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The life cycle of cities☆

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ABSTRACT

While an ever-growing percentage of the world's population is urban, the rate at which cities grow is not uniform. The lifetime of individual cities includes periods of fast growth, slow growth and periods of shrinkage. There exists an extensive literature concerned with possible means to manage specific pathologies. It is our view that the design of specific policies should be the result of a comprehensive model of urban health. While not all cities go through the entire life cycle, a comprehensive theory of cities and specific policies need to include specification of the interaction of the various forces that shape the entire range of urban patterns and identification of specific combinations of values that create phase transitions among these patterns.

To sort these ideas we suggest that there is a need to consider and incorporate the structure and timing of innovation activities, agglomeration effects that they generate, interurban migration patterns and assorted feedback mechanisms. We hypothesize that these flows depend on the activity rhythms of the various processes and their differential impact on cities. We present a biology inspired rudimentary framework as a basis for the construction of an ABM of cities with a focus on the nature of time and as a basis for analyzing urban dynamics.[1]

1. Introduction

The last several decades witnessed an extensive policy discussion concerned with the growth and the spatial structure of cities (Cochrane, 2007). Discussion included efforts to promote the redistribution of populations from primate cities to secondary urban centers (He, Chen, Mao, & Zhou, 2016; Schmidheiny & Suedekum, 2015), the promotion of compact urban structures (Xia, Shen, Yan, & Bao, 2016; Yin, Mizokami, & Aikawa, 2015; Zhu, 2016), the prevention of sprawl (Balta, 2016; Jiang, Ma, Qu, Zhang, & Zhou, 2016; Milan & Creutzig, 2016) and the formation of self-organizing unplanned cities within cities (Rankin & McLean, 2015), management of rapid urban growth (Smith & Jenkins, 2015; Shafizadeh-Moghadam & Helbich, 2015) and the reversal of deindustrialization and shrinkage of many cities (Alves, Barreira, Guimarães, & Panagopoulos, 2016; Haase, Rink, Grossmann, Bernt, & Mykhnenko, 2014, 2016). The backdrop to the various policies is the increasing urbanization of the world. The variety of policies reflects the fact that while the world is becoming more urban, not all cities experience the same rates of growth.

According to Duranton and Puga (2014), during the 90 years between 1920 and 2010, the growth rates of cities in the US, Spain and France displayed great variation with means and standard deviations of similar magnitude. During various periods, some cities grow faster than others do. Some cities do not grow at all and some even shrink. While the history of some cities displays a complete life cycle that includes periods of slow and fast growth, periods of stagnant growth and periods during which they shrink, some cities go through a partial cycle only. Recently, urban shrinkage has become a topic of concern, especially in Europe. There Albeit incomplete, the literature concerning the emergence and evolution of cities is enormous (Fischer & Nijkamp, 2014; Gabaix & Ioannides, 2004; Glaeser, 2000). An interesting recent analysis of the formation of cities in Europe gives credence to the importance of *1st nature* and suggests that water and land-based transportation access were the dominant determinants in early

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[1] Longo & Montévil, 2014.

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urban history. The locations of later city formations were influenced by proximity to already existing cities (Bosker & Buringh, 2015). Analytic analyses focus on the causes of migration into cities and its contribution to entrepreneurship, new firm formations and promotion of urban growth. Various models explain variations and decelerating rates of urban growth in terms of the nature of urban industrial composition and structure. Yet, there is no comprehensive theory of cities that explains the entire range of urban growth patterns by means of a consistent set of variables that because of positive and negative feedbacks assume different combinations of values that lead to observed patterns of growth. Indeed, there is no consistent definition of the geographic extent of cities.[2] In this paper, we pull together the major strands of explanations from the existing literature in an attempt to formulate a rudimentary model that addresses the gap. The appropriate time scale used to observe urban processes may differ greatly, from decades (for example, structural change) to years (as firm development stages) and months (for example, individual migration). Generally, time is assumed to be uniform for all agents and processes involved in a system. Instead, we suggest the need for a fine-tuned pace of time adapted to the specific characteristics of each urban process. Therefore, we focus on the nature and role of time as a determining factor in urban dynamics.

We begin with agglomeration economies as a powerful force for the explanation of the emergence and evolution of cities. Marshall (1920) implied that positive feedbacks of city size reduce the cost of finding new ideas and promote innovations that create economic advantages. Agglomeration economies that are external to firms affect all firms in cities and cause output per capita to be significantly larger in bigger cities. In addition, talented people choose to live in larger cities. This *ex ante* sorting creates an advantage for bigger cities. A third explanation suggests that larger cities, with bigger markets create tougher competition, create and economic environment that *ex post* leads to the survival of more productive firms (Behrens, Duranton, & Robert-Nicoud, 2014).

However, others suggest that agglomeration may hinder innovation activities (Brezis & Krugman, 1997; Packalen & Bhattacharya, 2015). Recently we suggested that ICT may reduce significantly the importance of physical proximity for efficient communication and thus affect the spatial organization of cities (Czamanski & Broitman 2014). Furthermore, in the long run, urban growth is associated with entrepreneurship. The birth of new firms helps to disseminate innovations that drive out stagnant older firms (Bettencourt, Samaniego, & Youn, 2014; Bishop, 2012; Glaeser, Kerr, & Kerr, 2012). Here we suggest that the role of innovations is much more complicated and that it has a different effect on cities during various stages of their life cycle.

While rates of natural increase of populations differ among cities, these differences are relatively small. Differences in the growth of the populations of cities are mainly the result of migration. There is a vast literature on rural-urban and urban-urban migration. The overwhelming evidence suggests that such migrations are motivated by economic benefit-cost advantages to the migrants. Economic opportunities are an important ingredient in the positive feedback of migration-economic growth-migration dynamic (Fu & Gabriel, 2012; Mitze & Schmidt, 2015).

Much of the extant economic literature is fashioned in the context of static equilibrium models with economies of scale introduces by means of the standard Dixit and Stiglitz mechanism (Dixit & Stiglitz 1977). The models imply the existence of positive feedbacks in the urban growth process, but these are explored only partially. They also suggest that urban dynamics are the result of fast and slow processes. Without explicit suggestion, these models imply that in equilibrium cities are populated by homogeneous types of talents, firms, etc. A satisfactory theory should explain the vast and prevalent diversity in cities. In addition, it should generate a size distribution of cities and identify conditions for Zipf law. It is our view that a satisfactory and integrated model of urban evolution will provide an improved basis for the formulation of effective urban policies capable of addressing various urban pathologies.

The rest of the paper includes 3 sections. In section 2 we introduce the notion of urban rhythms and we present some rudimentary ideas concerning urban dynamics while pulling together ideas concerning the direction of migration streams in a system of cities, their impact on innovation and economic growth and associated feedback mechanism. In the following section, we present an agent-based model (ABM) that incorporates these ideas and is capable of generating the entire spectrum of evolutionary patterns of cities. In the last section we present some concluding remarks and suggestions for future research.

2. Some rudimentary ideas concerning urban rhythms and dynamics

The standard and generally accepted concept of time is linear and uniform. However, urban dynamics are the result of many interrelated processes with great temporal variability. At the highest level, long-term dynamics of urban systems can be described using periods of decades or even centuries (Batty, 2006). However, underneath the reported patterns there are annual, monthly and even hourly processes with elaborate interactions that generate the big picture of urban life cycles.

With the exception of studies of the physical morphology of cities, heretofore urban phenomena were analyzed at a crude spatial and temporal resolution. Thus, the life cycle of cities is described and examined as a process pertaining to aggregate entities.

The usefulness of disaggregated time frames while examining a single process is clear through the example of migration patterns underlying the life cycle of cities. Local inhabitants are able to change workplaces and become fully productive in their new jobs relatively fast. Immigrants may need a longer learning period before they can be fully integrated into the job market, especially if they arrive from other cultures. In the first case the productive cycle can be measured in weeks, while in the second, years is more appropriate time scale. In terms of impact, a local inhabitant that switches a workplace is likely to remain in the same sector, without any visible improvement in productivity. In the case of high-skilled migrants, it is likely that finding employment may take a much longer time. Nevertheless, once new jobs are found productivity may increase considerably.

There are four main types of actors in the urban story. Two types of people make decisions whether to migrate or to stay put. The migrants start new enterprises or go to work for innovative firms (Gagliardi, 2015). Those who do not migrate tend to be less entrepreneurial. We hypothesize therefore, that places with high rates of outmigration experience lower rates of new firm formations. There are also two types of firms. Innovative, mostly small, firms absorb creative migrants. Traditional, mostly very large, firms sometimes take over the innovative firms.

Innovations include a very broad spectrum of phenomena with some universal features (Rogers, 2003). The S-shaped adoption curve of the innovation diffusion process includes five stages:

(i) Knowledge (gain knowledge of an innovation);
(ii) Persuasion (form an attitude/opinion towards it);

[2] This is particularly troublesome in empirical analyses of the various hypotheses concerning urban growth.