Cybergeo : European Journal of Geography

Systèmes, Modélisation, Géostatistiques

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Référence électronique
Clarice Maraschin et Romulo Krafta, « Growth dynamic of retail locations: a methodological approach using a logistic model », *Cybergeo : European Journal of Geography* [En ligne], Systèmes, Modélisation, Géostatistiques, document 650, mis en ligne le 02 août 2013, consulté le 09 août 2013. URL : http://cybergeo.revues.org/26002 ; DOI : 10.4000/cybergeo.26002

Éditeur : CNRS-UMR Géographie-cités 8504
http://cybergeo.revues.org
http://www.revues.org

Document accessible en ligne sur :
http://cybergeo.revues.org/26002
Document généré automatiquement le 09 août 2013.

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Introduction

1 Retail trade is a vital part of the economy and structure of contemporary cities. The presence of a diversified commercial hierarchy is a factor of status and prosperity for cities. Moreover, the population's access to trade stores is considered a key indicator of quality of life in cities. The organization of the retail sector has explicit spatial consequences. Commercial activity is an essential component in the formation and ranking of urban and regional centers (Christaller, 1966; Berry, 1967.) The known tendency of agglomeration of retail establishments in clusters shows a locational strategy that aims to enhance their business (Nelson, 1958; Arentze, Oppewal and Timmermans, 2005). The spatial distribution of retail reflects the overall demand conditions, i.e., the density of the population, purchasing power, spending habits and the ease of access. At the same time, the presence of a commercial agglomeration affects the development of its surroundings, which can generate real estate appreciation, attracting other services, employment and urban facilities, also promoting residential densification, infrastructure improvements, and jams, among other effects. According to Longley et al (2003:213) the ratio of retail to the city can be thought of as a co-evolutionary process in which changes in the internal structure of retail organizations affect the environment and this, in turn, influences changes in the retailing structure. Since retail is an activity essentially focused on the demand, the failures in this activity relate primarily to a lack of response, or a very slow response, to changes in the environment (Longley et al, 2003).

2 This dynamic would then be an inherent characteristic of retailing. In terms of urban space, this dynamic is reflected in the continuous emergence of multiple formats and types and also in different locational strategies. Commercial areas will arise and develop, and over time will compete with others that are more efficient in meeting consumer needs. At first, the emergence of new trade centers within the city can be triggered by different factors: the concentration of population in a new area of the city, the opening of new streets, the location of some pioneer business that will attract others, the deployment of a large equipment attractor, such as a shopping center, etc. From its initial formation, the commercial areas may have a faster or slower rate of growth. Moreover, these areas can house a large number of premises or stabilize with smaller amounts. Empirical evidence indicates that some commercial areas reach a level of saturation before others, growing strong for longer periods of time with respect to the evolution of the city.

3 A permanent dynamic of the relationship between retail centers and urban space creates different challenges to its understanding. There are theoretical difficulties in identifying the rules that guide the evolution of the retail system and the possibilities of controlling the movement of trade centers. For the retailers there is the risk of an inappropriate locational decision, which is difficult to reverse. (Longley et al, 2003:213).

4 This raises the importance of studies that address the dynamic of growth of retail centralities in urban spaces. This paper presents a proposal to model the growth dynamic of commercial locations in urban areas over time. We propose the adaptation of a logistic model, a nonlinear dynamic model, originated in studies of population ecology, used to describe the dynamic of growth in environments with limited growing capacity. This work adopts a deductive approach, proposing a theoretical and methodological argumentation about modeling and, in addition, develops an empirical application in order to obtain a preliminary validation with real data from a city. Model application is developed in four areas in the city of Porto Alegre, Brazil, considering data of the number of shops during 23 years, from 1983 to 2006.

5 This paper is organized into four sections. The following section provides a theoretical framework, including a brief review of theories and models of retail location, and also the phenomena of its growth and diffusion. In section two, a methodology for modeling is outlined. Strategies are outlined, the proposed model is presented and its main features are discussed. The third section deals with the empirical validation of the model. We present the empirical data related to commercial business in the city of Porto Alegre, as well as the application of the model and its main results. Finally, the last section presents the main findings and conclusions of the potential and limits of the proposed model.

Theoretical framework of analysis

6 To address the problem of retail growth in urban areas, concepts and approaches of two distinct areas should be brought together: theories that treat spatial features of retail and those referring to growth and diffusion phenomena. Considering the extensive literature on these issues, a short summary is presented below, which will serve as a framework for more direct references to the model.

Retail and urban space

7 The relationship between commercial activity and urban space has long been treated in the field of urban geography. Christaller (1966) and Berry (1967) analyze the trend of trade activities and services to cluster in the same area, forming different hierarchized centers. According to this approach, consumers seek a trade center that allows them to purchase products with minimum effort (shortest distance). Thus, the formation of trade and services nuclei with different hierarchies allows the consumer to decrease traveling distances. For frequent purchases, consumers chose short-distance places, but for less frequent purchases, there may be a willingness to go to more distant places, visiting centers with a greater variety of goods and services. Berry points out that, within the metropolis, factors such as population density, the price of urban land and accessibility influence the spatial distribution of trade centers, the size of their areas of influence and their specialization. Therefore, the social-spatial differentiation of cities ensures that there are places which are more favorable to the growth of trade centers in terms of quantity (number of establishments) and quality (diversity and/or specialization of establishments).

8 When the subject is location, there is a vast bibliography about spatial variations in demand and supply of retail activity – some publications of the 1980's are references in this area (Guy, 1980; Dawson, 1981). Location is considered an important factor to the long-term success of a firm, along with other aspects such as retail image and mix, service level, size of the shop, among others (Mejia and Benjamin, 2002). For some authors, the store location may be considered the most important determinant of success. A good location provides the firm with some strategic advantages that competition may find difficult to overcome (Gosh and Craig, 1983). While other marketing mix elements may be easily modified in response to a changing environment, store location represents a long-term investment that can be changed only at considerable costs. Even if we consider a number of transformations in the retail environment, such as the growing mobility of consumers, the increase of e-commerce, changes in the size of families, economic concentration, saturation and changes in urban legislation – even then, the problem of location is still considered extremely important for all types of retail (Birkin, Clarke and Clarke, 2002; Mendes and Themido, 2004).

9 Several models have been developed in order to determine the best location of a store. Among them, the best known are the gravity models and the spatial choice models (Huff, 1962; Lakshmanan and Hansen, 1965). The most important variables in these models are: the distance or traveling time between the store and the consumers; a measure of the size or attractiveness of the store; and the location of the competitors. Over time, such models received countless upgrades (see Brown, 1992 for a good review), generating a very fertile investigative line.

10 Another factor that affects the success of a retail firm and is related to location is spatial agglomeration. The retail clustering, both of similar or complementary types, whether planned or not, has a direct influence on shopper behavior. The agglomeration of several stores in

a single space brings advantages to consumers, such as multipurpose shopping, comparison shopping and the reduction of time and transportation costs (Eppli and Schilling, 1995). In this sense, agglomeration is recognized as the attempt made by retailers to reduce consumer search costs (Gabzewicz and Garella, 1987; Wilde, 1992). Studies have shown that the agglomeration of stores of different types and sizes positively influences consumer choice, not only in the case of multipurpose shopping, but also in the case of single-purpose trips (Arentze, Oppewal and Timmermans, 2005). According to these authors, several mechanisms may underlie this fact. The agglomeration of stores is generally part of larger centralities, enabling consumers to combine shopping and other activities, such as workplaces and leisure or transport facilities, creating other types of multipurpose trips. The agglomeration of stores determines habits of purchasing and familiarity, attracting the consumers to all kinds of shopping - even those with a single purpose. Besides, the diversity of stores may contribute to the overall pleasantness of the shopping environment.

11 One issue which is important for this work and is related to the development of retail business is the idea of saturation. Guy (1994a) states that the term *saturation* in retailing suggests that there is a maximum possible number of lucrative stores within a consumer market. Saturation is said to occur when new store development has reached a certain level above which any further store will not be economically viable, since it will not be able to achieve sufficient share of the local market – unless this occurs at the expense of the closure of some existing stores (Guy, 1994a: 3).

12 In the case of the United Kingdom grocery industry, Guy notes that the great food retailers (Sainsbury, Tesco and Safeway) have been using some strategies - such as the reduction of the size of the stores and the increase of the range of goods sold - in order to increase their share in the amount of spending of the local populations. In this sense, saturation should be examined at a local level rather than a national or regional one (Guy, 1994 b: 136).

13 The author mentions an attempt to describe the process of general saturation of local markets with multiple grocery stores (Guy, 1994a). Such a process would involve four stages: introduction, expansion, characterization and rationalization. In the introduction stage the developing of a superstore (hypermarket) occurs, which captures a proportion of the local market for grocery products. Expansion involves the development of new stores of the same chain, capturing further amounts of local expenditure. The stage called characterization would occur after this area has become saturated with this type of superstore. At this moment, the retailers would try to tailor their stores to particular characteristics of the local catchment. This adaptation can include the refurbishment of the existing stores or even new development of stores in more central areas, near employment zones and other business. Finally, the stage of rationalization involves closures or repositioning of the food stores which exceed the needs of their local catchment. The opening of new stores does not occur at this stage, except of those which will replace the existing ones.

14 Other authors (Langston, Clarke and Clarke, 1998; Poole, Clark and Clark, 2006) relativize the notion of saturation, noting that the great British food retailers have been increasing their participation in the market. This fact indicates that saturation does not have a unique and fixed parameter. Even with the stability of the United Kingdom's population growth, both the distribution and the social composition of the population are strongly changing, creating opportunities for new stores. Retailers are attentive to these facts and are able to manage the saturation, modifying the type and the size of stores, as well as the variety of supplied goods. Thus, saturation presents both quantitative and qualitative aspects, and there are still few studies about this process.

15 In this study, we assume the notion that the quantitative growth of core business is not unlimited. As Berry points out, the urban spatial structure itself restricts the growth of trade in these spaces, while social-economic and spatial factors limit the number of establishments. This limit may be due to factors such as a demand that has been completely met, the unavailability of areas/land for the business location, legal restrictions and zoning, deterioration of accessibility, among others. It must also be highlighted that the saturation of the aggregate amount of stores does not mean stagnation in a qualitative – or even spatial –

point of view. The fact that an area has reached saturation in the aggregate number of stores does not eliminate the dynamic of another nature. For example, some types of stores may have been replaced by others; old stores may have been demolished and replaced by new formats; new business streets may appear in a certain area, at the same time that former shopping places are eliminated. What we mean by this is that the equilibrium or saturation in the quantity of stores may have a very dynamic qualitative and spatial expression.

16 Still on the issue of business dynamic, we observed that the theme of retailing transformations have been studied based on different approaches, for example: changes in the economy and in the market; the social impact of the new retailing typologies; and the role of social-political and cultural factors in the retailing modernization process (Péron, 2001). Another approach, which is more specific, is based on models of evolution of the retail structure of cities (Harris and Wilson, 1978; Clarke, Langley and Cardwell, 1998). These models are based on gravitational principles and spatial interaction.

17 Several works have explored the theme of spatial dynamic of retail development using new technologies (Benati, 1997; Lombardo, Petri and Zotta, 2004; Penn and Turner, 2004; Huang and Levinson, 2011). Lombardo et al (2004) proposed the use of a hybrid model that combines a spatial interaction model with agent-based models, aiming to simulate the growth of shopping areas. This model is characterized by three key components: the environment in which the agents operate, the agents (including their pre-defined goals and choosing procedures) and the mechanism of interaction, which defines the evolution of the system. The model considers only two agents (consumers and retailers) that interact in an environment (interconnected cells at different distances from each other). Generally speaking, retailers make location decisions so as to maximize profit. The consumers, on the other hand, seek to meet their needs and desires, trying to minimize costs and disadvantages. The ultimate decision of location by the retailers is mediated by his/her perceptions of the environment, the communication obtained, and also by his/her own characteristics and abilities (Lombardo et al, 2004). Decisions taken by agents affect the environment itself and the decisions of other agents. Despite being an extremely simplified model, it encompasses the emergence of macroscopic spatial patterns (trade growth in a cell, for example) from the interactions of agents at the micro level.

Growth and diffusion phenomena

18 Theories focused on the dynamic of growth and diffusion of social-spatial phenomena began about 200 years ago, in the works on population growth developed by Malthus (1798) and Verhulst (1838).While Malthus developed an exponential growth model, Verhulst proposed a logistic equation, which included a growth limit for the population. The applicability of the logistic model is extremely broad, encompassing such phenomena as the spread of diseases, the diffusion of technologies or the growth of plants (Banks, 1994). An application of the model for the analysis of urban dynamic was developed by Allen (1997), where the author tried to show how the macroscopic pattern of a hierarchy of cities and settlements result from the aggregate effect of individual decisions (Allen, 1997; Allen and Sanglier, 1981). One of Christaller’s findings (1966) is that the spatial and hierarchical relationships between cities reflect the interaction of economic forces, where major economic centers have many functions while small centers have few. In the model proposed by Allen, the urbanization of a region is a result of the successive integration of economic innovations (the emergence of an exporting function) introduced in the system at random places and times. It considers that, as the different centers grow and compete, there is an evolution of the means of transportation and communication. The population distribution reflects the number of jobs presented in different locations and is controlled by a logistic model. Batty (2005) also applies the logistic equation to represent the phenomenon of city spread in a simplified model. The author makes an analogy between the process of land conversion (from non-urban into urban) and the idea of an individual becoming infected with a disease and then recovering (Batty, 2005:389). Thus, the process of land conversion resembles the spread of an epidemic and is based on the logistic model.

19 In the studies of growth, the *diffusion of innovations* theory (Hägestrand, 1967; Rogers, 1975) constitutes a specific field that analyzes the spread of phenomena in time and space. As a hypothesis, the growth of retail locations in urban areas could also be thought of as the diffusion of an innovation: new commercial areas that could be adopted by retailers. In this sense, some concepts and procedures of this theory were reviewed. An innovation (idea, practice, or object that is perceived as new by an individual or enterprise) spreads through a process of communication between agents. The attributes perceived in an innovation are considered as important explanatory factors for its rate of adoption. The greater the perception of relative advantage of an innovation, the faster it is adopted.

20 Communication is the process by which participants create and share information with one another in order to reach a mutual understanding (Rogers, 1995:17). Diffusion is a particular type of communication in which the content of the message exchanged holds a new idea. The essence of the diffusion process is the information exchange through which one individual communicates a new idea to another or several others. Most people depend mainly on a subjective evaluation of an innovation that is conveyed by other individuals who have already adopted the innovation. This dependence on the experience of peers suggests that the heart of the diffusion process consists of the imitation by potential adopters of the network of those who had previously adopted the innovation. Thus, diffusion is a highly social process (Rogers, 1995:18).

21 Diffusion involves the characterization of a diffusion rate, reflecting the speed at which an innovation is adopted by individuals. The adoption of an innovation usually follows a normal curve of frequency distribution over time. Considering the cumulative number of adoptions, the result is a curve in the shape of an "s", this being its typical representation. This curve involves three stages: an initial stage of slow diffusion, followed by a faster spread and a final one, when the innovation reaches a point of saturation or equilibrium.

Methodology for modeling

Study Scope

22 The main hypothesis of this paper considers that the logistic model is able to describe and analyze the dynamic growth of retail locations in urban areas. This model is dynamic, that is, it is focused on the process of growth of the number of retail locations (retail units), rather than on the final equilibrium or stability. The temporal dynamic is explicitly modeled, whereas the spatial dynamic is only implied, treated within the urban sectors studied. This does not intend to belittle the problem of spatial description, which is a central concern in urban models, it is a mere segmentation that will enable a first approach, from which the analysis of spatial patterns would be included. Thus, the analysis done here is not linked to a specific spatial distribution or pattern, such as poles, corridors or isolated stores. It deals with the amount of existing retail establishments within the defined urban areas for analysis.

23 The model addresses only the quantitative growth of commerce and the variable *quantity of retail units* was adopted as an indicator of the retail locations' growth. Other indicators could have been chosen, such as the turnover of the stores or the sales area. The advantage of adopting the quantity of retail units is that it better represents one model assumption: *all retailers have homogeneous access to information on the growth of retailing in the area* (see item *Retail Location Growth Model*). The number of stores is an available information in the space of the city itself, one that is accessible to everybody. On the other hand, one has to be careful when interpreting the results. To consider only the quantity of stores has the inconvenience of standardizing all the establishments and not revealing more qualitative aspects of growth.

24 The model can be considered one of aggregated dynamic, as it simulates the behavior of retailers as a whole, but does not explicitly model their individualized actions, which approximates it to the approach practiced by Allen (1997). Therefore, in the present paper, the term *growth of retail locations,* or *growth of trade,* will always refer to quantitative and temporal aspects: number of shops, growth rates, instant of maximum growth, and long-term balance. The model is seen as a tool for collecting knowledge about the problem, allowing an analysis of the process of quantitative growth of these retail locations, as well as their main

features and attributes. Finally it is important to emphasize that this work does not intend to develop a comprehensive analysis of the growth of trade in the city of Porto Alegre, through its historical process. The city is considered here mainly as empirical basis aiming to develop and test the growth model.

Strategies for modeling

25 Urban theories point out a general trend of retail establishments to agglomerate, leading to different clusters or centers. This process is caused by different factors, such as: a reduction of consumer travelling distances (Christaller, 1966), comparisons between stores and a reduction of the uncertainty of finding a desired item (Eppli and Benjamin, 1994), cumulative attraction (Nelson, 1958). In these centers, retail tends to grow quantitatively, due to these location advantages. However, this quantitative growth does not go on forever, it is limited. Urban spatial structure imposes restrictions on retail growth (Berry, 1967) both locally, in the form of limited offer of locations in each center, and globally, by limiting the total amount of shops, consumers and locations. These restrictions can result from existing retail fully meeting demands, the unavailability of areas for retail location, zoning restrictions, problems in accessibility, among others. Batty (2008) identifies these situations as positive and negative *feedbacks*, the former tending to accelerate growth and the latter tending to slow it down. In this sense, a proposed dynamic model of retail location growth must include both accelerating and deterring forces of growth.

26 The location of retailers in specific places of the city is a process that occurs in a decentralized fashion, with decisions taking place in time and space. According to Fujita (1989), in most western societies, land use is defined primarily through the market, with a greater or lesser presence of public regulation. Therefore, in such societies, the existing urban spatial structure is the product of millions of actions that individuals have adopted in the past. One might suspect that the outcome of such uncoordinated individual actions would be chaos. However, the history of science suggests the opposite: the larger the number of individual actors in a system, the stronger the regularities it will display. (Fujita, 1989:2). The model presented here assumes precisely this type of decentralized decision-making by retailers. Our interest here is to study the aggregate effect of decisions made by individual retailers. It is important to note that location advantages or disadvantages are not a value in themselves; they make sense through the perception of agents, in this case, retailers who consider opening a shop. Retail location dynamic results from the decisions of many retailers, acting through their own perceptions, without a central coordination. Accelerating and deterring forces of growth, emanating from urban spatial structure, go through a sort of filtering process: the way agents perceive and interpret the environment.

27 Considering that the growth of retail locations in urban areas has similar characteristics to the diffusion of an innovation (Rogers, 1995), we could characterize “innovation” as different shopping areas that can be adopted by retailers in a city. Each retailer that considers opening a shop (“adopting” a retail area) must make a location decision involving some degree of uncertainty. The model assumes that these decisions are not independent from others and there is a communication effect between individuals. A process of decision making is simulated in which the locational behavior of the agents is influenced by the decisions of others. The answer depends on the interaction with an environment that is changing, therefore the responses vary, in other words, are not linear.

28 The communication of all the information takes place through the retailer’s perception of environment. The model presupposes that all relevant information needed to make a location decision is public and available. This information manifests itself on urban space, and refers to the number of existing stores in addition to household income, density, available spaces, etc. This information also implies retailers making an estimate of the probable level of saturation in each shopping area. We can argue that, the greater the number of retailers adopting a specific location, the greater the reduction of uncertainties and risks for those who have not yet adopted that location, and the greater the imitation (contagion) expected, until the saturation level is achieved. It is important to mention that this decision will depend on the agent’s willingness

to take risks, adopting a specific location. Individual behavior will have a strong component of imitation and the aggregate behavior will present regularities.

Logistic Model

29 As mentioned before, a logistic model was originally posited by Verhulst (1838), in his pioneer work on limits to population growth, and is defined by the following differential equation:

$$\frac{dN}{dt} = aN \cdot \left(1 - \frac{N}{N_*}\right)$$

[1]

30 [1]

31 Where:

N = magnitude of a growth quantity

t = time

a = intrinsic growth coefficient

N_* *= carrying capacity, "ceiling" or maximum value that N will assume*

32 In this equation, the quantity

is termed growth rate for *N*. We identify the expression *(a.N)* as related to growth acceleration, in direct proportion to the existing quantity *N*, and the expression

33 to growth deceleration, which increases as *N* approaches N_*.

34 The solution for differential equation [1] is:

$$N = N_*\left[1 + \left(\frac{N_*}{N_0} - 1\right)e^{-at}\right]^{-1}$$

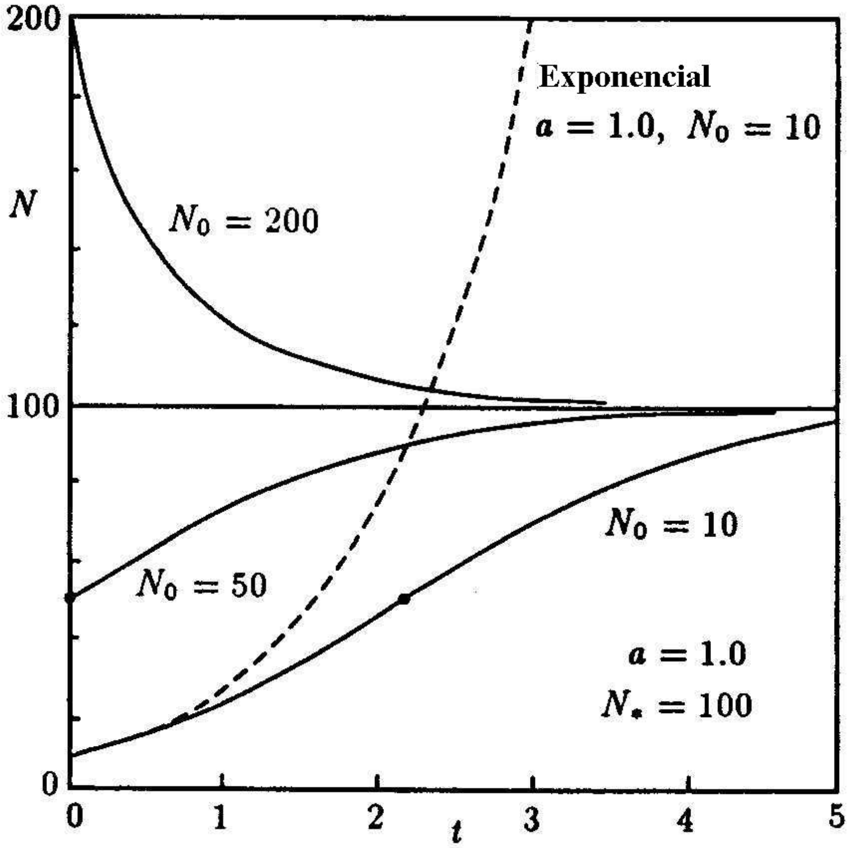
[2]

35 [2]

Where N_0 is the value for *N* at time $t = 0$.

36 Figure 1 presents the plot (*N x time*) for a family of logistic curves where $a=1.0$ and $N_*=100$, showing some of the possible solutions for various values of N_0 .

Figure 1 - Plots of logistic equation for various values of N_0.



Source: Banks, 1994, pg. 30

37 In Figure 1, three curves are shown for which $a=1.0$ and $N_*=100$. The values for N_0 are respectively: 10 (in the lowermost curve), 50 (in the middle curve) and 200 (in the uppermost curve). Substituting these values into equation [2], produces the familiar S-shaped curve associated with the logistic distribution. For large values of time, the curves approach the carrying capacity, $N_* =100$. For comparison, the dashed curve shown in Figure 1 is the exponential equation (Malthusian growth equation).

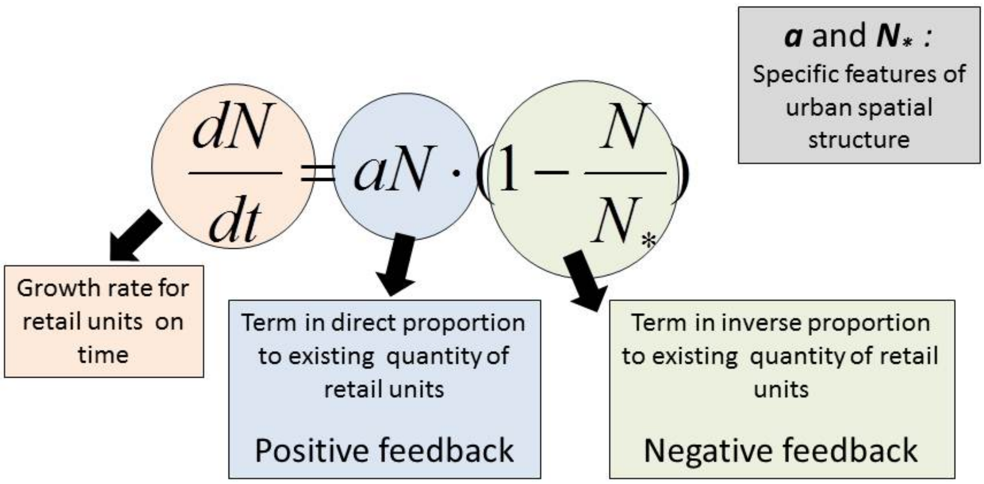
38 To fit a logistic curve into existing data, the numerical values of the three parameters must be determined: *a*, N_0 *and* N_*. In many problems, the value of N_* (maximum value that *N* will assume) is not known. The value of the growth coefficient *(a)* is also unknown.

39 There are numerous computational procedures to determine the values of the three parameters of the equation (Banks, 1994:46). In this work, we employed the *finite difference method,* which is a straightforward procedure using the straight line equation to support calculation[1].

Retail Location Growth Model

40 The proposed model of retail location growth is then presented as a logistic differential equation, in accordance with the guidelines already stated. Figure 2 defines the interpretive framework adopted for the case study.

Figure 2 - Interpretive framework of logistic model to represent dynamic of retail location



41 As mentioned above, the model assumes a decentralized process of individual location decisions made by retailers and constrained by the decisions of others. Such decisions interact on a changing environment, thus, the answers also change. Each agent observes the number of existing shops – represented by *(N)* in the model; the urban features of the area (household income, population density, available spaces, accessibility, legal incentives, etc.) - represented by *(a)* in the model; and make an estimate on the probable level of saturation in the area – represented by
in the model.

42 Several assumptions underlie the growth model stated above. The first assumption is that the growth in the number of retail shops in an urban area is limited by the maximum capacity *(N_*),* which remains constant over time[2]. It is therefore a fixed and finite value that can be estimated. The value of *(N_*)* depends on the features of urban spatial structure. The number of retail shops (*N*) tends to *(N_*),* that is, in some instant in time, any area will reach its saturation or equilibrium level in the number of retail establishments.

43 The intrinsic growth coefficient *(a)* is assumed to be a positive constant. From the analysis of logistic equation we obtain *($a = 1/t$).* The inverse of *(a)* represents a *characteristic growth time* of the system from its initial state to saturation (Banks, 1994:289). Because this model assumes that *time* is always positive, (*a*) should therefore always be positive[3]. This coefficient *(a)* is dependent on the features of urban spatial structure and influences the rate of retail location growth in the area.

44 The growth rate in number of retail establishments in each area (*dN/dt)* depends not only on the number of existing shops, but also on the proportion of the maximum number of shops that have still not been implemented (distance to ceiling *N_*).* In decision-making processes of opening a retail establishment in a particular area, all retailers make their decision taking into account their peer's decisions (imitation). All retailers have homogeneous access to information on the growth of retailing in the area, which is necessary for the decision. Finally, the geographical limits of the social system do not change during the course of the growth process, being confined to a single geographical area.

Model Application: Retail Growth as Logistic Path

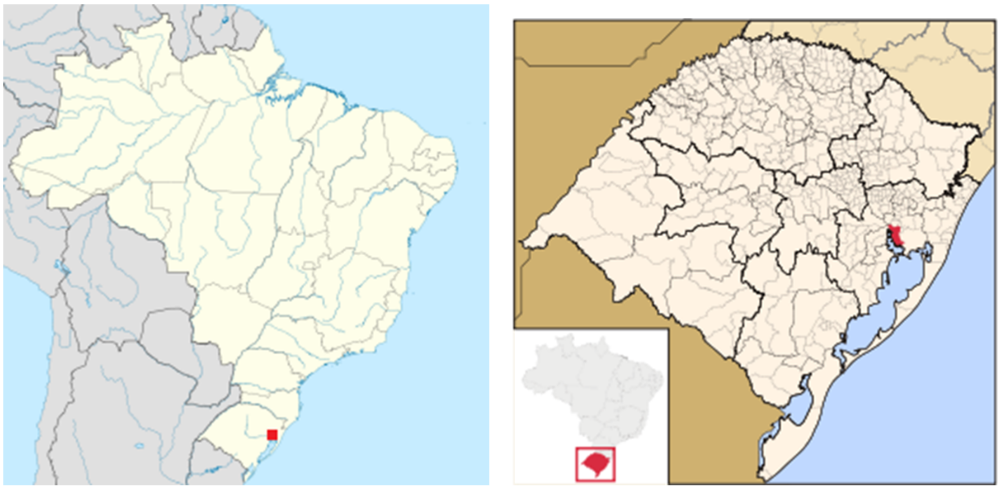
45 This item develops an empirical application of the growth model proposed. The objective is to perform an initial validation and also to illustrate the usage of this mathematical model in an empirical case.

The empirical case: Porto Alegre

46 Porto Alegre is located in southern Brazil (Figure 3), capital of the state of Rio Grande do Sul, with a population of 1,409,351 inhabitants (2010 Census), the tenth most populous city in the

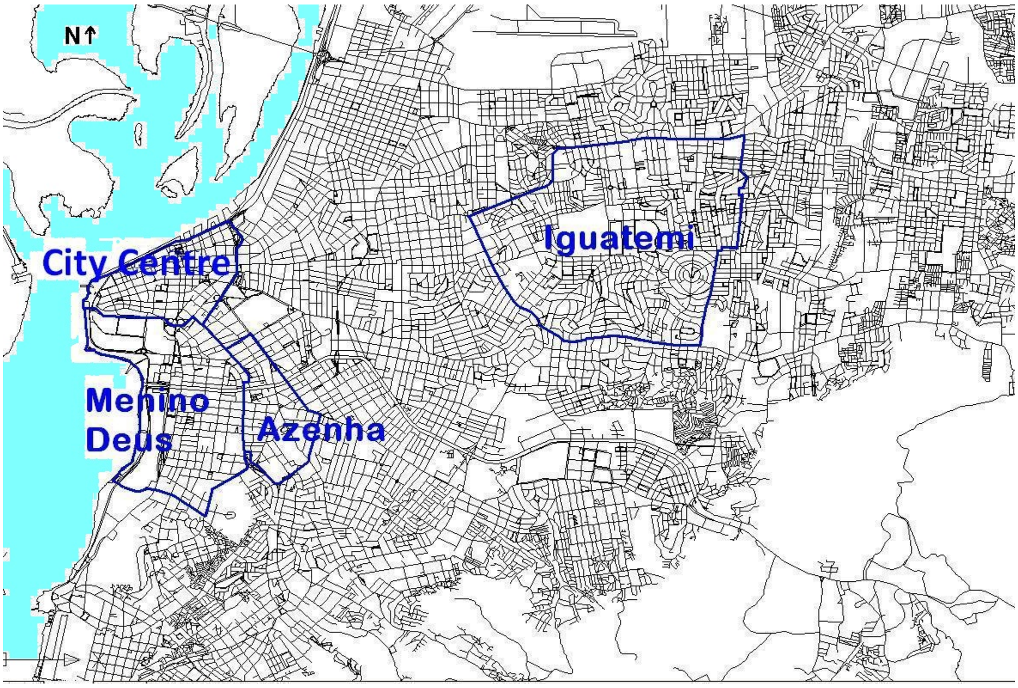
country. Porto Alegre was founded in 1772 by immigrants from the Azores, Portugal. In the late 19th century the city received many immigrants from other parts of the world, particularly Germany, Italy, and Poland. The city lies on the eastern bank of the Rio Guaiba (Guaiba Lake), where five rivers converge to form the Lagoa dos Patos (Lagoon of the Ducks), a giant freshwater lagoon navigable by even the largest of ships. This five-river junction has become an important alluvial port as well as a chief industrial and commercial center of Brazil. At present the economy of Porto Alegre consists mainly of the tertiary sector, which represented 71% of the Gross National Product of the city in 2009, while the industrial sector accounted for only 12% in the same year[4] . In 2009, the city had 71,031 service outlets and 37,470 retail establishments[5].

Figure 3 - Location of Porto Alegre in Brazil and in Rio Grande do Sul



47 The model was applied and validated in four distinctive areas in the city of Porto Alegre: City Centre, Azenha, Menino Deus and Iguatemi. Figure 4 illustrates these four areas.

Figure 4 – Location of the studied areas in Porto Alegre, Brazil



48 The basic criterion for the choice of the four areas for this study was to include a variety of urban situations. The purpose was to test whether the model was strong enough to respond to different scenarios and business processes within a city. Table 1 presents a comparison between the four study cases in terms of area *(ha),* number and density of stores, population

density and average household income. In the last line, it also presents the overall totals for the city of Porto Alegre, in order to contextualize the study[6].

Table 1 - Comparison between the studied areas.

Area	Acreage (ha)	% of total acreage	Number of Stores (2006)	% of Stores	Density of Stores (stores/ha)	Population Density (inhabit./ha)	Average Income (2000)
City Centre	221.60	0.73	4,239	12.15	19.12	169.61	12.70
Men. Deus	416.60	1.38	1,324	3.79	3.17	98.86	13.96
Iguatemi	1,012.40	3.36	2,919	8.36	2.88	77.28	13.57
Azenha	173.80	0.57	770	2.20	4.43	99.72	12.29
P. Alegre	30,081.90	100	34,880	100	0.71	28.55	10.47

49 The data show that, in Porto Alegre, retail trade is decentralized in quantitative terms: only 12.15% of all retail establishments are located in the City Centre. This area has the highest density of shops and people, but the average income of the population is lower than that of the two residential neighborhoods studied (Iguatemi and Menino Deus). Iguatemi has the second biggest number of shops, containing 8.36% of the establishments and has the largest physical surface and the lowest density of population and establishments. This is an area of recent occupation, which was largely urbanized from the 1980s on. The case of Azenha is a noteworthy case since this area has received strong legal incentives. In the Master Plan of 1979 it was projected to become the most important pole in the city, only behind the City Centre. The area currently has a high density of shops, but represents only 2.2% of establishments in the city. Azenha has the lowest average income among the four studied areas. In the Menino Deus area, the population density is just over half (58%) of that of the City Centre, but the average household income is the largest among the four areas studied, a fact that certainly contributes to ensure it have 3.79% of the amount of total number of shops in the city. The analysis revealed that the City Centre is still extremely vital in terms of number of stores.

Empirical Data on Retail Shops

50 In this work, growth of *retail location* will be represented by a variation in the *number of existing retail shops* in time. We will consider data on address and number of retail units through a temporal period of 23 years, from 1983 to 2006. There were many problems in obtaining this time-series data, leading to the adoption of two primary data sources in this research. The first was JUCERGS *(Junta Comercial do Rio Grande do Sul)* – a state board of Trade, for the period from 1983 to 2002; the second source was the CEE database *(Cadastro do Estabelecimento Empregador - Ministério do Trabalho e Emprego - MTE)* – Federal Bureau of Labour, for the period from 2003 to 2006.

51 The strategy of combining these two data sources was the solution to overcome the limitations that both presented. The JUCERGS database contains records of all retailer active (but not necessarily all records are real firms). The number of records tends to be higher than the actual amount of active firms, since there are records of firms that fail to materialize and those related to closed firms that did not apply for their exclusion from the registration list of the Commercial Registry. On the other hand, data from the Federal Bureau of Labor (MTE, in Portuguese) are based on an annual and obligatory declaration (RAIS[7]) from all establishments within the national territory. This is a database of higher quality because it constitutes a kind of corporate annual census, which covers more than 97% of the formal universe (MTE RAIS, 2007). However, the specific data containing the addresses of the companies are considered classified by the Bureau and therefore access to it is extremely limited and bureaucratic. Data for the years prior to 2003 were not provided.

52 For the initial years (1980 to 2002), the data from the Board of Trade was used. At the beginning of the series, the number of firms is small, which means that the effect of the accumulation of potentially inactive companies tends to be lower. For the final years (2003 to 2006), the CEE database (MTE) was used since it is a database of better quality. It should be noted that the data refer to formal enterprises classified in the *retail*[8] category; therefore, it does

not include informal trade (street vendors). Both databases provided the list of all businesses in the city and its address, but only the Commercial Registry database gave detailed specifications of the type of retail activity of each company. Because of this, it was not possible to deal with the classification of types of trade. Another aspect worth mentioning is that the addresses of the companies had to be checked one by one as to the location in the neighborhoods for all the years considered in this study. This fact hindered the inclusion of more districts in the analysis.

Model applications: neighborhoods in Porto Alegre

53 The process of fitting the model to empirical data involved several stages, where the equation parameters were determined for each case. Figures 5 - 8 show the result of applying the model to the four studied areas.

Figure 5 - Curve of *N* (cumulative number of retail units), comparing empirical data and modeled values, in City Centre

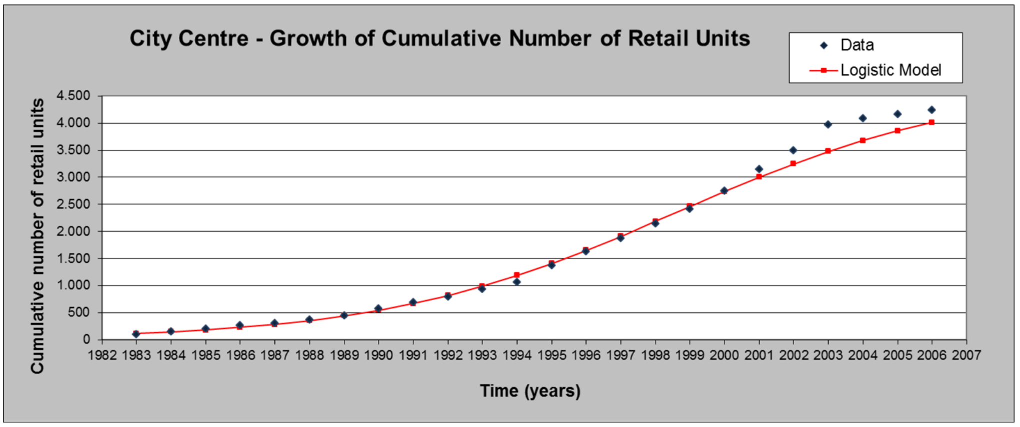


Figure 6 - Curve of *N* (cumulative number of retail units), comparing empirical data and modeled values, in Iguatemi

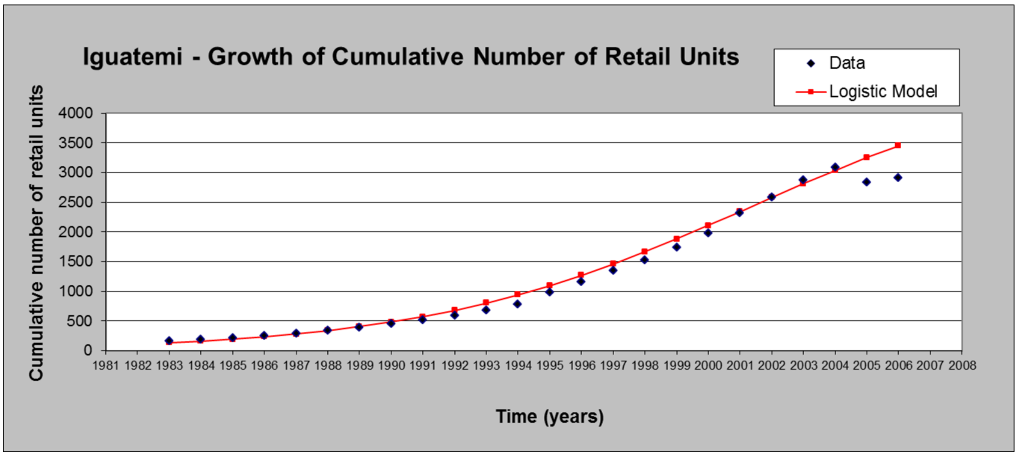


Figure 7 - Curve of *N* (cumulative number of retail units), comparing empirical data and modeled values, in Menino Deus

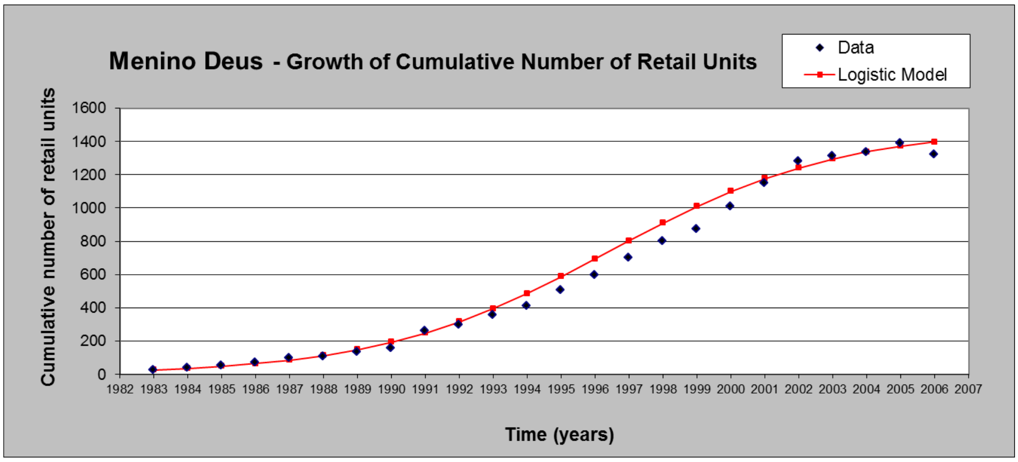
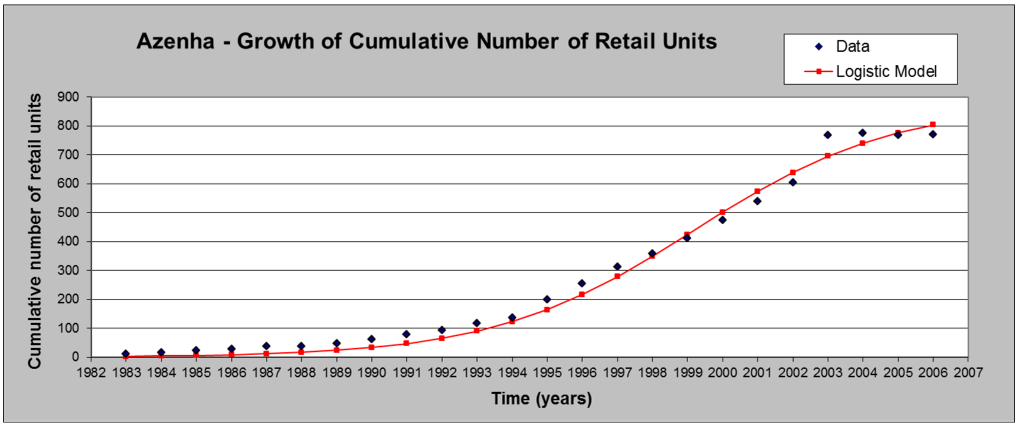


Figure 8 - Curve of *N* (cumulative number of retail units), comparing empirical data and modeled values, in Azenha



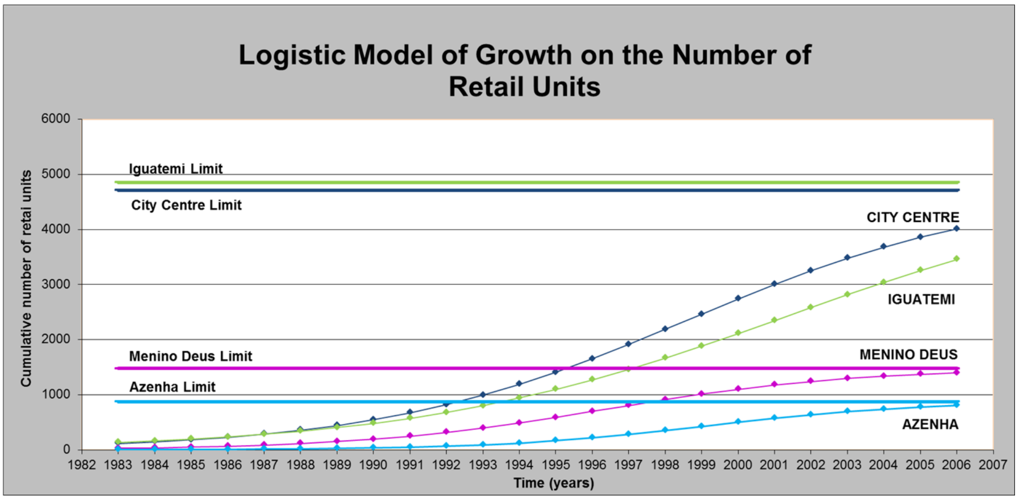
54 The results presented a good fit of the model to empirical data in four specific cases in the city of Porto Alegre. Table 2 presents the results of logistic equation parameters, adjusted for each studied area.

Table 2 - Logistic equation parameters, adjusted for each studied area

Area	Origin of growth		Growth Coefficient	Growth Limit
	t_0	N_0	a	N_*
City Centre	1983	116	0.2357	4,714
Menino Deus	1983	28	0.2958	1,479
Iguatemi	1983	134	0.1942	4,855
Azenha	1983	3	0.3507	877

55 Figure 9 presents the results of the four studied areas together, showing logistic models of growth in the number of retail units and also the growth limits.

Figure 9 – Graph comparing the values of modeled *N* (cumulative number of retail units) and their respective growth limits, in the studied areas



56 After model validation, we can explore some possibilities for analysis and projections, which are presented below. It is important to highlight that model predictions are valid as long as boundary conditions are maintained. This means the maximum capacity of retail units remains the same, implying that the conditions of population density, income, etc. do not change significantly. Moreover, the growth coefficient (which represents the interest in opening stores) does not change for any reason. Table 3 presents the calculations for time growth limits.

Table 3 - Calculation of growth limits through the logistic model in each study area

Area	Logistic Growth Limits[9]		
	Date of Origin	Max. Number	Final Date
	$T_{10\%}$	N_*	$T_{95\%}$
City Centre	1989	4,714	2011
M. Deus	1989	1,479	2006
Iguatemi	1990	4,855	2016
Azenha	1995	877	2007

Other points of interest of the logistic curve were also calculated and are presented in Table 4.

Table 4 - Calculation of critical points of the logistic model in each study area

Area	Inflection points of growth curve *(i)*		Maximum acceleration points of growth curve *(c)*	
	Time	Cumulative	Time Period	Cumulative
	t_i	N_i	t_c	N_c
City Centre	1998	2,357	1993-2004	996 - 3717
M. Deus	1996	740	1992-2000	312 - 1166
Iguatemi	2001	2,428	1994-2008	1025 - 3829
Azenha	1999	425	1995-2003	185-691

57 We can observe that in Menino Deus and Azenha the retail growth process is near saturation. The City Center is the oldest retail area in the city, however, its process recently completed a period of greater acceleration of growth (1993-2004). The City Centre has an intermediate value of growth rate in the four studied areas (0.2357) and will reach its limit of quantitative growth only in 2011. The Iguatemi area presents the lowest coefficient of growth among the four areas (0.1942). The period of greatest acceleration of growth occurred between 1994 and 2008, and its growth limit will be reached in 2016.

58 We can also recognize the conditions of saturation of retail location in each area in the present moment (2009). The City Centre has fulfilled 92% of its maximum capacity of retail units; Menino Deus, 97.6%; Azenha, 96.9% and Iguatemi, 81.5%. Iguatemi is the area that shows the best conditions to absorb a growing number of retail units.

59 It is interesting to point out the problem of the City Centre, where logistics growth has remained higher than in the other areas during this period. In Porto Alegre, the period of the greatest decentralization of the city occurred in the 1970s and 1980s. This decentralization occurred due to the deterioration of the central urban area, since residents with a higher income left the City Centre, followed by the emergence of large retail formats in more distant neighborhoods. Empirical evidence shows that many department stores and other high-standard retail business left the City Centre during this period, giving place to more popular retail. Some of the large buildings of those old department stores in the central area have been subdivided into a great number of small shops, creating shopping malls of a sort. These factors could help explain the high growth in the number of retail locations in City Centre, in a period of strong decentralization. This growth would be based on the presence of a great number of small and popular retail units.

60 Since this study is only quantitative, qualitative aspects such as the ones mentioned above are not the scope of the article. However, the model predictions indicate that Iguatemi will overcome the City Centre in the short run, in terms of number of retail units.

Conclusions: model potential and limitations

61 This work has proposed a theoretical model of retail location growth. As a complement, the paper developed an empirical application, in order to obtain a preliminary validation with the real data of a city. It is important to note that more empirical studies are needed in order to validate the model through rigorous statistical analysis. In such studies, the quantity and quality of empirical data becomes essential, including the homogeneity in the methodology of data collecting over time.

62 The study of Porto Alegre showed a good fit of the model to empirical data in all studied areas. This was verified in four areas with very different characteristics in terms of historical and urban spatial structure. The model was able to estimate the value of saturation or equilibrium in the number of stores in each area, as well as to predict when this limit will be reached. The rate of growth of retail in each area was also found, as well as all the critical points of interest for the study of the growth path (acceleration and higher moments of inflection of the curve of growth, among others).

63 Other aspects of the proposed model are worth noting. A positive aspect of the model is the ease in which one can find the analytical solution to the differential equation, and also the estimate of its parameters. The necessary calculations are simple and can be run in conventional spreadsheets. The model also presents flexibility and the capacity to represent complex situations such as the intervention of external agents, for example, the government creating incentives for business locations in a given area. To take such situations into account, there are algebraic expressions that can be associated with the logistic model (Banks, 1994).

64 The proposed model can also be used to find explanations about the specificity of the growth path of retail locations in different areas, investigating, for example, why growth is faster in some places than in others or why the value of saturation is lower. In order to do this, one can propose correlations between the parameters of the model *(a and N*)* and the urban variables which constitute the business environment and are traditionally indicated in the literature (population density, average household income, accessibility, among others). This would allow us to evaluate the impact of these factors on the growth of retail locations.

65 The model allows one to analyze the influence of the insertion of a large commercial facility, like a shopping center, and its impact on the quantitative growth of commercial locations around the area (Maraschin, 2009).

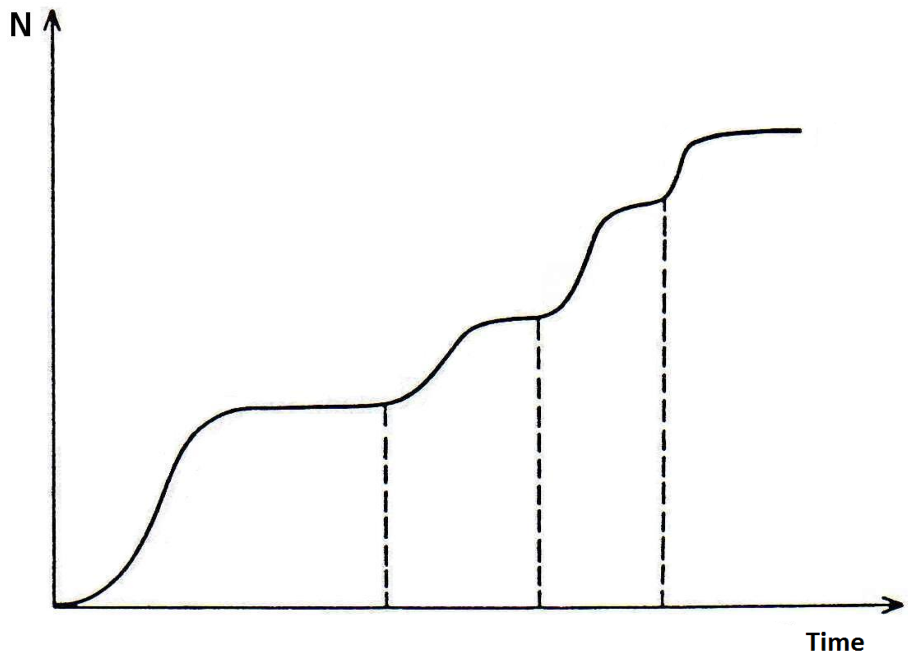
66 It also allows one to deal with qualitative trade growth, which means that, with a prior classification of the retailers, growth studies for specific types of commerce can be developed.

67 The size of the business can also be taken into account in the analysis if, instead of using the amount of establishments, we use the data of sale area or the turnover of the stores as indicators of the variable N in the model. This would allow a more qualitative analysis of the growth phenomenon.

68 The model presented here is dynamic and deterministic. It should be noted that such predictions are valid as long as the initial conditions remain valid, thus providing the possibility of at least a

short term forecast. However, the model also has the potential to represent urban development and changes in the long run. Figure 10 depicts a long-term hypothetical scenario in which new growth cycles of commercial locations occur while social-spatial transformations take place in different points in time.

Figure 10 - Modified logistic equation as urban spatial structure changes (based on Allen, 1997:32)



69 Changes in the logistic equation allow us to represent the possibility of a new cycle of growth in retail locations, assuming limits to growth *(N*)* and growth rate (*a*) variables. These new cycles can be caused by changes in residential density, income, population, qualification of the commercial offer according to the types and variety of goods offered, improvements in accessibility, infrastructure of roads, public transportation, new transport stations, among other factors. This is a potential of the model to be investigated in future studies.

WILDE, Louis L., 1992. "Comparison Shopping as a Simultaneous Move Game." *The Economic Journal*, vol. 102, n. 412, 561-569.

Bibliographie

ALLEN, P.M. and SANGLIER M., 1981. "Urban Evolution, Self-Organization and Decision Making". *Environment and Planning A*, 13, 167-183.

ALLEN, Peter M., 1997. *Cities and Regions as Self-Organizing Systems. Models of Complexity*. OPA, Amsterdam.

ARENTZE, Theo A., OPPEWAL Harmen, and TIMMERMANS Harry J.P.,2005. "A Multipurpose Shopping Trip Model to Assess Retail Agglomeration Effects". *Journal of Marketing Research*, 109 vol. XLII (February), 109–115.

BANKS, Robert, 1994. *Growth and Diffusion Phenomena. Mathematical Frameworks and Applications*. Springer-Verlag Berlin Heidelberg.

BATTY, Michael, 2005. *Cities and Complexity. Understanding Cities with Cellular Automata, Agent-Based Models and Fractals*. MIT Press, Cambridge, London.

BATTY, Michael, 2008. "Cities as Complex Systems. Scaling, Interactions, Networks, Dynamics and Urban Morphologies". CASA Paper 131, London. 02/25/2008, 62 p.

(http://www.casa.ucl.ac.uk/working_papers/paper131.pdf)

BENATI, S., 1997. “A Cellular Automaton for the Simulation of Competitive Location”. *Environment and Planning B, Planning and Design*, vol. 24, 205-218.

BERRY, Brian, 1967. *Geografia de los Centros de Mercado y Distribución al por Menor*. Ed. Vicens-Vives, Barcelona.

BIRKIN, Mark; CLARKE, Graham and CLARKE, Martin P., 2002. *Retail Geography and Intelligent Network Planning.* Wiley; 1 edition.

BROWN, Stephen, 1992. “The Wheel of Retail Gravitation?” *Environment and Planning B*, vol. 24, n. 10, 1409-1429.

CHRISTALLER, Walter, 1966. *Central Places in Southern Germany*. Englewood Cliffs: Prentice-Hall.

CLARKE, Graham; LANGLEY, Rob and CARDWELL, Wayne. “Empirical Applications of Dynamic Spatial Interaction Models”. Comput. Environ. and Urban Systems, vol. 22, n. 2, 157-184, 1998.

DAWSON, John A., 1980. *Retail Geography*. J. Wiley.

EPPLI, Mark and BENJAMIN, John, 1994. “The Evolution of Shopping centre Research: A Review and Analysis”. *The Journal of Real Estate Research, vol.* 9, n. 1, 5-31.

EPPLI, Mark and SHILLING, James D., 1995. “Large-Scale Shopping Center Development Opportunities”. *Land Economics*, vol. 71, n. 1, 35-41.

FUJITA, Masahisa, 1989. *Urban Economic Theory – Land Use and City Size*. Cambridge University Press.

GABSEWICZ, Jean J. and GARELLA, Paolo G., 1987. “Price Search and Spatial Competition”. *European Economic Review*. vol. 31, Issue 4, 827-842.

GOSH, Avjit and CRAIG, C. Samuel, 1983. “Formulating Retail Location Strategy in a Changing Environment”. *Journal of Marketing*. vol. 47, 56-68.

GUY, Clifford, 1980. *Retail Location and Retail Planning in Britain*. Gower Publishing Ltd; 1st Ed.

GUY, Clifford, 1994 a. “Grocery Store Saturation. Has it Arrived Yet?” *International Journal of Retail & Distribution Management,* vol. 22, n. 1, 3-11.

GUY, Clifford, 1994 b. *The Retail Development Process. Location, Property and Planning*. Routledge.

HÄGERSTRAND, Torsten. *Innovation Diffusion as a Spatial Process*. Chicago: The University of Chicago Press, 1967.

HARRIS, B. and WILSON, A.G., 1978. “Equilibrium Values and Dynamics of Attractiveness Terms in Production-Constrained Spatial Interaction Models”. Environment and Planning A, vol. 10, 371-388.

HUANG, Arthur and LEVINSON, David, 2011. “Why Retailers Cluster: an Agent Model of Location Choice on Supply Chains.” *Environment and Planning B: Planning and Design,* 38 (1) 82 – 94.

HUFF, David L., 1964. “Defining and Estimating a Trading Area”. *Journal of Marketing*, vol. 28, Jul, 34-38.

LAKSHMANAN, T.R. and HANSEN, W. G., 1965. “A Retail Market Potential Model.” *Journal of the American Institute of Planners,* vol. 31, 134-143,

LANGSTON, P., CLARKE G.P. and CLARKE D. B., 1998. “Retail Saturation: the Debate in the Mid-1990s.” *Environment and Planning A*, vol. 30, p 49-66.

LOMBARDO, S., Petri M. and Zotta D., 2004. “Intelligent GIS and Retail Location Dynamics: a Multi Agent System Integrated with ArcGIS”. *Computational Science and its Applications – ICCSA, Lecture Notes in Computer Science.* vol. 3044, 1046-1056.

LONGLEY, Paul; BOULTON, Charles; GREATBATCH, Ian and BATTY, Michael, 2003. “Strategies for Integrated Retail Management Using GIS”. In: LONGLEY, Paul and BATTY, Michael. *Advanced Spatial Analysis – The CASA Book of GIS*. ESRI Press.

MALTHUS, T. *An Essay on the Principle of Population*. Reprint 1970, Penguin Books, England, 1798.

MARASCHIN, Clarice. *Localização Comercial Intra-Urbana – Análise de Crescimento através do Modelo Logístico*. Doctoral thesis, PROPUR, UFRGS, Porto Alegre, 2009.

MEJIA, Luis C. and BENJAMIN, John D., 2002. What Do We Know About the Determinants of Shopping Center Sales? Spatial vs. Non-Spatial Factors. *Journal of Real Estate Literature*, vol. 10, n.1, 3-26.

MENDES, A. B, and THEMIDO, I. H., 2004. “Multi-Outlet Retail Site Location Assessment.” *International Transactions in Operational Research*, 11, 1-18.

NELSON, R., 1958. *The Selection of Retail Locations*. New York: F.W. Dodge Corp.

PENN, Allan and TURNER, Alasdair, 2004. “Movement-Generated Land-Use Agglomeration: Simulation Experiments on the Drivers of Fine-Scale Land-Use Patterning.” *Urban Design International*, 9, 81–96.

PÉRON, René, 2001. “The Political Management of Change in Urban Retailing.” *International Journal of Urban and Regional Research.* vol. 25.4.

POOLE, Rachel; CLARKE, Graham P. and CLARKE David B., 2006. “Competition and Saturation in West European Grocery Retailing.” *Environment and Planning A*, vol. 38, 2129-2156.

ROGERS Everett, 1995. *Diffusion of Innovations*. 4th edition. New York: The Free Press.

VERHULST, P.F., 1838. *Notice sur la Loi que la Population Poursuit dans son Acroissement. Correspondance Mathématique et Physique*, 10, 113-121.

Notes

1 For more details on the calculations necessary to determine the three parameters of the model [a, N_0 and N_*] see Maraschin (2009).

2 *We will discuss this assumption further in the final part of the article, showing that the model admits (N*) variable.*

3 This does not imply that the model cannot represent situations in which there is a decreased amount of retail establishments. In such cases, the value of (N_*) will be lower that (N_0), therefore the solution of logistic equation will describe a descending curve, tending to (N_*).See example in Figure 1(N_0=200).

4 Source: IBGE - Cidades (Instituto Brasileiro de Geografia e Estatística).

5 *Source: RAIS – MTE 2009 (Relação Anual de Informações Sociais, Ministério do Trabalho).*

6 The data on the number of stores is from 2006. The basis for the data on population and average family income (in minimum wages) is the 2000 Census. The global calculation for Porto Alegre in regard to the measurement of acreage does not consider unoccupied areas – of environmental preservation.

7 *RAIS (Relação Anual de Informações Sociais), Ministério do Trabalho – Annual Report of Social Information.*

8 In the category retail business, one can include: automobiles, food, fuel, construction materials, computer related products, household appliances, pharmaceuticals, medical products, used and non-specialized products. Wholesale business and services of all types are not included. Source: Classificação Nacional de Atividades Econômicas (CNAE 2.0), Instituto Brasileiro de Geografia e Estatística (IBGE).

9 Date for growth origin is when 10% of growth is reached ($N_{10\%}$) and final date is when 95% of growth is reached ($N_{95\%}$).

Pour citer cet article

Référence électronique

Clarice Maraschin et Romulo Krafta, « Growth dynamic of retail locations: a methodological approach using a logistic model », *Cybergeo : European Journal of Geography* [En ligne], Systèmes, Modélisation, Géostatistiques, document 650, mis en ligne le 02 août 2013, consulté le 09 août 2013. URL : http://cybergeo.revues.org/26002 ; DOI : 10.4000/cybergeo.26002

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Droits d’auteur

Résumés

This study investigates the processes of growth and development of retail locations in urban space. The formation and development of multiple business centers is part of the contemporary urban landscape, creating heterogeneous spatial and temporal patterns which defy the understanding of urban theorists and planners. The study of these processes requires dynamic approaches, consistent with the scale and pace of such changes. This paper presents a proposal for the model of growth dynamic of commercial locations in urban areas over time. It also proposes the adaptation of a logistic model, a nonlinear dynamic model originated in studies of population ecology, which is used to describe growth dynamic in environments with a limited capacity. In this study, the growth of retail locations is represented by the variation in the amount of retail establishments over time in specific urban sectors. In order to develop a preliminary empirical validation of the model, its application is developed in four areas in the city of Porto Alegre, Brazil, considering data on the number of shops during 23 years, from 1983 to 2006. The investigation showed a good fit of the model to empirical data in all studied areas.

Cette étude examine les processus de croissance ainsi que le développement des emplacements commerciaux dans l'espace urbain. La formation et le développement des centres d'affaires fait partie du paysage urbain contemporain, créant des configurations spatiales et temporelles hétérogènes, qui défient sa compréhension de la part des théoriciens et des planificateurs. L'étude de ces processus nécessite des approches dynamiques, compatibles avec l'échelle et la vitesse du changement. Ce travail présente une proposition visant à modéliser la dynamique de croissance des localisations commerciales dans des zones urbaines au fil du temps. Il propose l'adaptation d'un modèle logistique, un modèle dynamique et non linéaire, provenant des études en écologie des populations, qui est utilisé pour décrire la dynamique de croissance dans des environnements ayant des capacités limitées. Dans cette étude, la croissance des emplacements commerciaux est représentée par la variation dans la quantité d'établissements de vente au détail au fil du temps, dans des secteurs urbains spécifiques. Afin de développer une validation empirique préliminaire du modèle, il est appliqué dans quatre secteurs de la ville de Porto Alegre, au Brésil, en tenant compte des données concernant les commerces sur une durée de 23 ans, de 1983 à 2006. Cette recherche montre au final un bon ajustement du modèle aux données empiriques dans tous les domaines étudiés.

Entrées d'index

Mots-clés : commerce, modélisation, modèle logistique, Porto Alegre
Keywords : retail, modeling, logistic model, Porto Alegre

Notes de l'auteur

The authors would like to thank the support of NET-UFRGS (Núcleo de Estudos de Tradução), Prof. Rosalia Neumann Garcia and Renato Augusto Vortmann de Barba and also NAE – UFRGS (Núcleo de Assessoria Estatística), Prof. Jandira Fachel.