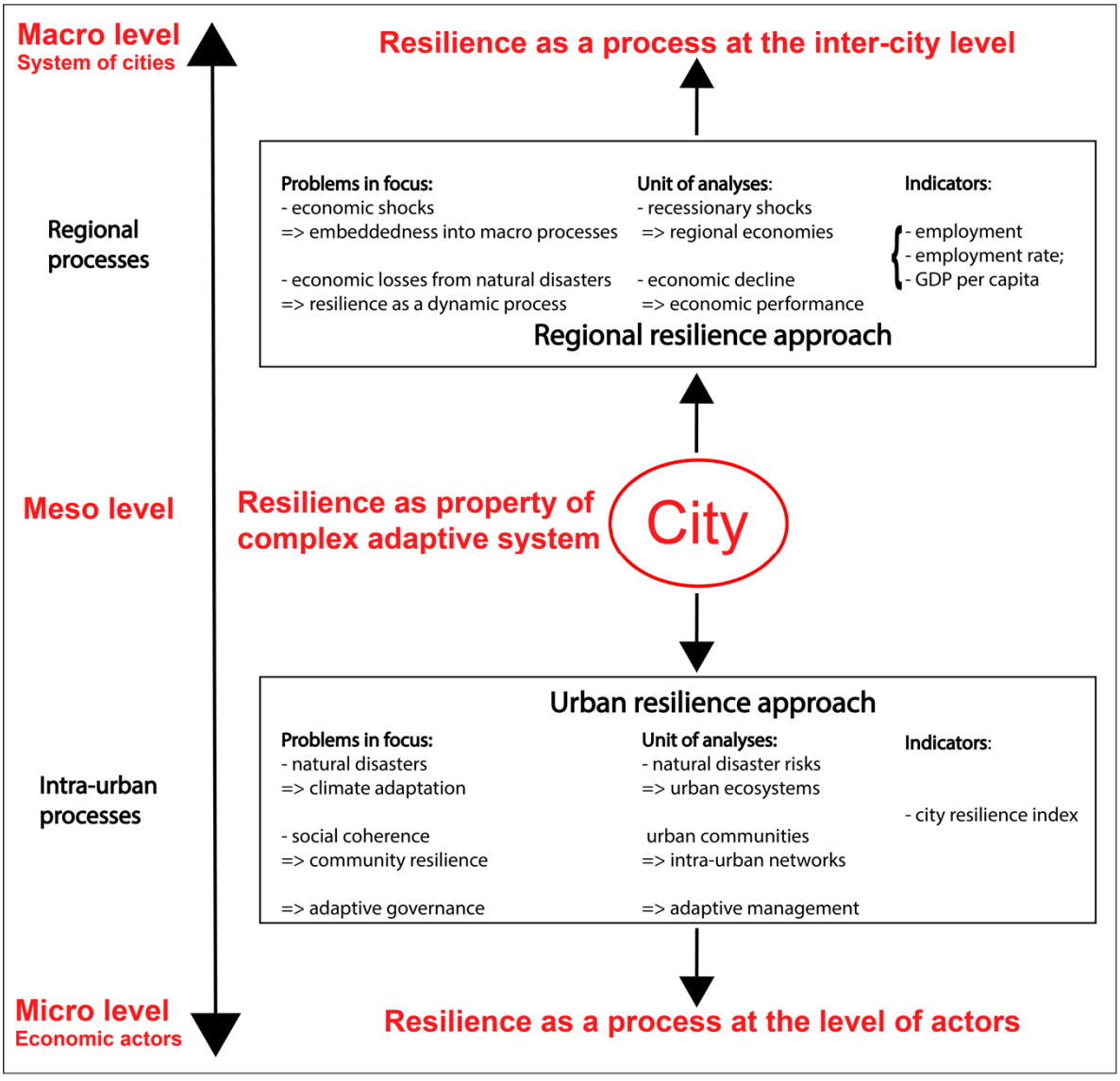

Figure 5. Urban and regional resilience research in a multi-level perspective.

In Figure 5 we embedded urban and regional resilience approaches into a multi-level perspective. Since each of these two approaches emphasizes different origins of shocks, namely, urban resilience is focused on bottom-up shock emergence, and regional resilience concentrates on top-down processes, we place a city between them, underlying the nature of "*a city as a system within system of cities*" [100]. We consider that a city is constituted both by the processes inside (intra-urban) and outside on the regional, national, or global scales (inter-urban). Furthermore, we incorporated an important distinction between an economic approach to resilience and a complex system perspective: the economists emphasize resilience as a **process** that can be divided into several stages, while the complex system approach underlines resilience as a **property** of complex adaptive systems. We do not think that it is a strong dichotomy and argue that these two perspectives can be defined differently and even combined in various contexts. Therefore, we illustrate a complementarity of these two approaches and argue that they should be integrated into a multi-level perspective on cities' resilience.

4.1. Integrating Urban and Regional Resilience Approaches

Starting from the contributions of urban resilience and regional resilience scholars, we consider that there are multiple interactions between the three micro, meso, and macro levels: for example, a city specialization (meso level) defines a position of this city in the system of cities (macro level); migration of people (micro level) foster a development of organizations in cities (meso level). Then we assume that these levels operate within different time scales: micro level is more dynamic because people's behavior inside cities changes quicker than diverse socioeconomic flows between cities (macro level).

4.2. Definition of Cities' Levels in a Panarchy Perspective

Taking a city as a cohesive unit of analysis, we propose to consider a city as a connector between inter and intra urban processes and to approach urban resilience as a result of their interactions. In fact, Pumain [5] argues that multiple interactions between individuals, firms and institutions inside a city constitute a special level: meso level, being the product both from micro and macro levels. Particularly, she empathizes that "*at this level, new properties emerge and characterize the city as a collective entity*" ([5], p. 172) and these new properties are the result of both collective self-organization and intention of some institutions. Taking a network approach, Rozenblat [6] argues that "*the micro, meso and macro levels describe the same networks, yet different processes occur at each level*" ([6], p. 2846). We assume that one of these emerging urban properties on the meso level can be the resilience property, that is shaped both by inter and intra urban processes. We can note that this multi-level perspective is distinct from the multilayer one [25]. Multi-level considers the same dimension (layer), but nested levels of apprehensions (or processes).

Therefore, the key question for urban resilience is the relationships between different levels. Only once having known how each level can be measured, can one undertake the analyses of the interactions between them. In case of an economic shock, urban resilience will depend both on the behavior of individual economic actors inside a city (micro level), and on the different types of flows between cities (such as configuration of economic and trade networks, human migration, government financial support etc.) on the macro level. We argue that to explain urban resilience, one should understand how these multi-level processes are interconnected and synchronized.

It is noteworthy, that Holling introduced the notion of resilience into ecological discourse, and as a continuum 30 years after, he proposed the panarchy perspective [32] to explain resilience of human and natural systems, where the key element is interactions between different adaptive cycles. According to panarchy [32], an adaptive cycle operates within three dimensions: potential (inherent potential of a system that is available for change), connectedness (measure of flexibility or rigidity) and resilience, where resilience is equal to adaptive capacity and opposite to vulnerability. Different levels are identified, and the upper levels are wider in space and longer in time than lower ones. Panarchy recognizes these time and space cross scale interactions and states that "*slower and larger levels set the conditions within which faster and smaller ones function*" ([104], p. 397). Thus, the panarchy framework can be used to explain long-run and short-run urban resilience and can identify their key factors of formation. The resilience of systems varies depending on the stage of their multi-level time and space adaptive cycles (exploitation, conservation, release, or reorganization) and the interactions between them.

Thus, the essential idea of panarchy is that different levels of a system's organization are connected through the relationships between these adaptive cycles. Therefore, in any multi-level approach it is crucial to clearly define each level in both conceptual and empirical terms and their stage of "adaptive cycles". The panarchy perspective [32] addresses this issue describing each level in terms of adaptive cycles, and their interactions and their synchronicity, but it has never been applied in an urban perspective, incorporating the knowledge produced both by urban resilience scholars and regional resilience scholars.

4.3. Evaluating the Three Level Adaptive Cycles and Their Synchronicity

There have been some attempts to apply the panarchy theory to urban or regional resilience in the economic perspective [28–30], but they limit their research only to the analyses of adaptive cycles on meso-level, without studying the links between different levels. For example, Simmie and Martin [28] propose an evolutionary approach to regional resilience that is based on the four-phase adaptive cycle model. Based on two city region case studies from the United Kingdom, they estimate the duration of an adaptive cycle to several decades [28] and the processes unfolding within these years, contribute (or not) to local adaptive capacities (for example, diversification of local economies): first, influence economic trajectories of local economies in the long run, what is resilience as a process, and second, strengthen resilience as an urban property that is revealed during a particular shock in the short run. They recognize an importance of linkages across scales; however, they do not go further in explaining the relationship between adaptive cycles of different levels in economic systems.

Therefore, the relationship between different adaptive cycles on the distinct levels remains a black box that opens an opportunity for further research. The ongoing processes of change of cities' actors' behaviors (at *micro-level*), depends on both the structural and evolutionary properties at the city level (*meso-level*) and at the urban system level (*macro-level*) including long- and short-term periods. In fact, we assume that cities' transformations are the product of the combination of internal emergences and interdependencies with other cities, forming all together the whole urban system with many top-down implications [5,96].

In a bottom-up perspective, emerging organizations in geographic spaces, in sectors or communities forming agglomeration economies [105] can either come from human initiative as policy actions, institutions, training, formation of clubs, corporations or associations [106,107], or they can be spontaneous self-organized processes between individuals without any awareness such as transitivity [108], local buzz [109] and mass effects [110,111]. It is in the collective processes at the meso-level that multiplier effects strengthen the capacity of each actor to develop global linkages [6]. With the path-dependency, the future status of each city is partly a result of the previous situations and the positive feedback of the economic agents with each context, bring up learning processes and adaptation [112]. However, the capacity of local reactions to external investments are very uncertain and this bottom-up view must be coupled with a top-down one.

From a *top-down* point of view, while each single person has his own relational history, the meso-level of a city contains the whole history of interactions (previous interactions or accessibility or routines) and thus it provides the pathway whereby agents move into the future [113]. Holland [114] proposed that the meso-level also contains the locus of process functionality procuring the sense and values of individual or collective actions. In this way, the meso-level contains some conservative structures providing *a memory* that encourages reorganization around the same structures and processes.

The field of *Urban Complex Systems* with multi-level urban networks and systems analyses, evaluates the impacts of the strengthening of the connectedness of the regional and national urban systems [40,115–117]. Through diffusion processes impelled by different time scale cycles at every organizational level, urban hierarchies and diversities of cities are shaped and non-linear effects operate in the interdependent cities [5,100,118]. Considering the time and space scales, the evolving economies of cities in the global macro context, their economic "*tightness*" in the meso level and the transitional processes of the stakeholders' behavior in some major cities on the micro level, create a question of synchronicity. After having defined the three level adaptive cycles and their temporal stages, their synchronicity in a "panarchy" approach would prospect the potential development of the urban systems in a resilience perspective evaluating opportunities and constraints at each level. The output of the research would shed light for regional planners to deal with the uncertainties of the new arriving economic forces.

4.4. Research Agenda for Cities' Multi-Level Resilience

Therefore, introduction of the multi-level approach into the urban resilience discourse also suggests new questions on the synchronicity of different levels in a long/short run. Particularly, it questions how adaptive cycles of different levels affect sustainable urban development. We agree with those, who argue that *"sustainable development in a changing global environment will require resilience at many levels, including human communities and economic enterprises"* ([102], p. 20); however, we acknowledge that the role of every level in sustainable development creation has to be studied deeper, particularly, in the urban context. For instance, if we take the context of economic crises (causes that are often on the international scale), the resilience at the meso-level of a city will depend on both:

- the relationship between adaptive cycles of its own economy (the diversity of its activities and their relatedness) with national and global economic adaptive cycles (if it is specialized on activities in crisis or their emergence),
- and on the actors' behavior in each city (their capacity to create positive answers to local failures).

Empirical implementations of the multi-level panarchy approach on urban resilience, using both quantitative and qualitative methods, will manage to define urban levels' adaptive cycles and their synchronicity, and to discuss further the conditions of urban resilience. Models based on these stylized facts could also complete the empirical results by the understanding of interaction processes between levels. These approaches, that would be developed in a comparative perspective, would allow to go further in addressing new questions for cities' sustainability and resilience. This is the next step of our research agenda.

5. Conclusions

We explored the evolution of resilience and its current fragmentation into different domains addressing diverse levels. We have illustrated that due to the multidisciplinary nature of the resilience notion, there is often a confusion between quite similar, but still distinct terms such as vulnerability, adaptability, transformability, and sustainability. By conducting a literature review, we explored the differences between resilience and sustainability as the terms that generate the biggest confusion. Taking a perspective of complex systems approach, we explained the relationships between these terms through the time cross-scale dynamics. We argued that resilience is shaped through a long-term path-dependent process and it operates within adaptive cycles, but, as a property, it is revealed in short-term dynamics in a system's reaction to shocks. Sustainability, in turn, is based on the predefined outcomes that imply transformative change of a system in the long-term. Simply put, the relationship between these two concepts can be described as follows: sustainability prioritizes outcomes, and resilience prioritizes process (but is not equal to it!).

The meta-analysis of the literature on urban and regional resilience showed that urban resilience is analyzed on the micro-meso levels (community/city scales) taking into account local bottom-up shocks such as natural disasters. Contrary to it, in the regional resilience approach scholars consider top-down shocks such as economic recessions or global crises as a main stress factor, therefore, emphasizing a link between meso and macro levels.

Assuming that resilience relates to both bottom-up and top-down types of shock, we find these two approaches complementary and integrate them into the multi-level perspective to urban resilience. Taking an urban economic perspective, we identified three levels: the micro level of economic actors inside a city, the macro level that highlights the embeddedness of cities into global processes through a system of cities, and the meso level that is a city itself, being the product of bottom-up and top-down processes. We consider each level's dynamics within their respective adaptive cycles and argue that cities' resilience depends on interactions between these three adaptive cycles that in the long run become a *multi-level synchronicity* that, in the end, predefines resilience. To address these multi-level interactions, we argue that it is necessary to apply a panarchy framework. By opening a discussion

about the applications of the panarchy framework to urban resilience, we aim to overcome the existing "lock in" of scale and domain (layer) in urban and regional resilience research.

We encourage scholars for more complex research in these areas that would go beyond the current limitations linked, on the one hand, to a single level analysis of one type of shock (either bottom-up, or top-down) and, on the other hand, to one prevailing domain in each discourse (such as ecology in urban resilience and economy in regional resilience). It is crucial for institutions (including memberships, constituencies, and stakeholders) to define these multi-level interactions permitting to better delineate the whole city system impacted by the upper or lower forces. It would permit to adapt institutions and their policies while most cities are spread between numerous municipalities, where institutional power is distributed and rarely coordinated.

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References

1. Marino, D. The Networking Structuration Process of Urban Resilience Concept in Habitat III Agenda. Master's Thesis, University of Lausanne, Lausanne Switzerland, 2017.
2. Miller, F.; Osbahr, H.; Boyd, E.; Thomalla, F.; Bharwani, S.; Ziervogel, G.; Walker, B.; Birkmann, J.; van der Leeuw, S.; Rockström, J.; et al. Resilience and Vulnerability: Complementary or Conflicting Concepts? *Ecol. Soc.* **2010**, *15*, 11. [CrossRef]
3. Young, O.R.; Berkhout, F.; Gallopin, G.C.; Janssen, M.A.; Ostrom, E.; van der Leeuw, S. The globalization of socio-ecological systems: An agenda for scientific research. *Glob. Environ. Chang.* **2006**, *16*, 304–316. [CrossRef]
4. Martin, R.; Sunley, P. On the notion of regional economic resilience: Conceptualization and explanation. *J. Econ. Geogr.* **2015**, *15*, 1–42. [CrossRef]
5. Pumain, D. (Ed.) Alternative explanations of hierarchical differentiation in urban systems. In *Hierarchy in Natural and Social Sciences*; Methods Series; Springer: Dordrecht, The Netherlands, 2006; Volume 3, pp. 169–222.
6. Rozenblat, C. Opening the Black Box of Agglomeration Economies for Measuring Cities' Competitiveness through International Firm Networks. *Urban Stud.* **2010**, *47*, 2841–2865. [CrossRef]
7. Holling, C.S. Resilience and Stability of Ecological Systems. *Annu. Rev. Ecol. Syst.* **1973**, *4*, 1–23. [CrossRef]
8. Holling, C.S. *Adaptive Environmental Assessment and Management*; John Wiley and Sons: Chichester, UK, 1978; Available online: http://pure.iiasa.ac.at/id/eprint/823/1/XB-78-103.pdf (accessed on 21 November 2018).
9. Pimm, S.L. The complexity and stability of ecosystems. *Nature* **1984**, *307*, 321–326. [CrossRef]
10. Perrings, C.; Folke, C.; Maler, K.-G. The ecology and economics of biodiversity loss: The research agenda. *Ambio* **1992**, *21*, 201–211.
11. Carpenter, S.; Walker, B.; Anderies, J.M.; Abel, N. From Metaphor to Measurement: Resilience of What to What? *Ecosystems* **2001**, *4*, 765–781. [CrossRef]
12. Tugade, M.M.; Fredrickson, B.L.; Feldman Barrett, L. Psychological Resilience and Positive Emotional Granularity: Examining the Benefits of Positive Emotions on Coping and Health. *J. Pers.* **2004**, *72*, 1161–1190. [CrossRef] [PubMed]
13. Folke, C. Resilience: The emergence of a perspective for social–ecological systems analyses. *Glob. Environ. Chang.* **2006**, *16*, 253–267. [CrossRef]
14. Quinlan, A.E.; Berbés-Blázquez, M.; Haider, L.J.; Peterson, G.D. Measuring and assessing resilience: Broadening understanding through multiple disciplinary perspectives. *J. Appl. Ecol.* **2016**, *53*, 677–687. [CrossRef]

15. Xu, L.; Kajikawa, Y. An integrated framework for resilience research: A systematic review based on citation network analysis. *Sustain. Sci.* **2018**, *13*, 235–254. [CrossRef]
16. Patriarca, R.; Bergström, J.; Di Gravio, G.; Costantino, F. Resilience engineering: Current status of the research and future challenges. *Saf. Sci.* **2018**, *102*, 79–100. [CrossRef]
17. Levin, S.A.; Barrett, S.; Aniyar, S.; Baumol, W.; Bliss, C.; Bolin, B.; Dasgupta, P.; Ehrlich, P.; Folke, C.; Gren, I.-M.; et al. Resilience in natural and socioeconomic systems. *Environ. Dev. Econ.* **1998**, *3*, 221–262. [CrossRef]
18. Walker, B. Resilience, instability, and disturbance in ecosystem dynamics. *Environ. Dev. Econ.* **1998**, *3*, 259–262. [CrossRef]
19. Turner, B.L. Vulnerability and resilience: Coalescing or paralleling approaches for sustainability science? *Glob. Environ. Chang.* **2010**, *20*, 570–576. [CrossRef]
20. Walker, B.; Holling, C.S.; Carpenter, S.; Kinzig, A. Resilience, Adaptability and Transformability in Social–ecological Systems. *Ecol. Soc.* **2004**, *9*, 5. [CrossRef]
21. Nelson, D.R.; Adger, W.N.; Brown, K. Adaptation to Environmental Change: Contributions of a Resilience Framework. *Annu. Rev. Environ. Resour.* **2007**, *32*, 395–419. [CrossRef]
22. Redman, C.L. Should sustainability and resilience be combined or remain distinct pursuits? *Ecol. Soc.* **2014**, *19*, 37. [CrossRef]
23. Romero-Lankao, P.; Gnatz, D.M.; Wilhelmi, O.; Hayden, M. Urban sustainability and resilience: From theory to practice. *Sustainability* **2016**, *8*, 1224. [CrossRef]
24. Leitner, H.; Sheppard, E.; Webber, S.; Colven, E. Globalizing urban resilience. *Urban Geogr.* **2018**, *8*, 1276–1284. [CrossRef]
25. Hollnagel, E. Resilience engineering and the built environment. *Build. Res. Inf.* **2014**, *42*, 221–228. [CrossRef]
26. Hollnagel, E. RAG—The resilience analysis grid. In *Resilience Engineering in Practice: A Guidebook*; Hollnagel, E., Pariès, J., Woods, D.D., Wreathall, J., Eds.; Ashgate: Farnham, UK, 2011; Available online: http://erikhollnagel.com/onewebmedia/RAG%20Outline%20V2.pdf (accessed on 21 November 2018).
27. Dubé, J.; PolèSe, M. Resilience Revisited: Assessing the Impact of the 2007–2009 Recession on 83 Canadian Regions with Accompanying Thoughts on an Elusive Concept. *Reg. Stud.* **2016**, *50*, 615–628. [CrossRef]
28. Simmie, J.; Martin, R. The economic resilience of regions: Towards an evolutionary approach. *Camb. J. Reg. Econ. Soc.* **2010**, *3*, 27–43. [CrossRef]
29. Simmie, J. The evolution of economic resilience in cities: Re-invention versus replication. In *Creating Resilient Economies: Entrepreneurship, Growth and Development in Uncertain Times*; Williams, N., Vorley, T., Eds.; Edward Elgar Publishing Ltd.: Cheltenham, UK, 2017; pp. 70–88.
30. Shutters, S.T.; Muneepeerakul, R.; Lobo, J. Quantifying urban economic resilience through labour force interdependence. *Palgrave Commun.* **2015**, *1*, 15010. [CrossRef]
31. Cainelli, G.; Ganau, R.; Modica, M. Industrial relatedness and regional resilience in the European Union. *Pap. Reg. Sci.* **2018**. [CrossRef]
32. Gunderson, L.; Holling, C.S. *Panarchy: Understanding Transformations in Human and Natural Systems*; Island Press: Washington, DC, USA, 2002; ISBN 978-1-55963-857-9.
33. Zhang, X.; Li, H. Urban resilience and urban sustainability: What we know and what do not know? *Cities* **2018**, *72*, 141–148. [CrossRef]
34. Fröhlich, K.; Hassink, R. Regional resilience: A stretched concept? *Eur. Plan. Stud.* **2018**, *26*, 1763–1778. [CrossRef]
35. Xu, L.; Marinova, D.; Guo, X. Resilience thinking: A renewed system approach for sustainability science. *Sustain. Sci.* **2015**, *10*, 123–138. [CrossRef]
36. Marchese, D.; Reynolds, E.; Bates, M.E.; Morgan, H.; Clark, S.S.; Linkov, I. Resilience and sustainability: Similarities and differences in environmental management applications. *Sci. Total Environ.* **2018**, *613–614*, 1275–1283. [CrossRef] [PubMed]
37. Franceschini, F.; Maisano, D.; Mastrogiacomo, L. The museum of errors/horrors in Scopus. *J. Informetr.* **2016**, *10*, 174–182. [CrossRef]
38. Franceschini, F.; Maisano, D.; Mastrogiacomo, L. Empirical analysis and classification of database errors in Scopus and Web of Science. *J. Informetr.* **2016**, *10*, 933–953. [CrossRef]
39. Blondel, V.; Guillaume, J.-L.; Lambiotte, R.; Lefebvre, E. Fast Unfolding of Communities in Large Networks. *J. Stat. Mech. Theory Exp.* **2008**, *10*, 10008. [CrossRef]

40. Batty, M. Cities as Complex Systems, Scaling, Interactions, Networks, Dynamics and Urban Morphologies. In *Encyclopedia of Complexity and Systems Science*; Meyers, R., Ed.; Springer: New York, NY, USA, 2009.
41. Meerow, S.; Newell, J.P. Urban resilience for whom, what, when, where, and why? *Urban Geogr.* **2016**, 1–21. [CrossRef]
42. Olsson, P.; Galaz, V.; Boonstra, W.J. Sustainability transformations: A resilience perspective. *Ecol. Soc.* **2014**, *19*, 1. [CrossRef]
43. Derissen, S.; Quaas, M.F.; Baumgärtner, S. The relationship between resilience and sustainability of ecological-economic systems. *Ecol. Econ.* **2011**, *70*, 1121–1128. [CrossRef]
44. Folke, C.; Biggs, R.; Norström, A.V.; Reyers, B.; Rockström, J. Social-ecological resilience and biosphere-based sustainability science. *Ecol. Soc.* **2016**, *21*, 41. [CrossRef]
45. Espiner, S.; Orchiston, C.; Higham, J. Resilience and sustainability: A complementary relationship? Towards a practical conceptual model for the sustainability–resilience nexus in tourism. *J. Sustain. Tour.* **2017**, *25*, 1385–1400. [CrossRef]
46. McCool, S.; Butler, R.; Buckley, R.; Weaver, D.; Wheeller, B. Is Concept of Sustainability Utopian: Ideally Perfect but Impracticable? *Tour. Recreat. Res.* **2013**, *38*, 213–242. [CrossRef]
47. Woods, D.D. Essential Characteristics of Resilience. In *Resilience Engineering. Concepts and Precepts*; Hollnagel, E., Woods, D.D., Leveson, V., Eds.; Ashgate Publishing Company: Burlington, VT, USA, 2006; pp. 21–34.
48. Luthar, S.S. *Resilience and Vulnerability: Adaptation in the Context of Childhood Adversities*; Cambridge University Press: Cambridge, UK, 2003.
49. Haffar, M.; Searcy, C. Target-setting for ecological resilience: Are companies setting environmental sustainability targets in line with planetary thresholds? *Bus. Strat. Environ.* **2018**, *27*, 1079–1092. [CrossRef]
50. Irwin, E.G.; Jaquet, T.; Faggian, A. Regional sustainability and resilience: Recent progress and future directions. *Adv. Spat. Sci.* **2017**, 277–295. [CrossRef]
51. Common, M.; Perrings, C. Towards an ecological economics of sustainability. *Ecol. Econ.* **1992**, *6*, 7–34. [CrossRef]
52. Holling, C.S.; Walker, B. Resilience Defined. *In Internet Encyclopedia of Ecological Economics*. International Society of Ecological Economics, Ed. 2003. Available online: http://isecoeco.org/pdf/resilience.pdf (accessed on 13 November 2018).
53. Trosper, R. *Resilience, Reciprocity and Ecological Economics: Northwest Coast Sustainability*; Routledge: London, UK; New York, NY, USA, 2009.
54. Wilson, G.A. "Constructive tensions" in resilience research: Critical reflections from a human geography perspective. *Geogr. J.* **2018**, *184*, 89–99. [CrossRef]
55. Silici, L.; Ndabe, P.; Friedrich, T.; Kassam, A. Harnessing sustainability, resilience and productivity through conservation agriculture: The case of Likoti in Lesotho. *Int. J. Agric. Sustain.* **2011**, *9*, 137–144. [CrossRef]
56. Marston, J.M. Modeling Resilience and Sustainability in Ancient Agricultural Systems. *J. Ethnobiol.* **2015**, *35*, 585–605. [CrossRef]
57. Serrão, E.A.S.; Nepstad, D.; Walker, R. Upland agricultural and forestry development in the Amazon: Sustainability, criticality and resilience. *Ecol. Econ.* **1996**, *18*, 3–13. [CrossRef]
58. Burg, R.G.; Mlutkowski, K.P.; Sordyl, D.J.; Wight, J.K. American activities toward development of a unified front to advance concrete sustainability and resilience. In Proceedings of the FIB Symposium: Concrete Structures for a Sustainable Community, Stockholm, Sweden, 11–14 June 2012; pp. 15–19.
59. Rodriguez-Nikl, T. Linking disaster resilience and sustainability. *Civ. Eng. Environ. Syst.* **2015**, *32*, 157–169. [CrossRef]
60. Kato, K. Debating Sustainability in Tourism Development: Resilience, Traditional Knowledge and Community: A Post-disaster Perspective. *Tour. Plan. Dev.* **2018**, *15*, 55–67. [CrossRef]
61. Manyena, S.B.; Mutale, S.B.; Collins, A. Sustainability of rural water supply and disaster resilience in Zimbabwe. *Water Policy* **2008**, *10*, 563–575. [CrossRef]
62. Asprone, D.; Manfredi, G. Linking disaster resilience and urban sustainability: A glocal approach for future cities. *Disasters* **2015**, *39*, s96–s111. [CrossRef] [PubMed]
63. Anderies, J.M.; Folke, C.; Walker, B.; Ostrom, E. Aligning key concepts for global change policy: Robustness, resilience, and sustainability. *Ecol. Soc.* **2013**, *18*, 8. [CrossRef]

64. Folke, C.; Carpenter, S.; Walker, B.; Scheffer, M.; Chapin, T.; Rockström, J. Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecol. Soc.* **2010**, *15*, 20. [CrossRef]
65. Walker, B.; Gunderson, L.; Kinzig, A.; Folke, C.; Carpenter, S.; Schultz, L. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecol. Soc.* **2006**, *11*, 13. [CrossRef]
66. Fingleton, B.; Garretsen, H.; Martin, R. Recessionary shocks and regional employment: Evidence on the resilience of U.K. regions. *J. Reg. Sci.* **2012**, *52*, 109–133. [CrossRef]
67. Gunderson, L.H. Ecological Resilience—In Theory and Application. *Annu. Rev. Ecol. Syst.* **2000**, *31*, 425–439. [CrossRef]
68. Papadaki, M.; Kalogeraki, S. Social support actions as forms of building community resilience at the onset of the crisis in Urban Greece: The case of Chania. *Partecip. Conflitto* **2017**, *10*, 193–220.
69. Patel, R.B.; Gleason, K.M. The association between social cohesion and community resilience in two urban slums of Port au Prince, Haiti. *Int. J. Disaster Risk Reduct.* **2018**, *27*, 161–167. [CrossRef]
70. Plough, A.; Fielding, J.E.; Chandra, A.; Williams, M.; Eisenman, D.; Wells, K.B.; Law, G.Y.; Fogleman, S.; Magaña, A. Building community disaster resilience: Perspectives from a large urban county department of public health. *Am. J. Public Health* **2013**, *103*, 1190–1197. [CrossRef] [PubMed]
71. Su, Y.-S. Rebuild, retreat or resilience: Urban flood vulnerability analysis and simulation in Taipei. *Int. J. Disaster Resil. Built Environ.* **2017**, *8*, 110–122. [CrossRef]
72. Ajibade, I. Can a future city enhance urban resilience and sustainability? A political ecology analysis of Eko Atlantic city, Nigeria. *Int. J. Disaster Risk Reduct.* **2017**, *26*, 85–92. [CrossRef]
73. Parés, M.; Blanco, I.; Fernández, C. Facing the Great Recession in Deprived Urban Areas: How Civic Capacity Contributes to Neighborhood Resilience. *City Community* **2018**, *17*, 65–86. [CrossRef]
74. Antoniucci, V.; Marella, G. Small town resilience: Housing market crisis and urban density in Italy. *Land Use Policy* **2016**, *59*, 580–588. [CrossRef]
75. Meerow, S. Double exposure, infrastructure planning, and urban climate resilience in coastal megacities: A case study of Manila. *Environ. Plan. A* **2017**, *49*, 2649–2672. [CrossRef]
76. Lee, D.-S. Towards urban resilience through inter-city networks of co-invention: A case study of U.S. cities. *Sustainability* **2018**, *10*, 289. [CrossRef]
77. Peyroux, E. Discourse of Urban Resilience and 'Inclusive Development' in the Johannesburg Growth and Development Strategy 2040. *Eur. J. Dev. Res.* **2015**, *27*, 560–573. [CrossRef]
78. Han, G.; Johannessen, Å.; Pålsson, A.; Rosemarin, A.; Ruben, C.; Stenström, T.A.; Swartling, Å. Enhancing urban resilience to extreme waters: The WASH & RESCUE Initiative. In Proceedings of the International Disaster Risk Conference Integated Risk Management Change World—Pathways Resilient Social IDRC Davos, Davos, Switzerland, 26–30 August 2012; Stal, M., Ammann, W., Stiffler, M., Eds.; Global Risk Forum (GRF): Davos, Switzerland, 2012; pp. 296–299.
79. Stangl, P. Prospects for Urban Morphology in Resilience Assessment. In *Resilience-Oriented Urban Planning. Lecture Notes in Energy*; Yamagata, Y., Sharifi, A., Eds.; Springer: Cham, Switzerland, 2018; Volume 65, pp. 181–193.
80. McPhearson, T.; Hamstead, Z.A.; Kremer, P. Urban Ecosystem Services for Resilience Planning and Management in New York City. *Ambio* **2014**, *43*, 502–515. [CrossRef] [PubMed]
81. Vandergert, P.; Collier, M.; Kampelmann, S.; Newport, D. Blending adaptive governance and institutional theory to explore urban resilience and sustainability strategies in the Rome metropolitan area, Italy. *Int. J. Urban Sustain. Dev.* **2016**, *8*, 126–143. [CrossRef]
82. Chelleri, L.; Waters, J.J.; Olazabal, M.; Minucci, G. Resilience trade-offs: Addressing multiple scales and temporal aspects of urban resilience. *Environ. Urban.* **2015**, *27*, 181–198. [CrossRef]
83. Lhomme, S.; Serre, D.; Diab, Y.; Laganier, R. Analyzing resilience of urban networks: A preliminary step towards more flood resilient cities. *Nat. Hazards Earth Syst. Sci.* **2013**, *13*, 221–230. [CrossRef]
84. Bozza, A.; Asprone, D.; Manfredi, G. Developing an integrated framework to quantify resilience of urban systems against disasters. *Nat. Hazards* **2015**, *78*, 1729–1748. [CrossRef]
85. Beraud, H.; Barroca, B.; Serre, D.; Hubert, G. Making urban territories more resilient to flooding by improving the resilience of their waste management network. A methodology for analysing dysfunctions in waste management networks during and after flooding. In Proceedings of the Vulnerability, Uncertainty, Risk: Analysis, Modeling, Management—ICVRAM ISUMA Conference, Hyattsville, MD, USA, 11–13 April 2011; pp. 425–432.

86. Koren, D.; Kilar, V.; Rus, K. Proposal for Holistic Assessment of Urban System Resilience to Natural Disasters. In *IOP Conference Series: Materials Science and Engineering*; Marschalko, M., Segalini, A., Drusa, M., Rybak, J., Yilmaz, I., Coisson, E., Eds.; Institute of Physics Publishing: Bristol, UK, 2017; Volume 245.
87. Cavallaro, M.; Asprone, D.; Latora, V.; Manfredi, G.; Nicosia, V. Assessment of Urban Ecosystem Resilience through Hybrid Social-Physical Complex Networks. *Comput. Aided Civ. Infrastruct. Eng.* **2014**, *29*, 608–625. [CrossRef]
88. Irwin, S.; Schardong, A.; Simonovic, S.P.; Nirupama, N. ResilSIM-A decision support tool for estimating resilience of urban systems. *Water* **2016**, *8*, 377. [CrossRef]
89. ISO Standard No. 37123: Sustainable Cities and Communities—Indicators for Resilience Cities. 2018. Available online: https://www.iso.org/standard/70428.html (accessed on 23 November 2018).
90. Martin, R. Regional economic resilience, hysteresis and recessionary shocks. *J. Econ. Geogr.* **2012**, *12*, 1–32. [CrossRef]
91. Lagravinese, R. Economic crisis and rising gaps North–South: Evidence from the Italian regions. *Camb. J. Reg. Econ. Soc.* **2015**, *8*, 331–342. [CrossRef]
92. Augustine, N.; Wolman, H.; Wial, H.; McMillen, M. *Regional Economic Capacity, Economic Shocks, and Economic Resilience*; Building Resilient Regions (Working Paper); MacArthur Foundation Research Network: Washington, DC, USA, 2013.
93. Cellini, R.; Torrisi, G. Regional Resilience in Italy: A Very Long-Run Analysis. *Reg. Stud.* **2014**, *48*, 1779–1796. [CrossRef]
94. Xiao, Y.; Drucker, J. Does economic diversity enhance regional disaster resilience? *J. Am. Plan. Assoc.* **2013**, *79*, 148–160. [CrossRef]
95. Faggian, A.; Gemmiti, R.; Jaquet, T.; Santini, I. Regional economic resilience: The experience of the Italian local labor systems. *Ann. Reg. Sci.* **2018**, *60*, 393–410. [CrossRef]
96. Pumain, D.; Rozenblat, C. Two metropolisation gradients in the European system of cities revealed by scaling laws. *Environ. Plan. B Urban Anal. City Sci.* **2018**, 1–18. [CrossRef]
97. Pendall, R.; Foster, K.A.; Cowell, M. Resilience and regions: Building understanding of the metaphor. *Camb. J. Reg. Econ. Soc.* **2010**, *3*, 71–84. [CrossRef]
98. Swanstrom, T.; Chapple, K.; Immergluck, D. Regional resilience in the face of foreclosures: Evidence from six metropolitan areas. In *A Report Prepared for the MacArthur Foundation's Building Resilience Regions Project (Working Paper 2009-05)*; Institute of Urban and Regional Development: Berkley, CA, USA, 2009; Available online: https://cloudfront.escholarship.org/dist/prd/content/qt23s3q06x/qt23s3q06x.pdf (accessed on 13 November 2018).
99. Clark, J.; Huang, H.-I.; Walsh, J.P. A typology of "innovation districts": What it means for regional resilience. *Camb. J. Reg. Econ. Soc.* **2010**, *3*, 121–137. [CrossRef]
100. Berry, B. Cities as systems within systems of cities. *Pap. Reg. Sci.* **1964**, *13*, 149–163. [CrossRef]
101. Chirisa, I.; Bandauko, E. African Cities and the Water-Food-Climate-Energy Nexus: An Agenda for Sustainability and Resilience at a Local Level. *Urban Forum* **2015**, *26*, 391–404. [CrossRef]
102. Fiksel, J. Sustainability and resilience: Toward a systems approach. *IEEE Eng. Manag. Rev.* **2007**, *35*, 5. [CrossRef]
103. Bergström, J.; Dekker, S.W.A. Bridging the Macro and the Micro by Considering the Meso: Reflections on the Fractal Nature of Resilience. *Ecol. Soc.* **2014**, *19*, 22. [CrossRef]
104. Holling, C.S. Understanding the Complexity of Economic, Ecological, and Social Systems. *Ecosystems* **2001**, *4*, 390–405. [CrossRef]
105. Duranton, G.; Puga, D. *Micro-Foundations of Urban Agglomeration Economies*; National Bureau of Economic Research: Cambridge, MA, USA, 2003; Available online: https://econpapers.repec.org/paper/nbrnberwo/9931.htm (accessed on 13 November 2018).
106. Leydesdorff, L. The Triple Helix, Quadruple Helix, . . . , and an N-Tuple of Helices: Explanatory Models for Analyzing the Knowledge-Based Economy? *J. Knowl. Econ.* **2012**, *3*, 25–35. [CrossRef]
107. Leydesdorff, L.; Kushnir, D.; Rafols, I. Interactive overlay maps for US patent (USPTO) data based on International Patent Classification (IPC). *Scientometrics* **2014**, *98*, 1583–1599. [CrossRef]
108. Uzzi, B.; Gillespie, J.J. Knowledge spillover in corporate financing networks: Embeddedness and the firm's debt performance. *Strateg. Manag. J.* **2002**, *23*, 595–618. [CrossRef]

109. Storper, M.; Venables, A.J. Buzz: Face-to-face contact and the urban economy. *J. Econ. Geogr.* **2004**, *4*, 351–370. [CrossRef]
110. Porter, M.E. Clusters and the new economics of competition. *Harv. Bus. Rev. Watertown*. 1998, 76. Available online: https://hbr.org/1998/11/clusters-and-the-new-economics-of-competition (accessed on 13 November 2018).
111. Bathelt, H.; Glückler, J. *The Relational Economy: Geographies of Knowing and Learning*; Oxford University Press: Oxford, UK, 2011.
112. Boschma, R.A.; Frenken, K. Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. *J. Econ. Geogr.* **2006**, *6*, 273–302. [CrossRef]
113. Lane, D. Hierarchy, complexity, society. In *Hierarchy in Natural and Social Sciences*; Pumain, D., Ed.; Methods Series; Springer: Dordrecht, The Netherlands, 2006; Volume 3, pp. 87–119.
114. Holland, J. *Emergence: From Chaos to Order*; Addison-Wesley: Reading, MA, USA, 2000.
115. Rozenblat, C.; Mélançon, G. (Eds.) *Multilevel Analysis and Visualization of Geographical Networks*; Methods Series; Springer: Dordrecht, The Netherlands, 2013.
116. Pumain, D.; Reuillon, R. *Urban Dynamics and Simulation Models*; Springer: Berlin, Germany, 2017.
117. Rozenblat, C.; Zaidi, F.; Bellwald, A. The multipolar regionalization of cities in multinational firms' networks. *Glob. Netw.* **2017**, *17*, 171–194. [CrossRef]
118. Bettencourt, L.M.A.; Lobo, J.; Helbing, D.; Kuhnert, C.; West, G.B. Growth, innovation, scaling, and the pace of life in cities. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 7301–7306. [CrossRef] [PubMed]