ENV399 Research Opportunity Program

Professor Brad Bass

Using COBWEB to Measure the Effects of Key Factors Influencing the Success of Retail Businesses

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Introduction

As online shopping continues to grow, 75 000 stores are forecasted to be closed by 2026 in the United States alone (Whiteman, 2020). The retail sector is on the verge of an industry-wide permanent restructuring, some industry experts expressed concern over the catastrophic damage expected, even using the term “retail apocalypse” (Helm, Kim, & Van Riper, 2018). In the case of a new store construction, not only could the enormous capital invested be lost, but also potential harm could come to the company’s reputation due to one poorly selected site (Pope, Lane, & Stein, 2012; Wood & Tasker, 2008). As a result, whether it is a large retail chain corporation planning on expansion or a small business looking to enter the market, it has become more critical than ever before for decision makers to understand what the key factors are in the complex location decision-making process which have the ability to drive the company forward through long-term profitability and sustainability.

In this paper, the research question of what are the key factors influencing the success of retail businesses, more specifically in the format of physical retail stores, is explored. I argue that characteristics of the trade area, characteristics of the store, and distance to competition are all critical success criteria. Characteristics of the trade area consist of the location of potential sites and demographic characteristics of the population living in the area. Criteria such as accessibility by car/foot, visibility, and socio-economic profile of the potential market are important contributors to this theme (Roig-Tierno, Baviera-Puig, Buitrago-Vera, & Mas-Verdu, 2013). Characteristics of the store mainly consist of the quality of the establishment itself, including factors such as total leasable square footage and number of checkouts available to customers. Last, but not least, the concept of competition introduces a tradeoff phenomenon between volume of passing trade generated by competition and customers lost to competitors. These criteria are discussed, analyzed, and used to construct a series of models simulating the retail environment in COBWEB, also known as Complexity and Organized Behavior Within Environmental Bounds- an agent-based simulation modeling software.

Literature Review

Theme I: Characteristics of the Trade Area

Geography plays a key role in the success of a business and is the "keystone to profitability" (Roig-Tierno *et al.*, 2013; Hernandez & Biasiotto, 2001). Research shows that the success of retail businesses are significantly related to characteristics of the trade area such as location, accessibility, and visibility (Roig-Tierno *et al.*, 2013; Chacón-García, 2017; Pope *et al.*, 2012). Roig-Tierno *et al's* research (2013) confirms that a successful retail business benefits from a location with high accessibility by car and by foot, as well as high visibility from afar.

In addition, the theory of distance decay demonstrates that retail demand, supply, and the interaction between customers and stores are spatially constrained (Hernandez, 2007). As a result, the profile of the demographics which the trade area serves is critical to the success of the organization as well. Researchers have found the preferred means through which customers shop are associated with age (Helm et al., 2018). Younger generations may show more interest shopping in an online environment rather than a physical store; a trade area that serves an older population may generate more sales for the business. Moreover, other socioeconomic factors, such as income, are also closely associated with purchasing power. Chacón-García (2017) studied Spain's pharmaceutical market and found that stores located in census districts with a higher median household income tend to be more profitable. Last, but not least, the size of the potential market plays a role in success as well. Roig-Tierno *et al.* (2013) found in their study that census districts with a higher population density are considered more profitable.

Theme II: Characteristics of the Store (establishment)

Aside from being in a prime location with a demographic profile that contributes positively to the success of the store, the characteristics of the property itself need to appear attractive as well (Roig-Tierno et al., 2013). From Pope *et al.'s* (2012) interview with the directors at retail corporations, factors such as leasable square footage, arrangement of merchandise on the shelf, and number of checkouts available to the customers are essential to the success of a store. According to Burnaz & Topcu (2006), sufficient parking spaces also contribute to customers' willingness to come to the store in today's world.

Theme III: Competition

The existence of nearby competition not only elicits comparisons of all criteria in previous themes among competitors, but also introduces an interesting tradeoff between attracting and losing customers. Economies of agglomeration is the concept in which the same types of companies, services, or industries locate near one another in clusters in order to benefit from the created networks. Ideally, a profitable retail location benefits from the volume of passing trade generated by its competitors within this network without the depletion of customers caused by the same group of businesses (Clapp, Ross, & Zhou, 2017; Pope *et al.*, 2012). Competition can be further broken down into more specific sub-factors such as distance from competition, brand recognition, size of competition in sales floor area, as well as the type of competition (Roig-Tierno et al., 2013).

Methodology in Literature

Methods used to facilitate the choice of the most favorable locations for a retail business in existing literature include checklist methods, Geographic Information Systems (GIS), geovisualization techniques, statistical modelling, and Analytic Hierarchy Process (AHP) Multi-criteria process, among which the GIS and AHP methods are most prominent and widely used. Although formal techniques of locational analysis have matured over the past decades, no research has yet been found for developing a COBWEB model, which uses an agent based simulation model in the context of retail business location decision process. My research takes on the unique approach of simulations to validate the existing concept of critical success factors in physical retail stores. Similar to most existing research, my models are built based on the assumption that there are no budgetary or legal constraints to a potential site.

Method

Complexity and Organized Behavior Within Environmental Bounds (COBWEB) is used to construct simulation models in this research. COBWEB is a computer simulation software that allows users to execute experiments and simulate different systems. Research topics within a wide range of disciplines in which COBWEB can be applied to include simulating environmental changes, examining population growths, and analyzing complex behavioral patterns. COBWEB has many features that allow users to simulate different systems. Among which, simulations function critically and almost entirely on the movement and consumption of agents and the available resources.

Three simulation models are built to answer the research question: what are the key factors influencing the success of physical retail businesses. The three models are baseline model, competition model, and visibility model. The main parameters changed for three models are under the Abiotic Factors Tab in COBWEB. Islands with unique values are created in each model to represent the physical landscapes of retail environments. Abiotic preference values are adjusted for each food type so that one type of food appears within one designated island, forming physical stores on the grid. The agents in the models represent customers. Agent characteristics for all agents are identical and left unchanged from default. Agents have no preferred abiotic factor (islands) since they are already attracted to their preferred food value, which are linked to abiotic factors. To measure observed outcomes, the orders in which the agents approach the stores are deemed as the determining factors for success. The movements of agents are closely observed, visualized, and compared.

Baseline Model

The baseline model is used to test whether customers with identical characteristics would approach two identical stores at identical speed, validating the core methodology for this research. As shown in *Figure 1*, two identical stores appear as two islands located symmetrically on the grid. Yellow and blue food types reside each in one island. When the model is run, yellow and blue agents are attracted to its own favorite food source of identical color. It is expected that given all characteristics of the physical environment are the same, agents will consume their favorite food source at designated islands at identical speed, representing customers approaching retail locations.

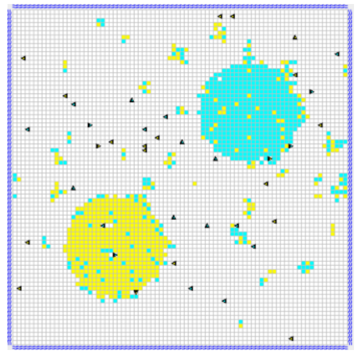

Figure 1 Baseline Model, Initial Set Up tick = 1

Competition Model

The competition model is built to study the relationship between distance to competitions and successful retail locations. Being located near a competitor creates a tradeoff effect where a nearby competitor can both generate foot traffic and create competition. As shown in *Figure 2*, three identical stores appear as three islands located on the grid, with two stores closer to each other and one isolated store located further away. Yellow, blue, and green food types reside each in one island. When the model is run, yellow, blue, and green agents are attracted to their own favorite food source of identical color. Whether the agents choose to approach a store located next to its competitor or a stand-alone store first determines the effect of competitions.

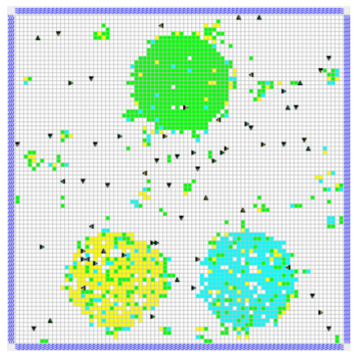

Figure 2 Competition Mode, Initial Set Up tick = 1

Visibility Model

The visibility model is built to study whether having more leasable square footage or higher visibility is a critical success factor for physical retail stores. As shown in *Figure 3*, two stores with almost identical characteristics with the sole exception of size are located on the grid. Yellow and blue food types reside each in one island. The yellow island on the bottom left represents the store with bigger size, thus presenting greater visibility to the public from afar. When the model is run, two types of agents are attracted to their own favorite food source of identical color. Whether the agents choose to approach the bigger store first determines the effect of visibility.

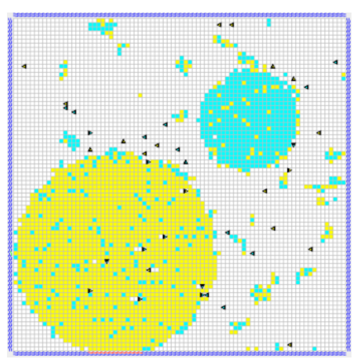

Figure 3 Visibility Model, Initial Set Up tick = 1

Results

In the baseline model, two islands are being approached by agents in a similar manner at identical speed. *Figure 4* visualizes this process from when the model begins to run till the desired results have been achieved. In the competition model where we have three identical islands located with varying distance from each other, as shown in *Figure 5*, two islands located on the bottom of the grid who are closer to each other attract the agents first, before the agents turn their attention away to the third island further away. In the visibility model, the islands are of identical characteristics with the exception of size. As shown in *Figure 6*, agents showed greater initial interest in the bigger island rather than the smaller one.

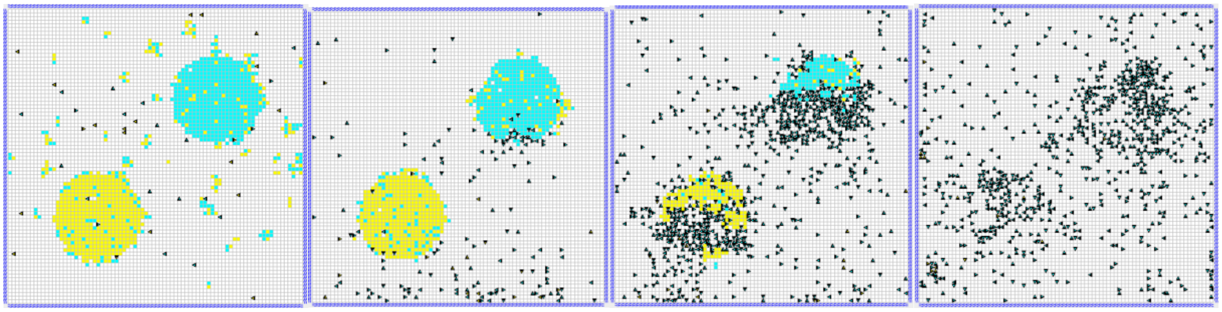

Figure 4. Baseline Model Results

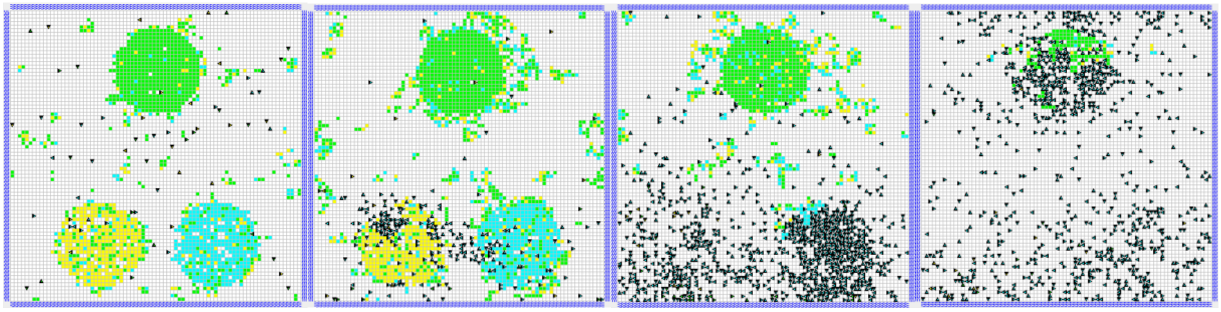

Figure 5. Competition Model Results

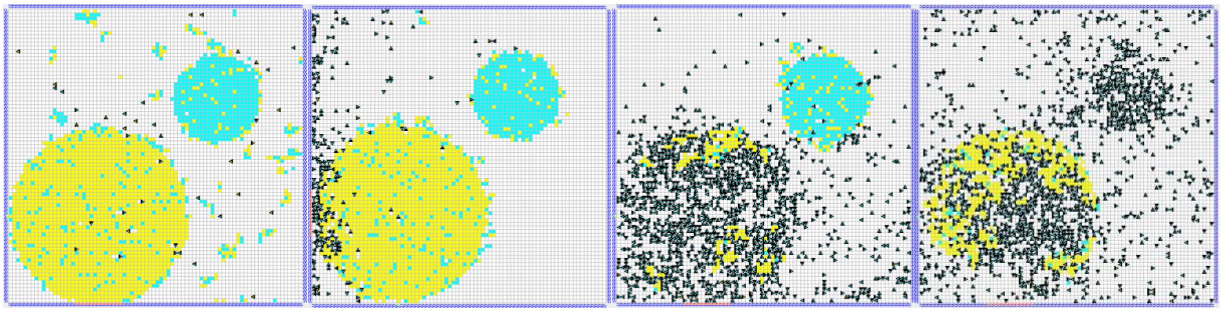

Figure 6. Visibility Model Results

Discussion

The success factors of retail stores, including characteristics of the trade area, characteristics of the store, and distance to competition, are simulated and modeled. The competition model validates the concept that customers are more likely to visit the stores closer to each other before shifting their attention to a stand-alone store further away. This raises questions for future research whether it is always better to choose to locate next to a competitor when all other factors remain the same.

The visibility model demonstrates two additional aspects of success factors in physical retail environments, characteristics of the trade area and characteristics of the store. A store with more leasable square footage most likely has better visibility from far. The model shows that customers tend to visit the larger store first if there are two otherwise similar stores within reasonable distance of each other. Last, but not least, the baseline model indicates that customers approach two identical retail stores within reasonable distance of each other at identical speed, validating the robustness of research methods.

The models built in this research validate the hypothesis that characteristics of the trade area, characteristics of the store, and competition are all critical contributing factors to the success of physical retail stores. Similar retail businesses located closer to each other have a higher probability of success than a stand-alone business. As for similar businesses close to each other, having more sales square footage increases the likelihood of success when compared with a smaller sales area.

Conclusion

The retail locational decision process is a combination of “art” and “science” (Hernández, T., & Bennison, D., 2000). To retailers, site selection is a complex and critical process and locational decisions carry long-term operational and strategic implications for the organization. An ideal retail location creates a profitable store for small businesses and maximizes the aggregated revenue for bigger retail chains (Hernández & Bennison, 2000). Numerous studies have demonstrated the importance of investing in the decision making process as poor location decisions are hard to remedy (Hernández & Biasiotto, 2001). The use of GIS and AHP multi-criteria models have proven to be effective and successful strategies in determining the location of a new retail store in existing literature.

My series of models offer a cost-effective way to simulate the decision-making process for a new physical retail location. The three models validate the findings in literature that characteristics of the store and distance to competition are indeed critical to the success of retail businesses. COBWEB is also capable of building a more complex retail environment. For example, by varying parameters in other tabs, it is likely that a retail environment with changing demographic profiles can be simulated as well. In light of COVID-19 global pandemic, the retail sector is once again undergoing industry-wide restructuring. It is important for industrial experts and researchers to closely track and monitor retail activities and update their academic and industrial understanding of the fast changing process of location decision-making. Future COBWEB researchers are suggested to explore other success criteria to build more models and potentially merge the series of models into one, enabling the interaction and ranking of important success factors.

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Appendix 1: Guide to Setting Up the Baseline Model

Environment

A 80x80 grid with 2 agents and 0 stones is used. Random seed is left at default value 42. Wrap edges is checked under environmental settings and spawn new agents is checked under environment transition settings.

Abiotic Factors

Table 1.1 shows the values used to create two identical islands symmetric on the grid.

Active Factors	Factor 1: Island	Factor 2: Island
Island value	1	2
Outside value	0	0
Island size X	0.3	0.3
Island size Y	0.3	0.3
Position X	0.3	0.7
Position Y	0.7	0.3
Edge hardness	100,000	100,000
Punishment/Barrier	Checked	Checked

Table 1.1 Abiotic Factors Tab Set Up for the Baseline Model

Agents and Resources

The baseline model has identical resources set up for food type 1 and food type 2. Abiotic preference values (*Table 1.2*) are adjusted for each food type so that they appear within each designated island, forming retail environments. Agents characteristics are also identical and left unchanged from default, but they have different preferences for food values and food types. Agents have no preferred abiotic factor (islands), as shown in *Table 1.3* since they are already attracted to their preferred food value, which are linked to abiotic factors.

Resource Type Parameters	Food 1	Food 2
Initial amount	20	20
Spawn rate	0	0
Growth rate	4	4
Depletion rate	0.9	0.9
Depletion time	20	20
Draught period	0	0
Abiotic 1 Preference value	0	1
Abiotic 1 Preference value range	0	0
Abiotic 1 Preference difference Factor	20	0
Abiotic 2 Preference value	2	0
Abiotic 2 Preference value range	0	0
Abiotic 2 Preference difference Factor	0	20

Table 1.2 Resources Tab Set Up for the Baseline Model

Abiotic Factor	Agent 1	Agent 2
Factor 1 Preference value	0	0
Factor 1 Preference value range	0	0
Factor 1 Preference difference Factor	0	0
Factor 1 Parameter	[Null]	[Null]
Factor 2 Preference value	0	0
Factor 2 Preference value range	0	0
Factor 2 Preference difference Factor	0	0
Factor 2 Parameter	[Null]	[Null]

Table 1.3 Agent Abiotic Tab Set Up for the Baseline Model

Appendix 2: Guide to Setting Up the Competition Model

Environment

A 80x80 grid with 3 agents and 0 stones is used. Random seed is left at 42. Wrap edges is checked under environmental settings and spawn new agents is checked under environment transition settings.

Abiotic Factors

Table 2.1 shows the values used to create three identical islands symmetric on the grid.

Active Factors	Factor 1: Island	Factor 2: Island	Factor 3: Island
Island value	1	2	3
Outside value	0	0	0
Island size X	0.3	0.3	0.3
Island size Y	0.3	0.3	0.3
Position X	0.3	0.7	0.5
Position Y	0.8	0.8	0.2
Edge hardness	100,000	100,000	100,000
Punishment/Barrier	Checked	Checked	Checked

Table 2.1 Abiotic Factors Tab Set Up for the Competition Model

Agents and Resources

The competition model has identical resources set up for food type 1, food type 2, and food type 3. Abiotic preference values (*Table 2.2*) are adjusted for each food type so that they appear within each designated island, forming retail environments. Agents characteristics are also identical and left unchanged from default, but they have different preferences for food values and food types. Agents have no preferred abiotic factor (islands), as shown in *Table 2.3* since they are already attracted to their preferred food values, which are linked to abiotic factors.

Resource Type Parameters	Food 1	Food 2	Food 3
Initial amount	20	20	20
Spawn rate	0	0	0
Growth rate	4	4	4
Depletion rate	0.9	0.9	0.9
Depletion time	20	20	20
Draught period	0	0	0
Abiotic 1 Preference value	0	1	0
Abiotic 1 Preference value range	0	0	0
Abiotic 1 Preference difference Factor	20	0	0
Abiotic 2 Preference value	0	0	2
Abiotic 2 Preference value range	0	0	0
Abiotic 2 Preference difference Factor	0	20	0
Abiotic 3 Preference value	3	0	0
Abiotic 3 Preference value range	0	0	0
Abiotic 3 Preference difference Factor	0	0	20

Table 2.2 Resources Tab Set Up for the Competition Model

Abiotic Factor	Agent 1	Agent 2	Agent 3
Factor 1 Preference value	0	0	0
Factor 1 Preference value range	0	0	0
Factor 1 Preference difference Factor	0	0	0
Factor 1 Parameter	[Null]	[Null]	[Null]
Factor 2 Preference value	0	0	0
Factor 2 Preference value range	0	0	0
Factor 2 Preference difference Factor	0	0	0
Factor 2 Parameter	[Null]	[Null]	[Null]
Factor 3 Preference value	0	0	0
Factor 3 Preference value range	0	0	0
Factor 3 Preference difference Factor	0	0	0
Factor 3 Parameter	[Null]	[Null]	[Null]

Table 2.3 Agent Abiotic Tab Set Up for the Competition Model

Appendix 3: Guide to Setting Up the Visibility Model

Environment

A 80x80 grid with 2 agents and 0 stones is used. Random seed is left at 42. Wrap edges is checked under environmental settings and spawn new agents is checked under environment transition settings.

Abiotic Factors

Table 3.1 shows the values used to create two almost identical islands with the exception of size.

Active Factors	Factor 1: Island	Factor 2: Island
Island value	1	2
Outside value	0	0
Island size X	0.6	0.3
Island size Y	0.6	0.3
Position X	0.3	0.7
Position Y	0.7	0.3
Edge hardness	100,000	100,000
Punishment/Barrier	Checked	checked

Table 3.1 Abiotic Factors Tab Set Up for the Visibility Model

Agents and Resources

The visibility model has identical resources set up for food type 1 and food type 2. Abiotic preference values (*Table 3.2*) are adjusted for each food type so that they appear within each designated island, forming retail environments. Agents characteristics are also identical and left unchanged from default, but they have different preferences for food values and food types. Agents have no preferred abiotic factor (islands), as shown in *Table 3.3* since they are already attracted to their preferred food value, which are linked to abiotic factors.

Resource Type Parameters	Food 1	Food 2
Initial amount	20	20
Spawn rate	0	0
Growth rate	4	4
Depletion rate	0.9	0.9
Depletion time	20	20
Draught period	0	0
Abiotic 1 Preference value	0	1
Abiotic 1 Preference value range	0	0
Abiotic 1 Preference difference Factor	20	0
Abiotic 2 Preference value	2	0
Abiotic 2 Preference value range	0	0
Abiotic 2 Preference difference Factor	0	20

Table 3.2 Resources Tab Set Up for the Size Model

Abiotic Factor	Agent 1	Agent 2
Factor 1 Preference value	0	0
Factor 1 Preference value range	0	0
Factor 1 Preference difference Factor	0	0
Factor 1 Parameter	[Null]	[Null]
Factor 2 Preference value	0	0
Factor 2 Preference value range	0	0
Factor 2 Preference difference Factor	0	0
Factor 2 Parameter	[Null]	[Null]

Table 3.3 Agent Abiotic Tab Set Up for the Size Model