Using the simulation of ecological systems to explain the wheel of retailing

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I. ABSTRACT

Understanding the change in retail structure has been a distinct challenge for many managers and policy analysts since the 1950s. Research has focused on concepts such as the wheel of retailing. However, this theory is more descriptive than explanatory of changes in market structure. In this paper we argue that changes in retail structure (discount stores, specialist stores, department stores and even malls versus online shopping), can be modelled using the ecological simulation concept of competing sessile species, with different growth rates and overgrowth rates based on changing suitability to the environment. Our results show that the application of the COMPETE model [see 1, 2] produce different results for retail coverage between larger and smaller shopping malls

II. INTRODUCTION

Trying to understand the changing nature of retailing has been an important area of research for managers, policy makers and researchers since the 1960s [3-10]. One of the most popular and wide ranging explanations offered is the "wheel of retailing" [11]. This theory suggests that retailing evolves according to a cycle, shown in Figure 1.

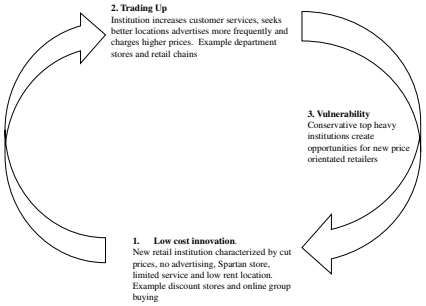

Figure 1: The wheel of retailing. Source [12].

According to the wheel of retailing theory, retail firms start with a low cost base as an entry strategy, usually beginning entrepreneurial activities with price discounts. These firms then "evolve" their strategies to focus more on higher margins and greater customer service, at the expense of volume (or there also evolves a market opportunity in this area). The wheel moves to full cycle, as the result of the gap in the marketplace now developing, where consumers look for low cost options at the expense of service and higher quality merchandise [5, 13-15]. Studies on the history of retailers and retail structure show mixed support for this model. Wood [8] finds support for the wheel of retailing in explaining the rise of the department store in the United States from 1920-1965, essentially steps 1-2 in Figure 1. Other researchers note that the market power of large firms has created barriers to market entry for innovative and low cost retailers in the past [16] and that some retail firms start at step 2, as specialty stores and department stores offering greater service and more expensive merchandise [10]. It has also been noted that in developing
economies that prestigious high end retailers also tend to be earlier entrants into the market [7]. Another issue complicating the understanding of retail industry structure is that many retailers co-locate. This is because of complementary benefits (increased traffic and complementary sales) for other retail chains co-locating with larger stores in shopping centers. Importantly, these benefits outweigh any increased competition from similar stores [17]. Shopping malls themselves can be conceptualized as pseudo department stores, without profit

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sharing, and as a larger, high-end full service retailer. Malls also face the global threat of low cost online retailers [18-20]. Although it is recognized that some low cost retailers may also be located within a mall, higher rents charged by mall owners may preclude long commitments by such retailers.

In summarizing the research on the wheel of retailing, Brown [21], argues that this theory is useful in that it seeks to explain the evolution of retailing. Furthermore, Hollander [22] argues that the theory is also valuable in showing how the competitive actions between different types of retailers change the structure of the industry. Other researchers such as Evans [23] argue that the wheel of retailing forces organizations to consider how they will adapt to both competition and market conditions, as there are always emerging opportunities for growth from rival firms at both the high and low cost end. What is not clear, apart from historical analysis [4, 8], is how the movement of the wheel can be affected by the advent of shopping malls and competition from online retailers. The object of the paper is to get a deeper understanding of this by applying a simulation of an ecosystem, which has competing species with differential growth rates, to the retail landscape of shopping malls.

III. Literature Review

A. *Shopping malls as an ecosystem*

Urban shopping malls occur throughout the developed world, across cultures, economies and relative consumer wealth. In the United States, for example, there are over 50 000 shopping centers and malls, which contribute an estimated 2.3 trillion dollars in sales to the world's largest economy and account for 75% of all non-automotive consumer sales [24]. Yet across countries, malls display remarkably similar patterns of shop distribution in contrast to the cultural diversity of their locations. Thus we conjecture that simple artificial life dynamics may go some way to modeling the shop distribution as a form of ecology. To illustrate this approach, consider a widespread retail phenomenon: identical shops tend to congregate, as in the ten or so outdoor shops in Kent Street in the Sydney CBD [17]. The consumer behavior explanation for this is that once a couple of shops are co-located, then new shops would be at a disadvantage if they located elsewhere, within a reasonable draw area for shoppers. Alternatively we could see this simply as a growth mechanism. New shops are likely to be similar to existing shops, since a market for their type of product or service has already been demonstrated. Shoppers also like choice. Having a concentration (critical density) in one area of different retailers selling the same kind of thing makes that area the 'go to' place for those goods (whether outdoor equipment, furniture, food (the restaurant belt).

The wheel of retailing theory however, suggest that there are differential advantages to different types of retailers [25]. Firstly, in a setting where there is sufficient retail growth across categories (such as an economic boom), then competition of one retailer at the expense of another will not be so great [26]. This is analogous to the world of vegetation cover where many exogenous factors determine plant species; soil nutrient content; water (rain and drainage); pollinators; herbivores; and so on. It is also quite possible that economic conditions (analogous to changes in the biological environment for plants) may also favor one retailer (species) over another. Low cost retailers, for example, may be favored by poor economic conditions such as a recession. The size of the mall, market (or in biology terms, the landscape) is also an important factor. It is much easier for a larger chain or mall to dominate a smaller market (or regional center), since by definition there are fewer opportunities for rival growth. It has been found that malls in smaller regional areas for example, have prospered more than those in cities during a recession [27]. The third issue in considering a mall as an ecosystem, is the number of different species (retail types). A greater diversity of stores will make it harder for one particular type to dominate.

Existing studies of terrestrial systems tend to show that one species will take over and dominate an area, which is not what happens in retail shopping precincts. Rather there may be a high preponderance of shops, selling, say young adult clothes, but one category is never totally dominant. A closer model is that of marine benthic species, i.e. sessile organisms on the ocean floor. Here one species will overgrow another, but there is an important difference: the overgrowth is non-transitive. Thus if A overgrows B and B overgrows C, a transitive relationship would require that A overgrows C. But it may be the other way around, in which case the relationship is said to be intransitive, which leads to stable patterns of multiple species.

Yet simple ALife models, such as the COMPETE model [2], have been remarkably successful in understanding species mix of marine benthic communities and we believe this can also be applied to understanding the change of retail structure as suggested by the wheel of retailing.

IV. Method

A. *Preliminary analysis on retail structure*

We collected data on shopping types across two major shopping centers in Sydney and shopping precincts of major regional towns within NSW Australia. For space and brevity a sample of data collected is shown Table 1.

Table 1: Distribution of retail types across selected Sydney and NSW regional areas.

City / Regional town NSW, Australia	**Sydney**	**Albury**	**Bathurst**	**Port Macquarie**	**Wagga-Wagga**
Shopping Mall	**Westfield City Centre**	**Lavington Square**	**Stocklands**	**Port Central**	**Market Place**
Food retailing (light blue in model)	1%	20%	7%	4%	5%
Household goods (electrical stores, yellow in model)	4%	8%	5%	6%	3%
Clothing, footwear and personal accessory retailing (red in the model)	38%	16%	21%	33%	20%
Department stores (purple in the model)	0.3%	4%	2%	2%	3%
Cafés, restaurants and take-way food services (green in the model)	27%	18%	19%	13%	15%
Other retailing and services (dark blue in the model).	10%	12%	12%	7%	8%
Total shops	**293**	**51**	**42**	**54**	**59**

As can be seen, there are important differences between malls in terms of the larger mall in Sydney, where there is a higher concentration of cafes and restaurants and fashion outlets than in regional areas, where there is a higher proportion of food retailing establishments, and department stores. Our total dataset of these towns and shopping centers had malls ranging from a size of 34 to 351 stores with an average of 102 stores per mall.

B. Simulation values and methodology

The simulation model is the COMPETE framework [2] used for marine benthic organisms (algae and sessile invertebrates on the seabed). In the variant used herein there are just four variable parameters:

1. The number of species (retail types); this is set from data collected from shopping precincts around Australia;
2. The growth rates, which are based on changes in quarterly retail sales growth, for various categories of retailers (e.g groceries, food and beverages, homeware, services)
3. The dominance factors, which are loosely based on the mall survey. These determine if a one shop category will displace another, such as a coffee bar replacing a hardware store.
4. The landscape parameter or the size of the market, or mall, as determined in the model as the number of cells (total possible number of retail locations).

The model is a spatial grid, where each point represents a shop, and the neighborhood is von Neumann [28], in other words, north, south, east and west. Different topologies and neighborhood sizes will change the results in detail, but in prior ecology studies, this architecture has proven adequate to determine important emergent behavior. All cells are updated synchronously at each time step. Each cell picks a neighbor at random, and the likelihood of that neighbor (N) overgrowing the cell (C), $p_{d,}$ is the product of the likelihood of N overgrowing C and the growth rate of N (g_d). This is shown in the following equation:

$$p_d = g_d(n_d)/4 \qquad (1)$$

Where g_d is the growth rate of the dominant neighbor and n_d is the number of times it occurs within a neighborhood. For growth rates we used the Australian Bureau of Statistics 2014 series of monthly retail sales growth for each type of retailer as shown in Table 1. Table 2 summaries the series of parameters used in the model. Note a larger landscape of 400 x 400 was used to make the pattern of results clearer and to reduce the likelihood of stochastic outcomes.

One important aspect of the dynamics is that the growth rates do not determine the ultimate survival of any given entity. It is the combination of growth rates and dominance factors that determine the ultimate outcome. One important aspect of the outcome of the model, is that of biodiversity. A biological system with its interdependencies cannot function as a monoculture [one species dominating, see 29].

Table 2: Parameters used in the COMPETE Model

Number of species (retailer type)	6	
Growth rate (x10) in terms of percent change (random high and low) for each species (retailer type) based on 2014 ABS data [30] retail monthly growth rate of sales for that sector.	1. Food retailing 1% (low), 5% (high). 2. Household/electrical -8% (low), 5% (high) 3. Clothing / fashion -1.1% (low), 8% (high) 4. Dept stores -3% (low), 2% (high) 5. Cafés and food -3% (low), 2% (high) 6. Other and services -2% (low), 14% (high)	
Species dominance (average retailer percentage of occurrence) across all malls.	Large malls	Small Malls
	1. Food retailing 2% 2. Household/electrical 4% 3. Clothing / fashion 35% 4. Dept stores 1% 5. Cafés and food 21% 6. Other and services 13%	1. Food retailing 8% 2. Household/electrical 6% 3. Clothing / fashion 25% 4. Dept stores 3% 5. Cafés and food 16% 6. Other and services 9%
Landscape size	Large : 400 X 400 Small: 80 X 80	
Number of generations (retail months)	1000	

Likewise a shopping mall relies on a combination of stores to be attractive to consumers as a retail destination [31-33], by providing complimentary benefits to stores, such as attracting customers to a mall, retaining them there for longer and providing a diversity of choice [34]. To simulate negative growth rates we used the mortality parameters in the model and also adjusted the growth rates. For example, household electrical had a mortality rate of .08, and the high growth rate used in model was then 13, which represents 13% growth, when the mortality rate is subtracted from this, it bring it back to a high growth rate of 5%, as shown in Table 2.

V. Results

Fig. 1 shows the landscape maps for larger shopping malls versus that of smaller regional malls. The outcome for large malls is on the left, and for smaller malls on the right. As can be seen there is greater diversity of retail types that occur in a larger mall (400 x 400 landscape). Whilst in the smaller mall on the right (80 X 80 landscape), there seems to mainly other retail and services, food retailing, café and food services and household and electrical stores. Fig. 2 shows the plot of coverage of retail types for large and small malls.

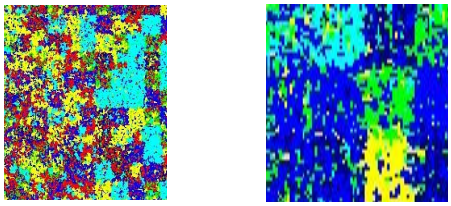


Figure 1: Landscape maps: Large and small malls (left to right).

Key:
Food retailing (light blue)
Household electrical (yellow)
Clothing /fashion (red)
Department stores (purple)
Café's and food (green)
Other and services (dark blue)

As can be seen in the larger mall there is a much greater diversity of retailer types making it a more attractive destination for consumers, with a reasonable representation of all retailers (as shown by the colored quilt pattern). This is the opposite case with regional malls as shown on the right (Fig.1), where the landscape map shows four types of retailers surviving, other retailers (dark blue), cafes and food services (green) and household electrical (yellow) and food retailing (light blue) with some scattering of department stores (purple).

As can be seen in the larger mall in Panel A (Fig. 2) the coverage of different types of retailers converges though fashion and clothing (see red color) declines over the period. Interestingly household and electrical stores are much greater than in the case with our sample in the large mall. Conversely the model shows a greater proportion of other retailing and services (dark blue) and cafés and food services (green) survive in regional areas (Fig 2, Panel B) than in larger shopping malls. Table 3, shows that the win: loss: standoff outcome matrix for each of the retail types, this result is the same for both types of shopping malls.

Table 4, shows the final distribution of retail malls in the big city mall and regional mall examples. As can be seen in the large city malls, all types of retailers survive with food and retailing and household and electrical being the most popular. This is not the case in the regional mall, where there are only five surviving retailers, with services and other retailers (47%) dominating, followed by department stores (18.6% of coverage) and cafes and food retailers 17.6%. Clearly the smaller the size of the mall, the less competition between all types of retailers, given the lack of an area of for expansion. The decline of clothing and fashion stores in regional areas is also a concern given that such stores have been found in other retail models to attract consumer to shopping malls [34].

Table 3: Outcome Matrix: used portion only. Lines are % Win: Loss: Standoff for each species. Large and Small Malls

No.	2	3	4	5	6
1	11	53	0	0	0
1	3	16	0	0	0
1	86	31	100	100	100
2		79	0	0	0
2		14	0	0	0
2		7	100	100	100
3			0	0	0
3			0	0	0
3			100	100	100
4				0	0
4				0	0
4				100	100
5					0
5					0
5					100

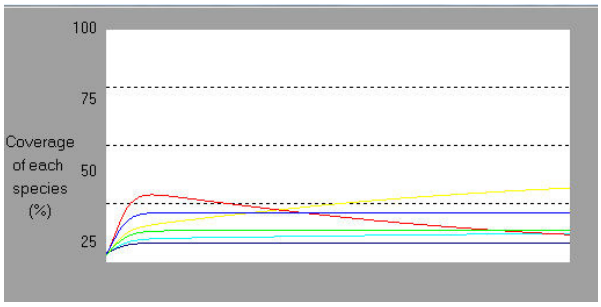
Key:

1) Food retailing
2) Household/electrical
3) Clothing / fashion
4) Dept stores
5) Cafés and food
6) Other and services

Table 4: Final retail coverage results (1000 generations).

	Food and retailing	Household /electrical	Clothing/ Fashion	Dept. stores	Cafes and food	Other and services
Large City Mall	32.8%	21.2 %	6.8%	7.8%	11.8%	19.5%
Small Regional Mall	8.8%	8.0%	0.0%	18.6%	17.6%	47.0%

Panel A: Large city mall



Panel B: Small regional mall

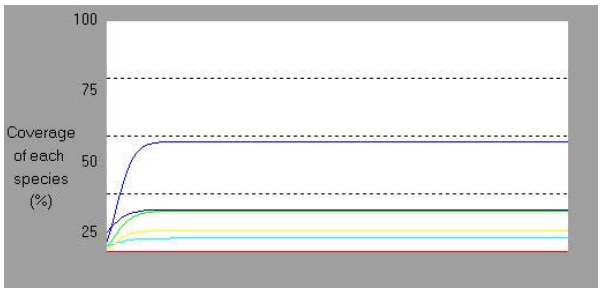


Figure 2: Plot of coverage of each type of retailer in (A) large city malls and (B) small regional malls.

Key:
Food retailing (light blue)
Household electrical (yellow)
Clothing /fashion (red)
Department stores (purple)
Café's and food (green)
Other and services (dark blue)

VI. DISCUSSION

Our model shows that the development of retail structures can be explained by differential growth rates and market size. In terms of the wheel of retailing, this is likely to turn faster in regional areas towards a more limited set of retail outlets than in larger markets and malls. For retail managers the results show that in smaller malls it is possible to have greater market dominance than in a larger setting and that a differential growth pattern in smaller malls results from a different mix of retail options than occurs in larger cities. The concern for regional malls is the early domination by one type of retailer, which limits and threatens diversity, making these smaller malls a less attractive option for consumers than larger city malls. This is similar to the issue

of a dominant species threating the diversity and therefore survival of an interdependent ecological system [29]. The model also estimates the different degrees of coverage of different retail types across large and small malls, results that are similar to the survey data. However, we cannot take into account different input costs (rent and transportation, for example) which would affect smaller regional and large urban malls differently, Nevertheless we have shown that an ecological model can be applied successfully to a business context, producing surprisingly accurate results.

Future development of the model for this context may also include interrelated malls, and the inclusion of empty space, as a field where shops close due to a change in economic conditions or more consumers choosing to buy online. We also used much higher growth rates (x10) as the original model does not allow growth rates less than 1, however, the relativities of growth rates were the same as in the Australian retail sector.

There are many factors that influence the replacement of space in a shopping precinct. The original shop may be suffering a global threat, such as recorded music (almost gone), and bookshops (endangered). It may have suffered from poor management or customer relations. Its replacement might be much more fashionable in some respect, such as a new trend in fast food (think of the growth of sushi). What we can do with a simple dynamic model such as this is to average out multiple factors, to capture the essential dynamics as in this case in physics with the spin glass model of magnetism [35].

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