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Cybergeo : European Journal of Geography

Débats

Des preuves par simulation

Christaller, still alive!

ARNAUD BANOS, DIEGO MORENO, CYRIL PIVANO ET PATRICK TAILLANDIER

Cet article est une traduction de :

Christaller, toujours vivant !

Résumé

This paper—by means of an agent-based model called “LivingChristaller”—explores the possibilities for the emergence of the regular spatial organisation of the centres of production proposed by Walter Christaller for two distinct populations (the producers of goods and the consumers of these goods), and on the sole basis of the working hypothesis formulated by the author.

Texte intégral

- 1 In his brief work *“The self-Organizing Economy”*, the American economist Paul Krugman, winner of the Nobel Prize in Economics in 2008, proposes a mathematical model of the emergence of polycentric urban areas. More specifically, he focuses on the way office centres (which he calls ‘edge cities’, in reference to the work by J. Garreau) can appear in a metropolitan area. His model, taking its inspiration from equations of reaction-diffusion, makes possible the emergence of different periodic spatial structures, beginning with an initial homogenous situation. In doing this, Paul Krugman distances himself in a somewhat ostentatious manner from the classical studies in geography conducted around central places (notably by Christaller and Losch), which he considers to be more descriptive than explanatory in nature. For an economist, he tells us, a model is considered to be explanatory if it manages to put structures of a macroscopic order in relation to behaviours of a microscopic order. But according to him, in his work on the urban hierarchy, Christaller would not take into account the manner in which individual behaviours would be likely to produce the observed urban regularity in terms at once of location and of hierarchy. In the same way, again according to him, if Losch showed that a hexagonal structure of market areas was efficient, he did not show that it tended to emerge from a decentralized process.

2 This abrupt disqualification of classical works of geographical theory, by one of the founders of the 'new' geographic economy, obviously offers something to attract the attention of geographers and prompt them to question anew the foundational works of their discipline. The multidisciplinary Network MAPS (<http://maps.csresgistry.org/>), labelled by the National Network of Complex Systems (<http://www.ms.cnr.it>), has rightly set itself the goal of contributing to this vast enterprise. At the time of its last working session (MAPS3¹), several working groups were formed in this way and focussed on classical models, one of which was the "Christaller model." We propose here to explore, by means of a distributed computer simulation, the possibilities of the emergence of this regular spatial organisation of the centres of production² proposed by Walter Christaller for two distinct populations (producers of goods and the consumers of these goods), and solely on the basis of the working hypotheses formulated by the author:

- Geographical space is homogeneous (isotropic).
- The population and the resources are uniformly distributed.
- The consumers are identical and are maximisers.
- The prices are fixed, and no producer can achieve an excess profit margin (perfect competition).
- The cost of transporting urban goods is the responsibility of the rural consumer.
- The producers of services in the equivalent range are grouped together in the same centres.

3 A central place of level t also produces goods of an inferior level (in a system of depth 3 ($k = 3$): the places of level 1 will also produce goods of levels 2 and 3, while the places of levels 2 will only produce goods of levels 2 et 3, and the places at the bottom of the hierarchy will only produce the goods of level 3)³.

4 These simple hypotheses have important direct consequences when they are combined. Thus hypotheses 3, 4 and 5 imply that the consumers are going to minimize the transportation costs, and therefore favour the nearest central place (implication 1).

5 In adding principle 6, we get a limited number of producers supplying the nearest consumers (implication 2)

6 Adding principles 1 and 2 then leads logically to the fact that these producers will be spaced out in a regular manner (implication 3 and the final consequence).

7 The objective of the model *LivingChristaller* is precisely to verify the final consequence of this logical sequence, *a priori* infallible, on the sole basis of these hypotheses. The two categories of agents are mobilized: the consumers seek to satisfy their needs by stocking up on provisions from the nearest producer, while the producers seek to be located in such a way as to draw enough customers.

8 Initially, the consumers are divided up in a regular way (hypotheses 1 and 2). Then, in the same way that Christaller fixes a number of central places N_t^i and hierarchical levels K , according to a geometric progression $N_t^i = Kt$, the model generates 3 central places of levels 1, 9 central places of level 2, and 27 central places of level 3. These central places, which we name 'producers' in our model, are all positioned at random at the moment of their creation. In agreement with hypothesis 7, a producer produces goods of his level and goods of all the lower levels (on level 1, the producers produce goods of level 1; on level t , the producers produce goods for all the levels, 1 to K).

9 An iteration of the model, then, is composed of two stages. First, each consumer chooses, for each of the 3 categories of available goods, the producer who is the nearest (implication 1). At the end of this phase of allocation, each producer determines whether or not he is satisfied. In case of dissatisfaction, the producer

moves in space. The simulation comes to an end when all the producers are satisfied. (implication 1).

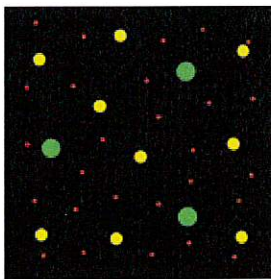
10 To evaluate the satisfaction of the producers, we follow hypothesis 4: the prices are fixed, and no producer realize an excessive profit margin. The producers are therefore satisfied as soon as they have a share of the market that is at least equivalent to the shares of the other producers of the same product range. Thus, in the case in which ten producers would share a consumers' market, each of them should draw at least 10% of the clientele, to be satisfied. The threshold of satisfaction S is thus defined by $S = (1 / P_i + a)$, with P_i the total number of producers of product i and a a variable of adjustment. The share of the market of a producer is defined by $m_i = c_i / C$, with c_i the number of consumers of the producer's goods, i et C the total number of consumers. The addition of the parameter a , when the constraint of equal distribution for the consumer is slightly relaxed, makes it possible to speed up the approach to a balanced position.

11 It was also necessary to define a strategy for re-locating the dissatisfied centres of production, a strategy missing in the initial model, which was fundamentally static.

12 In our model, each dissatisfied producer moves away according to the following rule: if the producer does not already find himself at the barycentre of his area of the market (the average in x and y of the coordinates of the consumers corresponding to the highest level of his aspirations), he moves towards this level in order to be as close as possible to his consumers. If he is already at this level, he moves in the direction of the producer at the same level who has the most consumers, in such a way as to 'take' some consumers from him. This last rule makes it possible to go out from the best places that can be formed when all the producers find themselves in the barycentre of their clientele. The model is stabilized when all the producers are satisfied.

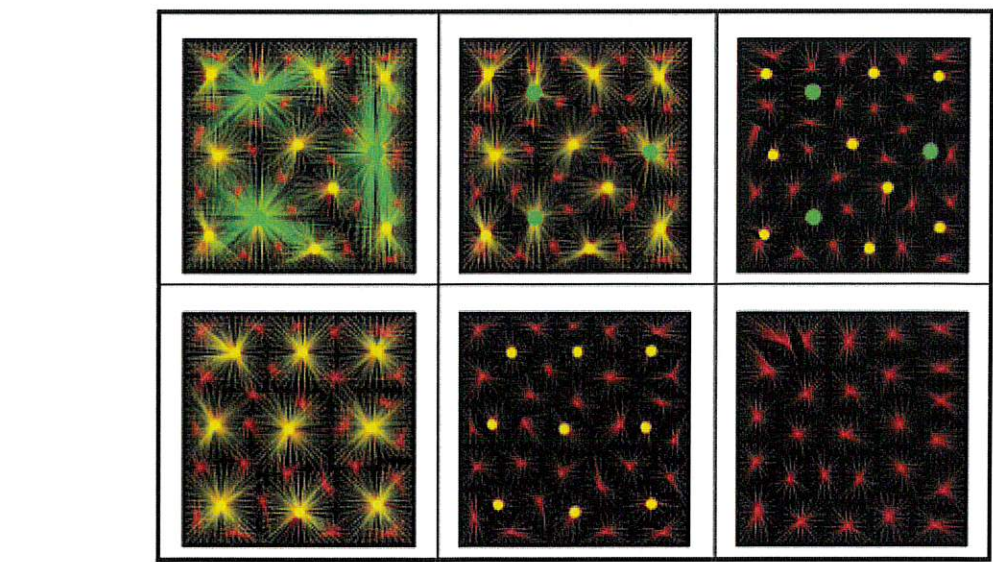
13 One of the first lessons to be drawn from the distributed computerized implementation of this model is that it is impossible to find the balance for a nil value of the parameter a . A second lesson, however, is that the spatial organisation of the most stable centres of production is indeed Christallerian in nature (figure 1). This structure has proven to be extremely robust.

Figure 1: example of a situation that is almost balanced



14 It is important to remember that in conformity with hypothesis 7, each centre of a higher level also produces all the goods of the lower level, which is illustrated in figure 2. The centres of level 2 (in yellow) thus possess 2 areas of the market, while the centres of level 1 (in green) have 3.

Figure 2: the places on the upper level are systematically in competition with all the places on the same or lower levels



15 This placing in competition of the production centres of different levels explains the forms obtained as a result of the simulations. In fact, in order for the producers to be satisfied, they must be separated by a sufficient distance from the other producers at the same level, thus enabling them to have access to a suitable market area. As a result, the weaker the share of the market asked of the producers, the more the distances between the producers can be reduced. As for the producers at the higher level, they must find a position that assures them of an acceptable share of the market for all the levels of goods. They must therefore find a position that is at a sufficient distance from the other producers on the same level, but which can be nearer to the centres of the lower level. This rule of functioning (hypothesis 7) plays a decisive role in the emergence of spatial structures that issue from the *LivingChristaller* model.

16 It will be noted that this model does not exactly reproduce the perfect hexagonal structures predicted by Walter Christaller. It does, however, make it possible to show that the behaviour of consumers and producers, as it is described by Christaller beginning in the 30s, tends to self-organise space in a regular and hierarchical manner. The Christaller model can no longer be considered a simplistic geometric description of geographical space. To the contrary, the hypotheses formulated by Christaller are sufficient to bring out the regular spatial structures starting from individual, uncoordinated but interdependent interactions. In this sense, the Christaller model is definitely an explanatory model...and it remains highly topical and useful today.

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Notes

1 For more information, see <http://maps.csregistry.org/tiki-index.php?page=MAPS-3>

2 Let us remember that in the central places theory, the cities (defined as central places) are essentially considered as purveyors of goods and services to the surrounding countryside.

3 This redundancy between the goods produced by centres of different levels is a fundamental characteristic of Christaller's theory of central places. Losch later dropped this constraint, in authorizing the possibility of specialized central places.

Table des illustrations



Titre Figure 1: example of a situation that is almost balanced

URL <http://cybergeo.revues.org/docannexe/image/24878/img-1.png>

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Titre Figure 2: the places on the upper level are systematically in competition with all the places on the same or lower levels

URL <http://cybergeo.revues.org/docannexe/image/24878/img-2.png>

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