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Greener and larger neighbourhoods make cities more sustainable! A 2D urban economics perspective

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ABSTRACT

We analyse urban growth forms by means of a 2D microeconomic model where households value green space at neighbourhood scale. We analytically demonstrate that cities can grow more densely when households have the possibility to enlarge the neighbourhood in which they value green space, thus emphasizing the importance of neighbourhood planning in particular for facilitating short trips and views of green amenities. We also show by simulation that the size and form of the city, relative to the size and form of neighbourhoods, impact on the decision of households to leapfrog land or not, thus impacting on the emergence of scattered urbanisation patterns. We conclude that carefully addressing the spatial arrangement of green space and buildings and facilitating trips within neighbourhood units constitute an effective policy lever and an attractive way to deliver more sustainable cities. We further argue that our theoretical experiment with complementary analytical and computer-based simulation provides micro-economic reasoning to the main elements of the Garden City and neighbourhood unit planning concepts.

1. Introduction

In this article we analyse urban growth forms as the result of the valuation by households of neighbourhood amenities and green space.

Green cities are indeed *en vogue* and urban planners indulge households' taste for green amenities. For example, in March 2014, the British government announced a new '*proper Garden City*' to be built in the Thames Gateway, East of London, 100 years after the first Garden City, Welwyn (The Guardian, 16/03/2014). In 1902, already, Ebenezer Howard (Howard, 1902), urban utopist and influential father of the Garden City movement suggested, as part of his '*Correct Principle of a City's Growth*', to always preserve a belt of country around our cities so that

> *each inhabitant […] would enjoy all the advantages of, a great and most beautiful city; and yet all the fresh delights of the country — field hedgerow, and woodland — not prim parks and gardens merely — would be within a very few minutes' walk or ride.*

The Garden City concept was aimed at synthesising the demand for both green (country) and urban amenities. Hall & Ward (1999) argue that this concept proved to be highly adaptive across the last century and is capable of handling today's social and sustainability goals. Increasingly over the last years, the question of growing cities while at the same time preserving nature within them for recreational use has also been added health and ecological dimensions, together reflected under the umbrella of urban ecosystem services (e.g. Bolunda & Hunhammar, 1999; Gómez-Baggethun & Barton, 2013).

A variety of planning forms have been proposed in order to ally socio-economic and environmental benefits, including circular arrangements (green belts) and radial structures (green ways or wedges). The first have been extensively analysed, even within urban economics because it is abstractable in 1D. The second, although appearing early as well, have been more confined to specific cases in planning literature (e.g. the plan of Berlin by Eberstadt, Möhring, & Petersen (1910), the palm plan of Hamburg by Schumacher (1927), or the finger plan of Copenhagen) and are less widely considered as generic concepts (Frankhauser, 2015).

Beyond the access to, and spatial arrangement of, green and urban amenities, the last bit of Howard's quote above — *within a very few minutes' walk or ride* — holds a second key notion of urban planning theory: local proximity, in particular to amenities and services. This is a notion that we can trace back to another planning tenor, Clarence Perry, who in 1929 put the stress of urban planning onto spatially

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arranging *neighbourhoods* (Perry, 1929). He devised a series of principles — the so-called *neighbourhood unit formula* — to guide the (re-) development of cities with a focus on how best to locally arrange the different land use and human activities. At that time, 5 min walk or a 1/4 mile was considered an optimal neighbourhood size. Nowadays, a neighbourhood unit limit is rather to be seen as a spatial break between motorised and non-motorised transport modes.

Perry's work on neighbourhoods has been very influential in planning practice across the 20th century (see Rohe, 2009 for a review) and his arguments on walkability and short distances transpire today in Smart Growth, New Urbanism or Mixed Used Development concepts (e.g. Calthorpe, 1993; Duany, Plater-Zyberk, & Speck, 2001).

There have been lots of rich ideas and principles in urban planning on the spatial arrangement of green space and activities at the neighbourhood scale. Urban policy debates and discourses where urban sprawl is simply opposed to the compact city fail to reflect these ideas. The benefits of urban compactness have actually been challenged by many authors (e.g. Breheny, 1997; Echenique, Hargreaves, Mitchell, & Namdeo, 2012; Ewing, 1997; Fouchier, 1995; Gordon & Richardson, 1997; Hall, 2001; Neuman, 2005; Schwanen, Dijst, & Dieleman, 2004, to name but a few) and better remedies to sprawl need to be proposed. Beyond density, further considering the relative spatial arrangement of green and built land can potentially reconcile environmental sustainability and residential satisfaction.

Conversely to urban planners, who mainly devise principles from observation and practice, urban and geographical economists use simplified models where urban form is the outcome of micro-behaviour. Despite geographical simplifications, economists formalise preferences and satisfaction levels, and are well aware that households have contrasting tastes with respect to density: on the one hand, households enjoy central density and amenities, which can explain agglomeration (Glaeser, Kolko, & Saiz, 2001; Fujita & Thisse, 2013) and, on the other hand, also dislike densities (Henderson, 1982; Glaeser & Kahn, 2004) or value green space (Caruso, Peeters, Cavailhès, & Rounsevell, 2007; Cavailhès, Frankhauser, Peeters, & Thomas, 2004; Coisnon, Oueslati, & Salanié, 2014; Irwin & Bockstael, 2002; Wu & Plantinga, 2003), which are incentives to sprawl (Brueckner, 2000). With this in mind, urban density and patterns can be shaped similarly to the way it is portrayed in Howard's Garden City. For example, Glaeser and Kahn (2004):

> *There are two concepts which come together in the popular conception of sprawl: decentralization and density. Decentralization refers to the spreading of employment and population throughout the metropolitan area. Density refers to the degree to which employment and population are centred in high density living and working areas. In principle, there could be decentralized, dense urban areas.*

Obviously, however, the 1D framework of standard urban economics is not ideal to handle rich ideas on the spatial arrangement of activities in cities. Ogawa and Fujita (1989) were well aware of this in-satisfaction and attempted 2D urban models, but, for analytical performance, preferred geometric simplifications:

> *In the context of a two-dimensional city, the central issue is the spatial form of the city. […] Although the satisfactory theory would yield all possible urban configurations, it may be acceptable [...] to assume either circular symmetry or axial symmetry.*

In this article, we use a 2D microeconomic model for a growing city with no circular or axial symmetry assumption, but two perpendicular axes.[1] The resulting spatial arrangement is completely 2D, i.e. not extrapolated from a rotation or mirroring. Our model accounts for the ambivalent taste of households toward density through neighbourhood interactions. We embed those two features — green space and the neighbourhood scale — that are so important in urban planning theory but never quite integrated in microeconomic reasoning. Our strategy pays off by demonstrating how cities can grow more densely while preserving internal green space when households have the possibility to enlarge the neighbourhood in which they value this green space (as a view or for short walking trips). We also show that the size and form of the city, relative to the size and form of neighbourhoods, impact on the decision of households to leapfrog rural land or not, therefore impacting on the emergence of sprawl patterns.

Our findings, rather than being stated as planning principles, are grounded on theoretical microeconomic reasoning, are independent of exogenous spatial heterogeneities, and determined from both mathematical analysis and computer-based spatial simulations, which strengthen the arguments and link 2D patterns, bearing different possible arrangements of green space and built-up areas, with households' decision making and utility.

The article is organised as follows: in Section (2), we present and position the model in the literature; in Section (3), we analytically solve the problem of the existence of a leapfrog that disrupts the continuous development of a 2D city and discuss leapfrog length in relation to city size and neighbourhood size. In Section (4) we undertake simulations in order to understand the role of green space and neighbourhood size on gradually emerging 2D equilibrium patterns, and to assess the impact of changing the size of neighbourhoods. The conclusion wraps up and relates our findings to policy.

2. A 2D city with neighbourhood interactions

2.1. Literature and novelty of the model

In our model, households value green space and interact with other households within their neighbourhood. Spatial interactions have been introduced in urban economics since Beckmann (1976) and Fujita (1982), who set up distance decaying effects to formalise distance as an obstacle to interactions. Fujita (1982), chapter 6 presents a round-up of these models applied to firms. Irwin and Bockstael (2002), Wu and Plantinga (2003), Turner (2005), Caruso et al. (2007), Coisnon et al. (2014), Cavailhès, Peeters, Sékeris, and Thisse (2004) propose models applied to households, including green space externalities.

In 1D, Turner (2005) and Peeters et al. (2015) show analytical how leapfrogging can occur when households have a strong preference for green space and have bargaining power over many landowners. Caruso, Peeters, Cavailhès, and Rounsevell (2009) use 1D simulation to emphasize the time component of urban development with leapfrogs and infills. They also test for the effect of positioning a green belt as a zoning instrument to contain urban growth. Nevertheless, while 1D models are very attractive for their mathematical tractability, in the real world spatial interactions obviously take place in all directions, not just along the way to the CBD. 2D models have a much higher appeal for urban planning and can still be associated with economic interactions. Cavailhès, Frankhauser, et al. (2004); Cavailhès, Frankhauser, Peeters, and Thomas (2010) and Tannier, Vuidel, Houot, and Frankhauser (2012) are such examples of models with a 2D exogenous form.

Urban economic models with interactions that endogenously lead to 2D urban forms have also been proposed and analytically resolved by Fujita (1982) and Lucas and Rossi-Hansberg (2002), but both rely on a radial symmetry assumption. Without a symmetry assumption, Caruso et al. (2007) proposed a model where a variety of 2D sprawl patterns emerge endogenously from the conflicting taste of households for both social and green externalities in their neighbourhood. The approach relied on simulations — not analytical findings — and was further developed by Caruso et al. (2011) to account for the coinciding emergence of the road network, which is an important element of city form and allows for a better representation of transport costs.

[1] Two axes were chosen for simplification, but more could have been equally considered.