A Theoretical Approach to Supermarket Chain Investment in Urban Food Deserts

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Introduction

A key factor in the success of a retail firm is the location of its stores. The distance a store is from their distribution channels, competitors and customers all affect their demand, costs and profits. Over the past 30 years, food retail environments have changed, from many small grocery stores widely dispersed in the cities and suburbs to big supermarkets concentrated in suburban areas (Blanchard and Matthews, 2007). This has led to urban food deserts[1] developing in many low-income communities throughout the United States. Research on food deserts emphasize how limited access affects a community's food purchasing behaviors and health, which has then lead to growing interest to address food deserts (Walker et al., 2010, Ball et al., 2009, Dubowitz et al., 2015). Policymakers are calling for supermarkets to open in food desert areas.

There are national, state, and local financing initiatives in place to help improve the availability and quality of healthy foods in low-income communities. The Community Development Financial Institutions (CDFI) fund within the United States Department of Treasury, in collaboration with the United States Department of Agriculture (USDA) and Department of Health and Human Services (HHS), supplement private sector capital with federal money to tackle economically distressed communities through Healthy Food Financing Initiative (HFFI) programs. The HFFI is a national campaign aimed at improving access of healthy food in food desert communities in the US. It is the federal government's first coordinated effort to address the issue of food deserts through business incentives (CDFI, 2017). Over $197 million has been allocated in underserved communities across 35 states through HFFI initiatives since 2011. Some examples of funded initiatives are the: Pennsylvania Fresh Food Financing Initiative; New Jersey Food Access Initiative; Michigan Good Food Fund; New Orleans Fresh Food Retailer Initiative; and the Healthy Food for Ohio (PolicyLink, 2017). These initiatives offer a variety of technical assistance and financial products and services for firms investing in healthy food retail and systems in disadvantaged communities. The HFFI helps attract investment into food deserts through providing one-time financing to help overcome the large initial barriers of entry and offers financial loan terms with lower interest rates, longer maturities and other more flexible terms than what traditional banks offer (CDFI, 2017). Other incentives used to increase investment in food deserts involve tax breaks, zoning bonuses, or an expedited approval processes. Despite all these

[1] The USDA defines an urban food desert as a low income (poverty rate of 20% or higher) urban area where at least one third of the population resides more than a mile away from a supermarket (FNS 2016).

efforts, roughly ten percent of the 65,000 census tracts in the United States and 11.5 million low-income people are living in areas that are classified as food deserts (FNS, 2016, Ver Ploeg et al., 2009).

There are several reasons why supermarkets may be reluctant to locate in urban food deserts, despite the increasing social and political pressure to do so. Market size is a key determinant in retail location decisions; the supermarket must believe that there are enough consumers wanting to and able to buy what they are selling. There is a common perception that consumer demand for healthy foods is low in food desert areas (Andreyeva et al., 2011). One explanation is that healthy foods are generally classified as normal or superior goods so they will be demanded more as income increases and food desert communities are by definition low-income (Bitler and Haider, 2011). Also the lack of storage and cooking options, like refrigerators and stoves in food deserts, limit the purchases of fresh foods that require special storage and cooking (Weatherspoon et al., 2012). Supermarkets also look for population growth in their potential investment locations for long term returns on their investment and food desert communities often have declining or aging populations (Morton and Blanchard, 2007). These factors, along with other demand side factors like high racial minority composition, high unemployment rates, high poverty, high crime rates, low education levels, and low vehicle availability within food deserts make them nontraditional retail environments for supermarket chains (Dutko et al., 2012).

There are also supply side factors that make food deserts less attractive to supermarkets. Logistic and distribution networks (road conditions and distance from pre-existing distribution centers) tend to be worse in food desert communities than suburbs, which leads to higher sourcing costs for the supermarket (Bonanno, 2012). The costs associated with training employees, security, construction and upkeep, and property tax are all higher in urban areas than suburbs (Karpyn et al., 2010). Also in low-income urban areas, large parcels of land are scarce making customer parking, and loading and unloading by distribution trucks more difficult compared to suburban communities (Pothukuchi, 2005). Lastly, many communities that are underserved by supermarkets also lack the amenities and services needed to attract and retain retail investment, such as sidewalks, lighting and good public transportation networks.

There are some potential benefits of operation in a food desert for a supermarket. Underserved communities can serve as a way for supermarket chains to maintain their corporate growth while confronting supermarket saturation in suburban communities (Hagan and Rubin, 2013). Since low-income urban residents spend money on groceries outside of the city limits, there is unmet market potential within the inner cities (Pothukuchi, 2005). Upon entry into a food desert, a supermarket chain faces minimal competition for healthy food sales given that small convenience and corner stores lack the refrigeration and equipment necessary to stock and sell a variety of healthy foods. As a monopoly in the food desert, the supermarket could charge higher prices. Food prices are often higher in food deserts compared to suburbs, on average (Howlett et al., 2015, LeClair and Aksan, 2014). This implies that despite the greater risk associated with operating in a food deserts, there is potential for increased profit.

There is also a corporate public relations benefit associated with entry into a food desert. If a supermarket chain enters these untapped markets they would create jobs, improve nutrition, boost economic activity, increase the city's tax base, increase property values and make the community livelier both directly and through a multiplier process (Winne, 2007, Fife, 2012, Larson, 2003). Supermarket entry can also attract other forms of retail and services into the food desert which will then lead to even further economic community development.

Objective

This study models the supermarket chain's decision making process for entering a food desert to determine: 1) the conditions under which supermarket chains would enter food deserts, and 2) how various interventions and incentives could influence entry. To meet this objective, a game theoretic model of supermarket chain entry into food deserts is developed. The remainder of this section provides a brief literature review. In the next section, the game theoretic model will be presented, followed by a discussion of the implications derived from the game.

Theory and Previous Literature

The United States supermarket industry is classified as a natural oligopoly (Ellickson, 2013); hence, investment decisions as well as many other decisions supermarkets make are often made strategically. Game theory is useful for modelling conditions with interdependent choices. Food desert investment opportunities are not only held by the one supermarket chain, but rather open to any supermarket chain also capable of undertaking the investment, which makes considering competitors optimal responses necessary (Shackleton et al., 2004). This model builds upon previous game theoretic models which assess the decisions of established businesses to either grow through entry into new markets or defer entry to gain more information, in the presence of uncertainty (Folta et al., 2006, Kulatilaka and Perotti, 1998, Rob, 1991).

Some studies have applied game theory to analyze supermarket decisions of entry and pricing (Ellickson, 2007); however, these are not focused in food deserts. A few studies have examined changes in a food desert community before and after a large supermarket enters (Wrigley et al., 2003, Dubowitz et al., 2015). Other papers have empirical or qualitative approaches to explain why supermarkets have not entered food deserts (Bonanno et al., 2012, Pothukuchi, 2005). However, there remains a gap in literature on supermarket strategic investment into food deserts.

Model Formation

The players of the game are two supermarket chains that are able to open a store in a food desert. Both supermarket chain players currently have no stores located in the food desert. According to the Food Marketing Institute website, a supermarket chain consists of 11 or more stores that offer a full line of groceries, meat, and produce with at least $2 million in annual sales per store and up to 15% of their sales coming from general merchandise and health/beauty care. Typically, each store carries between 15,000 to 60,000 stock keeping units and offers a service deli, a service bakery, and/or a pharmacy. The food retail industry is highly concentrated by a few supermarket chains (Wood, 2013). In this environment, the economy of scale (operational costs per unit declines as the store size increases) and scope (operational costs per unit declines with increase in the diversity of products), and the economy of agglomeration (operational costs decline as the number of stores nearby increases) are all significant factors. Small grocery stores and convenience stores struggle to sell the variety and quality of healthy, perishable foods at competitive prices. Hence, only supermarket chains are considered in this analysis since they typically offer lower priced, higher quality goods and can supply an extensive assortment of fresh, nutritious food at competitive prices all year round.

There are two time periods, $t = 1$ and $t = 2$. This model can be easily extended to incorporate more potential entrants as well as infinite time, but a two player, two-time period game is analyzed here for simplification.

The consumer demand for the supermarket offerings follows the linear inverse demand function:

$$P(Q, \theta) = \theta - Q$$

where θ represents the unknown component of demand, similar to other papers found in the literature (Kulatilaka and Perotti, 1998, Zhu and Weyant, 2003). θ is a random variable drawn from a uniform distribution with support [0, 1]. Define the true value of θ as θ^*, which neither supermarket knows in period 1. However, if one or both supermarkets enter the food desert in period 1 then θ^* is revealed to both in the second period.

Branding and product differentiation could provide competitive advantages to supermarkets. Some supermarkets strategically decide to vertically differentiate themselves (through offering more services or higher quality products) so they can soften price competition and gain higher profits from less price sensitive consumers. However, food desert residents are often price sensitive, particularly to fruits and vegetables (Weatherspoon et al., 2015, Weatherspoon et al., 2013), so these types of stores are less likely to consider food desert investment (Bonanno, 2012). Also in uncertain environments, like food deserts, competitive advantages are seldom sustainable in the long run (Sirmon et al., 2007). For these reasons this analysis, assumes the supermarket chains' offerings are homogenous. Another assumption is that both supermarket chains have the same knowledge about the food desert community and that any feasible site provides both chains with an equivalent market potential.

There are three main marginal operating costs supermarkets face: purchasing the goods, distributing the goods, and paying the store workers. Some other examples of marginal operational costs for a large supermarket are insurance, rent, packaging, marketing, and outreach (Anderson et al., 2012). This model rewards early initial investment (in period 1) with lower costs later (in period 2) because it assumes that early investment reduces the future unit costs due to learning, logistic and product developments (Kulatilaka and Perotti, 1998). This cost advantage for early investment could also be a policy initiative. Both supermarkets face the same costs schedule and there are two marginal costs possible: $\overline{c}$ and $\underline{c}$; where $\underline{c} = \overline{c} - \Delta c$. If a supermarket enters the food desert in period 1 it will face the higher costs, $\overline{c}$, in the first period but will face the lower costs, $\underline{c}$, in the second period. If a supermarket enters the food desert in the second period it will face the higher costs, $\overline{c}$. Both firms face the same investment costs, Φ, no matter which period they enter.

Timeline of Game

In period one, both supermarket chains simultaneously decide whether to enter or not.

- If any one firm enters, θ^* is revealed and the entrant will receive a cost advantage in period two.
- If both firms enter, they compete a la Cournot.
- If only one firm enters, it enjoys monopoly power for the period.

In period two, the game depends on the history in period one.

- If no firm has entered in period one, both firms again simultaneously decide whether to enter or not. They do not have any information on θ^*, nor do they enjoy the cost advantage that they would have had if they entered in period one.
- If both firms entered in period one, they continue to compete a la Cournot but now have lower marginal costs, $\underline{c}$.
- If exactly one firm has entered in period one, the other firm first decides whether to enter or not based on the revealed θ^* (but faces the higher marginal costs, $\bar{c}$). The incumbent observes the entrant's decision and a quantity competition follows.
  - If the entrant continues to stay out, the incumbent continues to have monopoly power and lower marginal costs, $\underline{c}$.
  - If the entrant comes in, the two firms compete a la Cournot.

Analysis

The supermarket chain's action sets are to open a store in a food desert (invest) or not (do not invest). The disadvantages of deferment are the missed potential profits while not invested and the missed opportunity for cheaper costs later, while the advantage of deferment is that they can learn more about market demand from observing the first firm and use that knowledge to decide whether to invest or not. Once a supermarket chain has invested, then its action is to choose quantity. Both supermarket chains make decisions to maximize their expected total profit.

Supermarkets operate on thin profit margins (roughly 1% on average), especially on perishable food items (Hagan and Rubin, 2013, FMI, 2017). The profit for each supermarket depends on whether they are invested, whether the other firm has invested, and the market demand. If both supermarkets are in the food desert at time t they will share duopoly profits of Cournot competition. Duopoly profit is dependent on the costs that both firms are facing. If both chains have the same cost (c) at time t then the duopoly profit for firm i in period t is,

$$\pi_{it}^{D}\left(c_i, c_j\right) = \pi_{it}^{D}\left(c, c\right) = \left(\frac{\theta - c}{3}\right)^2.$$

However, if firm i faces the lower cost, $\underline{c}$, and firm j faces the higher cost, $\bar{c}$, at time t then the two duopoly profits are:

$$\pi_{it}^{D}\left(c_i, c_j\right) = \pi_{it}^{D}\left(\underline{c}, \bar{c}\right) = \left(\frac{\theta + \bar{c} - 2\underline{c}}{3}\right)^2 \text{ and,}$$

$$\pi_{jt}^{D}\left(c_i, c_j\right) = \pi_{jt}^{D}\left(\underline{c}, \bar{c}\right) = \left(\frac{\theta + \underline{c} - 2\bar{c}}{3}\right)^2.$$

When there is sequential entry one supermarket chain invests in period 1 (firm leader) and the other does not (firm follower). While the follower is outside the food desert, the leader is a monopoly within the food desert, earning the following monopoly profit,

$$\pi_{it}^{M}(c) = \left(\frac{\theta - c}{2}\right)^2.$$

Table 1 lists the different notation used throughout the game and the analysis. Since the game is completely symmetric (from the homogeneous supermarket assumption) all the equilibria will also be symmetric for both supermarkets.

Characterization of Period Two Subgames

The characterization of the second period subgames depends on the history of the game, i.e. who entered in the first period. The following three lemmas will discuss the three possible cases.

Lemma 1 *If both supermarkets entered in the first period, in the second period they will simultaneously compete a la Cournot with low costs. Their second period payoffs will be:*

$$\left(E\left[\pi_{i2}^{D}\left(\underline{c}, \underline{c}\right)\right], E\left[\pi_{j2}^{D}\left(\underline{c}, \underline{c}\right)\right]\right)$$

Explanation: When both supermarkets invested in period 1, both are still invested in period 2 (since exiting is not an option in the model), but now both will face low marginal costs.

Table 1: Game Notation

Symbol	Description
Δc	cost advantage from investing early
$\underline{c}$	low marginal cost
$\bar{c}$	high marginal cost
Φ	investment costs
$\pi_{it}^{D}(c_i, c_j)$	profit for supermarket i in period t when both supermarkets are in the food desert and firm i is facing costs c_i and firm j is facing costs c_j
$\pi_{it}^{M}(c)$	profit for supermarket i in period t when they are the only supermarket in the food desert and they are facing marginal costs c
θ^*	true demand parameter
$\hat{\theta}$	minimum demand needed for follower entry
r	probability of entry in the first period
s	probability of entry in the second period given that no other supermarket has invested yet
t	probability that the entrant supermarket will invest in the food desert in the second period given that the incumbent already has and θ^* has been revealed

Lemma 2 *If exactly one supermarket entered in the first period, the entry game in the second period always has a unique Pure Strategy Nash Equilibrium (PSNE) and it is characterized as follows: There exists a cutoff value of demand, denoted* $\hat{\theta}$, *such that*

(a) *If* $0 \le \theta^* < \hat{\theta}$, *the entrant will not enter, yielding the second period (incumbent, entrant) payoffs of (*$\mathrm{E}[\pi_{i2}^{M}(\underline{c}) \mid \theta^*], 0$*).*

(b) *If* $\hat{\theta} \le \theta^* \le 1$, *the follower firm will enter, yielding the second period (incumbent, entrant) payoffs of (*$\mathrm{E}[\pi_{i2}^{D}(\underline{c}, \bar{c}) \mid \theta^*], \mathrm{E}[\pi_{j2}^{D}(\underline{c}, \bar{c}) \mid \theta^*] - \Phi$*)*

Where $\hat{\theta}$ *is defined as the* θ *that makes the follower indifferent to entry i.e. when*

$$\mathrm{E}[\pi_{j2}^{D}(\underline{c}, \bar{c}) \mid \theta^*] - \Phi) = 0$$

Explanation: Once one supermarket has invested the true demand is revealed and the entrant supermarket will base their entry decision on whether expected profit will be positive. If the entrant does not enter, the other supermarket will remain a monopoly with low costs. If the entrant does enter both will get duopoly profit where the leader faces low costs and entrant faces high costs.

Lemma 3 *If no entry has taken place in the first period, the entry game in the second period always has a unique Nash equilibrium and it is characterized as follows: There exist two cutoff values of the entry cost,* Φ, *denoted as* $\underline{\Phi}$ *and* $\overline{\Phi}$, *such that:*

(a) *If* $0 \leq \Phi < \underline{\Phi}$, *both supermarket chains invest.*

(b) *If* $\underline{\Phi} \leq \Phi < \overline{\Phi}$, *both supermarket chains use mixed strategies where each enters with probability*

$$s = \frac{9\,(1 - 3\bar{c} + 3\bar{c}^2 - 12\Phi)}{5\,(1 - 3\bar{c} + 3\bar{c}^2)}.$$

(c) *If* $\Phi \geq \overline{\Phi}$, *nether supermarket chain invests.*

Table 2 provides the normal form representation of this subgame where each cell reveals the expected second period profit for the supermarket's actions which are dependent on the other supermarket's action. The Appendix provides the derivations of $\underline{\Phi}$ and $\overline{\Phi}$.

Table 2: Normal Form Game Representation of Period 2 After No Entry in Period 1

		j: Invest (s)	j: Do Not Invest (1-s)
i (s)	**Invest**	$E\left[\pi_{i2}^{D}(\bar{c},\bar{c})\right] - \Phi$ $E\left[\pi_{j2}^{D}(\bar{c},\bar{c})\right] - \Phi$	$E\left[\pi_{i2}^{M}(\bar{c})\right] - \Phi$ 0
i (1-s)	**Do Not Invest**	0 $E\left[\pi_{j2}^{M}(\bar{c})\right] - \Phi$	0 0

Explanation: When investment costs are low enough, entry is profitable even though they must split the market and demand is still unknown, leading to a PSNE with simultaneous period 2 entry. When investment costs are moderate and demand is still unknown (again since no supermarkets invested yet) it is profitable for one supermarket to enter but not both, leading to a Mixed Strategy Nash Equilibrium (MSNE) where $0 < s < 1$. When investment costs are too high it is not profitable for either supermarket to enter even if it would be a monopoly in the food desert, leading to a PSNE of no entry in period 2.

Characterization of Period One

Table 3 shows the normal form representation of the game. Each cell reveals the total profit (over both periods) for the supermarket's actions which are dependent on the other supermarket's action.

Table 3: Normal Form Game Representation of Period 1

		r	**j**	(1-r)
		Invest		**Do Not Invest**
r **i**	**Invest**	$E\left[\pi_{i1}^{D}(\bar{c},\bar{c}) + \pi_{i2}^{D}(\underline{c},\underline{c})\right] - \Phi$ $E\left[\pi_{j1}^{D}(\bar{c},\bar{c}) + \pi_{j2}^{D}(\underline{c},\underline{c})\right] - \Phi$		$E\left[\pi_{i1}^{M}(\bar{c})\right] + E\left[\pi_{i2}^{D}(\underline{c},\bar{c}) \mid \theta^* > \hat{\theta}\right](1 - \hat{\theta}) + E\left[\pi_{i2}^{M}(\underline{c}) \mid \theta^* \leq \hat{\theta}\right]\hat{\theta} - \Phi$ $E\left[\pi_{j2}^{D}(\underline{c},\bar{c}) - \Phi \mid \theta^* > \hat{\theta}\right](1 - \hat{\theta})$
(1-r)	**Do Not Invest**	$E\left[\pi_{i2}^{D}(\bar{c},\underline{c}) - \Phi \mid \theta^* > \hat{\theta}\right](1 - \hat{\theta})$ $E\left[\pi_{j1}^{M}(\bar{c})\right] + E\left[\pi_{j2}^{D}(\bar{c},\underline{c}) \mid \theta^* > \hat{\theta}\right](1 - \hat{\theta}) + E\left[\pi_{j2}^{M}(\underline{c}) \mid \theta^* \leq \hat{\theta}\right]\hat{\theta} - \Phi$		$s^2 * \left(E\left[\pi_{i2}^{D}(\bar{c},\bar{c})\right] - \Phi\right) + s(1-s) * \left(E\left[\pi_{i2}^{M}(\bar{c})\right] - \Phi\right)$ $s^2 * \left(E\left[\pi_{j2}^{D}(\bar{c},\bar{c})\right] - \Phi\right) + s(1-s) * \left(E\left[\pi_{j2}^{M}(\bar{c})\right] - \Phi\right)$

Proposition: *Characterization of the Subgame Perfect Nash Equilibrium*

The entry game in the first period always has a unique Nash Equilibrium and it is characterized as follows:

For a given Φ, there exist two cutoff values of Δc, denoted as $\underline{\Delta c(\Phi)}$ and $\overline{\Delta c(\Phi)}$, such that:

(a) *If $\Delta c > \overline{\Delta c(\Phi)}$, both supermarket chains invest.*

(b) *If $\underline{\Delta c(\Phi)} \leq \Delta c < \overline{\Delta c(\Phi)}$ both supermarket chains use mixed strategies where each enters with probability r.*

(c) *If $\Delta c < \underline{\Delta c(\Phi)}$, nether supermarket chain invests.*

See the Appendix for derivation of the r, $\underline{\Delta c(\Phi)}$ and $\overline{\Delta c(\Phi)}$ values.

Explanation: For a given investment cost, there exists a cost advantage, $\overline{\Delta c(\Phi)}$, such that if the cost advantage is greater, then it is profitable for both supermarkets to enter in the first period, even with the demand uncertainty present. If the cost advantage is between $\underline{\Delta c(\Phi)}$ and $\overline{\Delta c(\Phi)}$ then it is only profitable for one supermarket to enter in period 1 with the demand uncertainty; so, both supermarkets will play a MSNE. If the cost advantage is less than $\underline{\Delta c(\Phi)}$, then it is not profitable even for one supermarket to be invested with monopoly power in the first period; so, neither supermarket will enter. As the cost advantage increases it becomes more profitable to invest early, despite the uncertainty of demand. Figure 1a plots Φ against Δc for the case where $\bar{c} = 0.25$ and distinguishes the different regions of entry in period 1. It reveals that unless the cost advantage is very low and investment costs are very high, both supermarkets will invest in period 1 with a positive probability.

Figure 1b is the same as Figure 1a but with an additional curve. This curve represents the follower's entry decision once the true demand has been revealed (in figure $\theta^* = 0.9$). Their profit is dependent on the cost advantage indirectly through the duopoly profits where the leader has the cost advantage and they do not; hence the higher the cost advantage the leader has, the lower the follower profit. When the true demand is known, the follower will enter when the cost advantage is low enough and the investment costs are low enough for them to be profitable.

Figure 1a: Period 1 Investment Decisions (given $\bar{c} = 0.25$)

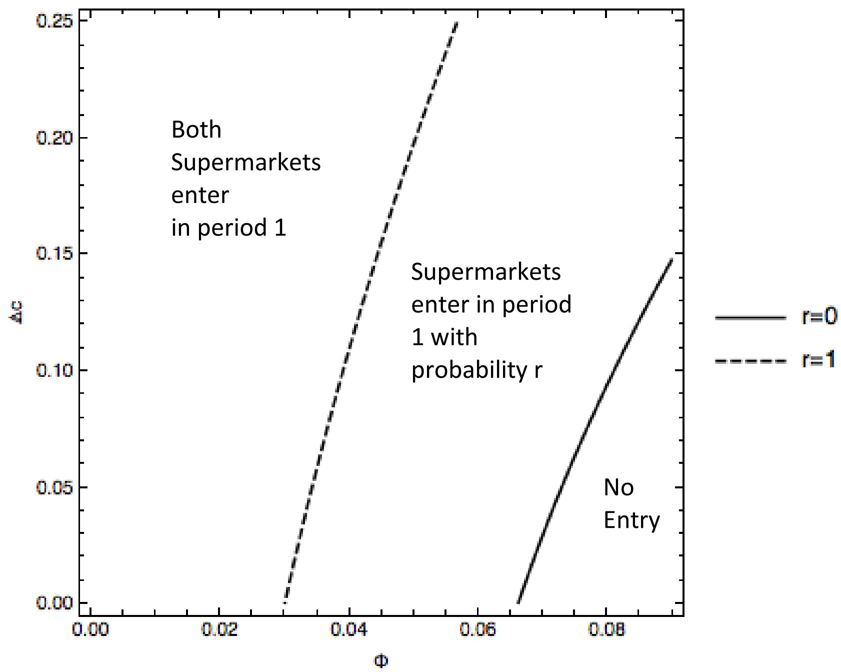
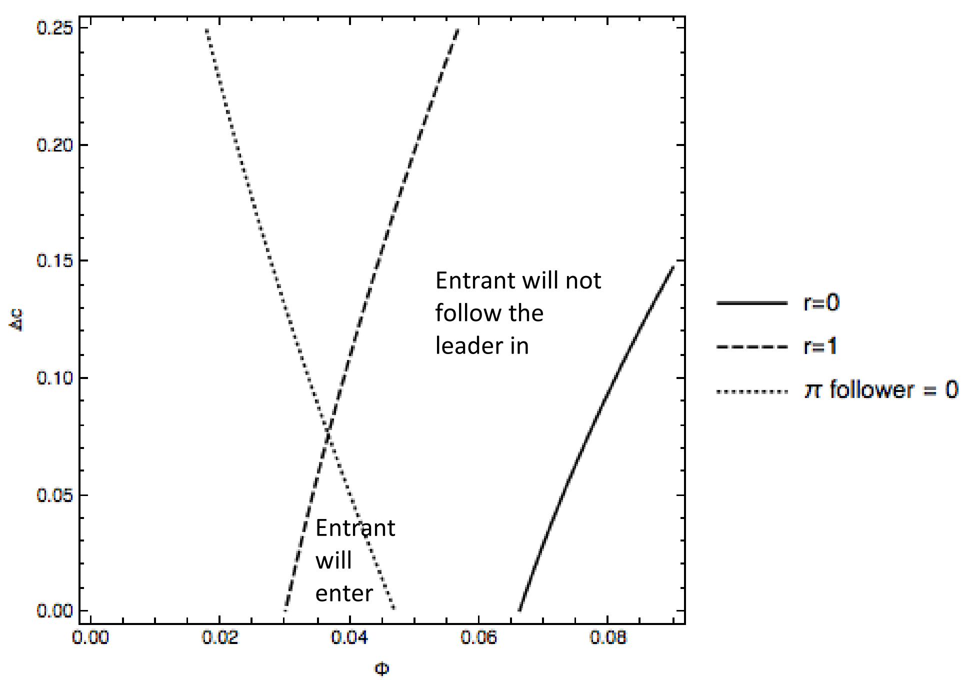


Figure 1b: Entrant Investment Decision (given $\bar{c} = 0.25$ and $\theta^* = 0.9$)



Examination of Entry Probabilities

There are three probabilities of interest in this analysis. First is the probability that a supermarket will invest in the food desert in the first period (r). Second is the probability that a supermarket will enter in the second period given that there was no entry in the first period (s). Lastly, if one supermarket invests in the first period, there is the probability that the entrant supermarket will follow the incumbent supermarket into the food desert (t).

Figure 2 displays how changes in the investment cost (Φ) affect the three entry probabilities with fixed $\bar{c} = 0.25$ and $\Delta c = 0.1$. All three probabilities are decreasing as the investment costs increase, the second period entry probability following no entry (s) decreases at a constant rate while the probability of first period entry (r) and sequential entry after leader (t) decrease at a decreasing rate. Both probabilities of second period entry (s and t) become 0 over the possible investment costs; however, the probability of sequential entry (t) reaches 0 at a higher investment cost value than the probability of late entry after no entry (s). This implies that supermarkets are willing to accept higher investment costs in the second period if they are not among the first to invest, since the demand uncertainty is resolved.

Figure 2. Investment Cost Effect on the Entry Probabilities: r (first period entry), s (second period initial entry), and t (sequential entry after leader) with fixed $\bar{c} = 0.25$ and $\Delta c = 0.1$

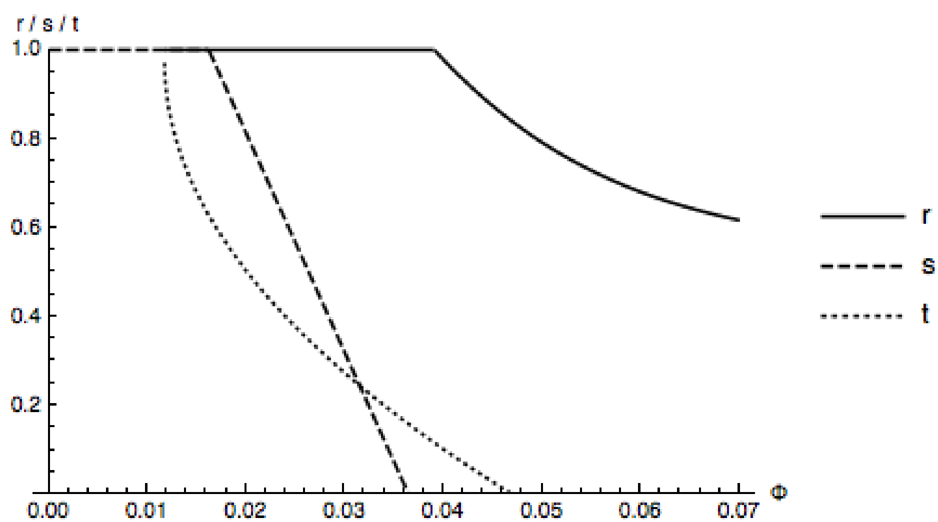
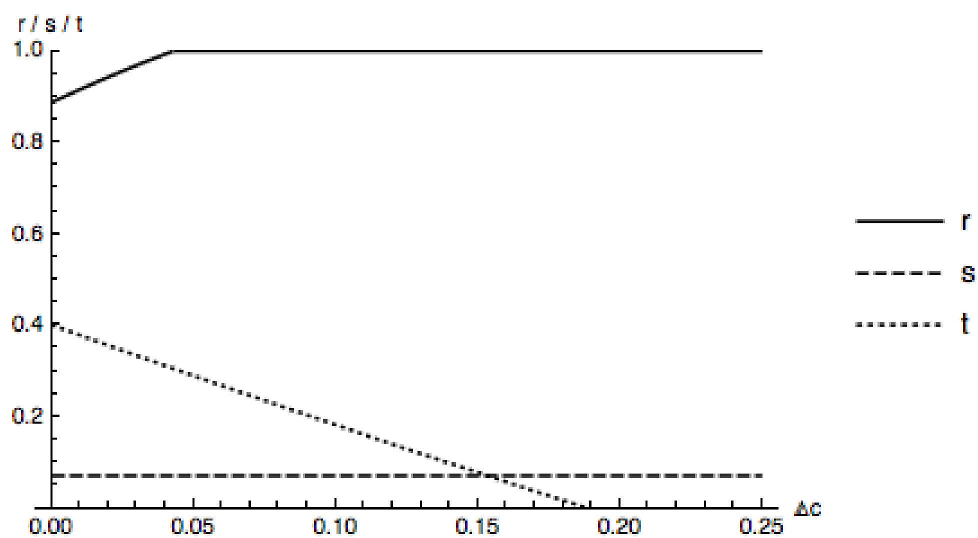


Figure 3 displays how changes in the cost advantage from early investment (Δc) affect the three entry probabilities with fixed $\bar{c} = 0.25$ and $\Phi = 0.035$. As the cost advantage from early investment increases, the probability that a supermarket will invest in the food desert in period 1 (r) increases at a constant rate and then levels off at 1. This means that if the cost advantage is above a certain threshold both supermarkets have a PSNE to enter in period 1 (recall Proposition). The probability of the entrant supermarket following the incumbent into the food desert (t) decreases as the cost advantage increases since the higher the cost advantage is, the more disadvantaged the entrant is compared to the incumbent. The probability of investment in the second period following no investment (s), is not dependent on Δc, since the cost advantage is no longer available to either supermarket; hence it is represented by the horizontal line in the figure.

Figure 3. Cost Advantage from Early Investment Effect on the Entry Probabilities: r (first period entry), s (second period initial entry), and t (sequential entry after leader) with fixed $\bar{c} = 0.25$ and $\Phi = 0.035$



Discussion

There are three major findings from this analysis of supermarket chain entry into an urban food desert. First, supermarkets will invest if the investment costs are low enough. Two, cost advantages for early investment are effective at speeding up initial entry. Lastly, earlier entry is better for both supermarkets (and the food desert community) than later or no entry. Both supermarkets would have higher expected profit as a leader than as a follower; however, as a leader they face the demand uncertainty and as a follower they do not. If simultaneous entry is to occur it will happen in period 1 rather than in period 2 because the benefit of waiting is demand revelation which will not occur if neither invests in the first period.

Though the grocery store industry is a huge industry that is relatively resilient in times of economic downturn (Hagan and Rubin, 2013), food deserts are still of great concern. In 2011, as part of the Obama Administration's healthy eating initiative, major supermarket chains promised to open stores in or around food desert communities by 2017; however, many still have yet to invest (AssociatedPress, 2017). A few supermarket chains have entered food desert communities profitably and were able to acquire customer loyalty. These successful cases were supermarkets that adjusted their services to effectively serve their respective communities. Most successful entry cases offer added services and perks, like a pharmacy, community center, credit union, staff nutritionists, social workers and a health clinic all inside the store since these communities are often deficient in these too (Singh, 2015). Communicating with community leaders before entry can reveal other examples of services to offer, such as shuttle rides home, calculators on the shopping carts, and bi-lingual employees (Pothukuchi, 2005, Singh, 2015).

Our model finds that supermarket entry will occur once investment costs and marginal costs are low enough. Our model also shows that cost advantages from early investment are effective, which might be just what is needed to incentivize investment. In general, when a firm faces no competition, demand uncertainty negatively influences their decision to enter. Conversely, whenever there are competitive advantages associated with earlier entry the effect of demand uncertainty becomes ambiguous and dependent on the firm's relative valuations of the cost of uncertainty and early mover advantages (Folta and O'Brien, 2004). Supermarkets place value on the removed demand uncertainty (seen through their willingness to accept higher investment costs in the second period if another supermarket has invested profitably). The results seem to support the theory of supermarket inertia (Dilling, 2014). That is, even if supermarkets think it may be profitable to enter the food desert, they are hesitant because their competitors have not invested. Another theoretical principle in retail location theory supported by the results is the Principle of Minimum Differentiation, which originates from Hotelling's famous hypothesis that retailers that sell similar merchandise tend to cluster together (Clarkson et al., 1996, Hotelling, 1990).

Without the urgency attached with the cost advantage supermarkets will continue to hold out for another supermarket to enter first to remove the uncertainty involved with being first. Initiatives should consider offering incentives, like cost advantages, but for only the supermarkets who invest first in a food desert, to help initiate early entry. The first supermarket that enters the food desert is essentially providing a positive externality to the market. They take on the full cost of unknown demand but do not fully internalize the benefits if other supermarkets also enter after. The cost advantage initiative can help decrease the costs the leader faces to incentivize early entry.

The other policies / initiatives which are currently in place through the HFFI (one-time financing, lower loan interest rates, and tax breaks) would all be more effective at incentivizing entry if they were only offered to the supermarket chains who invest early.

Appendix

Proof of Lemma 3: The Derivation of $\underline{\Phi}$ and $\overline{\Phi}$

The $\underline{\Phi}$ value is the Φ that makes even having duopoly profit with the high costs profitable in the food desert. Hence $\underline{\Phi}$ is the maximum value such that

$$0 \leq \mathrm{E}\left[\pi_{i2}^{D}\left(\bar{c},\bar{c}\right)\right] - \Phi \quad \text{which is when} \quad 0 = \mathrm{E}\left[\pi_{i2}^{D}\left(\bar{c},\bar{c}\right)\right] - \Phi.$$

Hence,

$$\mathrm{E}\left[\pi_{i2}^{D}\left(\bar{c},\bar{c}\right)\right] = \mathrm{E}\left[\left(\frac{\theta-\bar{c}}{3}\right)^{2}\right] = \Phi$$

which implies

$$\underline{\Phi} = \frac{1}{27}\left(1 - 3\bar{c} + 3\bar{c}^{2}\right).$$

The $\overline{\Phi}$ value is the Φ that makes having monopoly power with the high costs unprofitable in the food desert. Hence $\overline{\Phi}$ is the minimum value such that

$$0 \geq \mathrm{E}\left[\pi_{i2}^{M}\left(\bar{c}\right)\right] - \Phi \quad \text{which is when} \quad 0 = \mathrm{E}\left[\pi_{i2}^{M}\left(\bar{c}\right)\right] - \Phi.$$

Hence,

$$\mathrm{E}\left[\pi_{i2}^{M}\left(\bar{c}\right)\right] = \mathrm{E}\left[\left(\frac{\theta-\bar{c}}{2}\right)^{2}\right] = \Phi$$

which implies

$$\overline{\Phi} = \frac{1}{12}\left(1 - 3\bar{c} + 3\bar{c}^{2}\right).$$

Proof of Proposition: The derivation of the r, $\underline{\Delta c(\Phi)}$ and $\overline{\Delta c(\Phi)}$ values.

The probability r is probability associated with the MSNE of the first period game. It is the probability that makes a supermarket indifferent between entering and not entering in the first period given that the other supermarket will also enter with probability r.

The probability r is the solution to the following:

$$\text{rE(simultaneous entry in period 1)} + (1-\text{r})\text{E(leader profit)}$$
$$= \text{rE(follower profit)} + (1-\text{r})(\text{s}^2 * \text{(simultaneous profit in period 2)}$$
$$+ \left(\text{s}(1-\text{s})\right)\text{(monopoly profit in period 2))}$$

which is equivalent to

$$\text{r}\ \left[\text{E}\left[\pi_{i1}^{D}\,(\bar{c},\bar{c}) + \pi_{i2}^{D}\left(\underline{c},\underline{c}\right)\right] - \Phi\right] +$$
$$(1-\text{r})\ [\text{E}\left[\pi_{i1}^{M}\,(\bar{c})\right] + \text{E}\left[\,\pi_{i2}^{D}\left(\underline{c},\bar{c}\right) \,\middle|\, \theta^* > \hat{\theta}\ \right](1-\hat{\theta}) + \text{E}\left[\,\pi_{i2}^{M}\left(\underline{c}\right) \,\middle|\, \theta^* \le \hat{\theta}\ \right]\hat{\theta} - \Phi]] =$$
$$\text{r}\left[\text{E}\left[\,\pi_{i2}^{D}\left(\bar{c},\underline{c}\right) - \Phi \,\middle|\, \theta^* > \hat{\theta}\ \right]\left(1-\hat{\theta}\right)\right] +$$
$$(1-\text{r})\ [\text{s}^2 * \left(\text{E}\left[\pi_{i2}^{D}\,(\bar{c},\bar{c})\right] - \Phi\right) + \text{s}(1-\text{s}) * (\text{E}\left[\,\pi_{i2}^{M}\,(\bar{c})\right] - \Phi)]$$

which then implies

$$\text{r} = \frac{13 - 108\Phi + \Delta c^2\left(48 - 21\hat{\theta}\right) + 5\hat{\theta}^3 + 3\bar{c}^2\left(13 + 5\hat{\theta}\right) + 3\Delta c\left(8 + \hat{\theta}^2\right) - 3\bar{c}(13 + 5\hat{\theta}^2 + 2\Delta c(8 + \hat{\theta})}{9 + 27(\bar{c} - 1)\bar{c} + 48\Delta c^2 - 108\Phi + 3\hat{\theta}\left((\bar{c} - 11\Delta c)(\bar{c} + \Delta c) + 36\Phi\right) - 3(\bar{c} - 5\Delta c)\hat{\theta}^2 + \hat{\theta}^3}$$

The $\underline{\Delta c(\Phi)}$ and $\overline{\Delta c(\Phi)}$ values are the values that make the MSNE r probability equal 0 and 1, respectively, making the equilibrium a PSNE.

$\underline{\Delta c(\Phi)}$ is the Δc value that makes r = 0 so

$$\underline{\Delta c(\Phi)} = \frac{48\bar{c} - 24 - 3\hat{\theta}^2 + 6\bar{c}\hat{\theta} + \sqrt{(24 - 48\bar{c} - 6\bar{c}\hat{\theta} + 3\hat{\theta}^2)^2 - 4(48 - 21\hat{\theta})(13 - 39\bar{c} + 39\bar{c}^2 - 108\Phi + 15\bar{c}^2\hat{\theta} - 15\bar{c}\hat{\theta}^2 + 5\hat{\theta}^3)}}{2(48 - 21\hat{\theta})}$$

$\overline{\Delta c(\Phi)}$ is the Δc value that makes r = 1 so

$$\overline{\Delta c(\Phi)} = \frac{12\bar{c} - 6 + 3\hat{\theta}^2 - 6\bar{c}\hat{\theta} + \sqrt{3}\sqrt{12 - 48\bar{c} + 48\bar{c}^2 - 4\hat{\theta} + 36\bar{c}\hat{\theta} - 60\bar{c}^2\hat{\theta} - 12\hat{\theta}^2 + 24\bar{c}\hat{\theta}^2 + 108\Phi\hat{\theta}^2 - \hat{\theta}^4)}}{6\hat{\theta}}$$

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