A Real-options Approach to Modeling Investments in Competitive, Dynamic Retail Markets

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Abstract

The proliferation of retail outlets with nearly identical product offerings and similar costs due to market efficiency means that selecting an appropriate market to open a store is a critical decision for a retailer. It is an investment decision that is usually long-term and partially irreversible and can have a significant impact on market share and profitability of a retailer. In this paper, we look at retail market analysis from a theoretical investment perspective to overcome some of the limitations of marketing research. The objective of this paper is to present an integrated investment model that can be used to explore retailers' behaviors in competitive, dynamic markets. By use of this option-based model the impression that the small discount retailer invests earlier in a new developing market is confirmed.

1. Introduction

The proliferation of retail outlets with nearly identical product offerings and similar costs due to market efficiency means that selecting an appropriate market to open a store is a critical decision for a retailer. It is an investment decision that is usually long-term and partially irreversible and can have a significant impact on market share and profitability of a retailer [1, 2].

In addition to price and promotion, market selection is considered as one of the basic elements in defining retailer market strategy [3]. In the highly competitive, dynamic retail business, market selection is one of the most important instruments that a retailer has to improve its profitability. Thus, many retailers indicate the need for substantiate analytical models to base retail market decision-making on [4, 5].

There is an extensive body of research in marketing that deals with retail store market analysis (for a more complete review see [1, 3]). This body of research primarily deals with the determination of the most significant factors that derive store performance. Unfortunately, this body of research does not explore retailers' behaviors in competitive, dynamic markets from an investment perspective.

In this paper, we look at retail market analysis from a theoretical investment perspective. The objective of this paper is to present an integrated investment model that can be used to explore retailers' behaviors in competitive, dynamic markets. At a particular time, a retailer has a possibility to invest or not to invest in a new developing market. An investment can be open of a new store. By application of this model the best time to invest can be determined.

We use this model to explore how retailers' different fixed and variable costs determine their investment behaviors in competitive, dynamic markets. Particularly, by use of our model the impression that the small discount retailer invests earlier in a new developing market is confirmed. This paper is structured as follows.

A brief background of investment analysis theory and Net Present Value (NPV) is provided in section two. An investment evaluation process based on Net Option Value (NOV) is chosen to be used to valuate retailers' investment opportunities in dynamic, uncertain markets.

In section three, we present an integrated approach to evaluate retailers' investment opportunities based on their NOVs. First, we use a game-theory model to address competition in retail markets and show how retailers determine the values of their decision variables in these competitive markets. Second, we use a lattice model to address the dynamic uncertainty of retail markets. Finally, we integrate this game-theory formulation into the lattice model to evaluate retailers' investment behaviors as a decision tree. A simple numerical example is also provided to elaborate this investment analysis approach.

In section four, we set up a case to explore how the differences between retailers' fixed and variable costs impact their investment behaviors in a competitive, dynamic market. Conclusions and future work are discussed in section five.

2. Background

Opening a store in a competitive, dynamic market is an important decision for a retailer due to the required initial investment outlays that are usually substantial and partially irreversible. Traditionally, retailers use conventional Discounted Cash Flow (DCF) investment analysis approaches such as NPV to decide whether to open a store in a market. This approach is based on estimating the expected future cash flows that are derived from opening stores in the prospective markets.

However, the NPV approach to evaluate investments in retail markets is insufficient to capture several features of retailers' behaviors in competitive, dynamic markets. For instance, a retailer may defer his entry decision to observe how a dynamic, uncertain market evolves. This retailer may invest early in a new developing market to preempt opponents.

Therefore in the next section, we present an alternative investment analysis approach that addresses a retailer's timing decision to enter a dynamic, uncertain market in the face of competition of other retailers. This alternative approach is based on NOV instead of NPV and is capable of evaluating retailers' investment opportunities in competitive, dynamic markets under uncertainty.

NOV is used in this paper as our investment analysis methodology since it expands the static NPV valuation of the expected future cash flows by introducing the option premium to incorporate the value of flexibility and growth opportunities in an uncertain environment [6].

The major differences between these two investment approaches NPV and NOV can be summarized as follows.

- Uncertainty in the future cash flows: with regular NPV analysis this uncertainty is accounted for by adjusting the discount rate (using e.g. the cost of capital) or the cash flows (using certainty equivalents). This method does not properly account for changes in risk over a lifecycle of an investment opportunity and fails to appropriately adapt the risk adjustment. With NOV analysis, uncertainty inherent in investments is usually accounted for by risk neutral probabilities (a technique known as the equivalent martingale approach). Using standard methods, cash flows can then be discounted at the risk-free rate [7].

- Management flexibility in investment timing: the time that a retailer opens a store in a dynamic market is assumed to be given for the NPV analysis, i.e., it is an exogenous parameter in the NPV approach. The optimal entry time to a dynamic market can be determined in the NOV analysis, i.e., it is one of the retailer's decision variables and is an endogenous parameter in the NOV analysis.
- Strategic valuation of a retail store in a competitive market: with NPV analysis the strategic effects of competition in a retail market is simply captured by adjusting the cash flows. A game theory approach can be integrated into the real options framework to capture the competition effects in retail markets.

Hence, the NOV approach forces decision makers to be more explicit about the assumptions underlying their projections. In addition, the NOV approach helps the decision maker to include the value of his managerial flexibility in store evaluation and avoids the undervaluation that may occur due to using the NPV approach. In the next section, we describe our investment valuation model that can be used to study retailer behaviors in competitive, dynamic market.

3. Investment valuation

In this section, we outline an integrated investment analysis approach to evaluate retailers' investment opportunities based on their NOVs. This approach combines game theory and lattice approximation in a decision tree to determine retailers' investment behaviors in competitive, dynamic markets. Three issues are discussed in this section.

First, we present a game theory approach to address competition in retail markets. This approach shows how retailers determine their optimal quantities of goods in a competitive market. The game theory approach makes it possible to take the connections between the decisions of two retailers into account. Secondly, we present a trinomial lattice model to approximate the dynamic uncertainty of retail markets. This lattice model is required to approximate a Geometric Brownian motion. Finally, we integrate the game-theory approach into the lattice model to evaluate retailers' investment behaviors as a decision tree. A simple numerical example is provided to elaborate this investment analysis approach.

3.1. Competition in retail markets: a game theory approach

In this section, we present a game theory approach to address competition in retail markets. The objective is to show how a retailer determines his decision variable the optimal quantity of products in a competitive market considering the other retailer's decision. The game theory approach is used for this purpose.

For simplicity, we consider two retailers that have options to open stores in a new developing market. Currently there is no other retailer in this market. The case for more than two retailers has left for future research. We assume that all customers in this retail market have identical tastes and income levels. In addition, these two retailers provide identical products and services to their customers, i.e., customers do not differentiate between these two retailers and are indifferent to purchase their needs from either of them.

To facilitate modeling the demand side of the retail market, we use a typical product that both retailers offer. It is assumed that there is one single price for this product in this market at time t (denoted by $P(t)$). The price of this product is determined based on the total quantity of the product offered by two retailers to this market at time t (denoted by $TQ(t)$), i.e., retailers decide to offer a certain numbers of the product to this market, which in turns determine the price of the product in this market. The inverse relationship between price $P(t)$ and total quantity $TQ(t)$ is modeled by the following linear demand function as shown in Figure 1:

$$P(t) = -\gamma TQ(t) + X(t) \quad (1)$$

where γ represents the absolute constant slope of the price-quantity line and $X(t)$ represents the intercept of this line that changes over time.

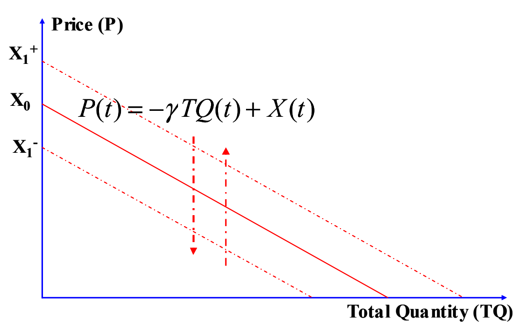

Figure 1. Demand model (Price-Quantity inverse linear relationship)

Therefore, both retailers have two decisions to make. First, they have to decide when they should open their stores in this new developing market. This decision is discussed in 3.2 and 3.3. The second decision is about the optimal quantities of goods that retailers should offer to this competitive market (denoted by $(Q_1^*(t), Q_2^*(t))$) when the stores are open. Each retailer determines his optimal quantity of goods in order to maximize his instantaneous profit considering the competition effect. Retailers' instantaneous profit functions can be written as:

$$\Pi_i(t) = (P(t) - VC_i)Q_i(t) - FC_i \quad i = 1,2 \quad (2)$$

Where, $\Pi_i(t)$ is retailer i's instantaneous profit at time t, $Q_i(t)$ is retailer i's quantity that he decides to provide to this market at time t, VC_i is retailer i's constant variable cost , FC_i is retailer i's constant fixed cost, and $P(t) = -\gamma(Q_1(t) + Q_2(t)) + X(t)$ is the price of this product at time t based on (1).

First, consider a duopolistic market. Both retailers simultaneously determine their quantities $(Q_1(t), Q_2(t))$ in order to maximize their profits $(\Pi_1(t), \Pi_2(t))$. The optimal values of retailers' quantities $(Q_1^*(t), Q_2^*(t))$ and their corresponding optimal profits $(\Pi_1^*(t), \Pi_2^*(t))$ are determined based on Cournot-quantity competition [8] as:

$$\begin{cases} Q_1^*(t) = \dfrac{VC_2 - 2VC_1 + X(t)}{3\gamma} \\ Q_2^*(t) = \dfrac{VC_1 - 2VC_2 + X(t)}{3\gamma} \end{cases} \quad (3)$$

$$\begin{cases} \Pi_1^*(t) = \frac{2}{9\gamma}(X(t))^2 \\ \qquad + \frac{1}{3\gamma}(VC_2 - 2VC_1)(X(t)) \\ \qquad + \frac{1}{9\gamma}(VC_2 - 2VC_1)^2 - FC_1 \\ \Pi_2^*(t) = \frac{2}{9\gamma}(X(t))^2 \\ \qquad + \frac{1}{3\gamma}(VC_1 - 2VC_2)(X(t)) \\ \qquad + \frac{1}{9\gamma}(VC_1 - 2VC_2)^2 - FC_2 \end{cases} \quad (4)$$

when
$X(t) \geq \max((VC_2 - 2VC_1), (VC_1 - 2VC_2))$
, i.e., $Q_i^*(t) \geq 0$.

Now consider a monopolistic market, in which there is one retailer for instance, retailer i. Similarly, retailer i's optimal quantity $Q_i^*(t)$ and his respective optimal profit $\Pi_i^*(t)$ in the monopolistic market can be determined as:

$$Q_i^*(t) = \frac{X(t) - VC_i}{2\gamma} \quad (5)$$

$$\Pi_i^*(t) = \frac{1}{4\gamma}(X(t))^2 + \frac{1}{2\gamma}VC_i X(t) + \frac{1}{4\gamma}VC_i^2 - FC_i \quad (6)$$

when $X(t) \geq VC_i$, i.e., $Q_i^*(t) \geq 0$.

The above game theory approach determines retailers' optimal quantities in a competitive market at time t. It can be seen that retailers' quantities change as $X(t)$ changes over time. Retailers' quantities also depend on their decisions of when to open their stores, which in turn depend on $X(t)$. In the next section, we present a lattice model to approximate the dynamic changes of $X(t)$ in a systematic discrete fashion to handle this investment timing problem.

3.2. A trinomial lattice model

In this section, we use an approximate trinomial lattice to model the dynamic uncertainty of retail markets in a discrete random walk fashion. This lattice formulation simplifies the evaluation of retailers' investment opportunities and facilitates the determination of retailers' investment decisions as a decision tree problem.

The dynamics of retail market uncertainty is included in the linear demand model. As $X(t)$ changes over time the demand curve shifts up and down, as shown in Figure 1. $X(t)$ can be considered as the shock parameter in the demand model that describes the stochastic nature of the retail market. $X(t)$ can be modeled as a geometric Brownian motion:

$$dX = \alpha X dt + \sigma X dz \quad (7)$$

Where dz is an increment of a Wiener process, α is the drift parameter, and σ is the volatility.

It turns out that this geometric Brownian motion can be approximated via a discrete random walk process. Particularly we use a trinomial approximating approach that is described in [9] for valuing options on one state variable. Figure 2 shows how this approximation can be used to represent the dynamic changes of $X(t)$, which is a continuous stochastic variable, in a discrete fashion.

Assume that the value of $X(t)$ at the beginning of the first period is X_0. For the next period, this value may increase by the ratio of u, stay constant, or decrease by the ratio of $(d = 1/u)$ with probability p_1, p_2, and p_3, respectively. This pattern continues for the subsequent periods until it reaches the period in which the option becomes expired. If the time step used is small enough and the process occurs over a long enough time, a trinomial lattice can be a fairly accurate representation of geometric Brownian motion [9]. With the trinomial lattice, the probability distributions become discrete, and the investment option can be valued as a decision tree.

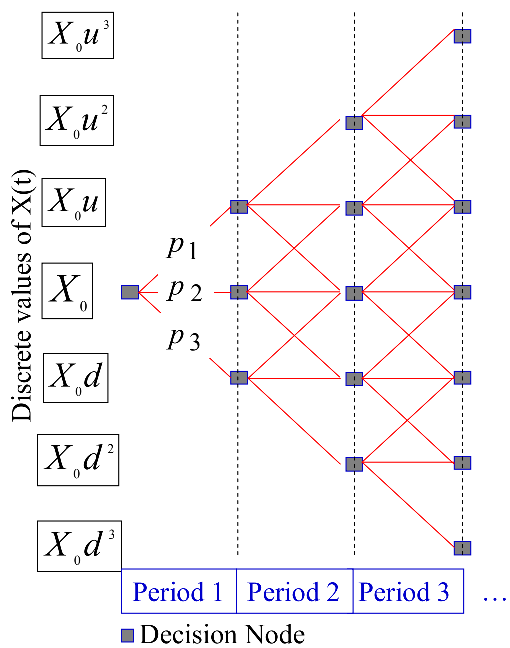

Figure 2. Lattice structure and decision tree

In addition, this lattice representation can be used as a decision tree to determine retailers' decisions in this competitive, dynamic market. Each node in this lattice represents a decision node for both retailers. Retailers decide to whether open a store or delay their investment opportunities with respect to the value of $X(t)$ at that node. Decisions about their optimal quantities follow this decision too. A detailed procedure of solving this decision tree is presented in the section 3.3.

To specify the lattice completely, we must define appropriate the values for the probabilities (p_1, p_2, p_3) and the jump parameters (u, d). These should be chosen in such a way that both the true stochastic nature of demand in the retail market and the risk aversion attitudes of retailers are captured as faithfully as possible. We use a standard option pricing technique, denoted by contingent claims analysis, for this purpose [7]. Therefore, the discrete risk-neutral probabilities (p_1, p_2, p_3) and the jump ratios (u, d) can be determined based on r (risk-free rate), δ (rate of return shortfall), and σ (instantaneous volatility of $X(t)$). The details of this approximate formulation can be found in [9].

Next we explain how this lattice can be used as a decision tree to explore retailers' investment behaviors and determine their decision variables including investment timings and quantities. We use an illustrative numerical example for our purpose.

3.3. An integrated investment analysis approach to evaluate retailers' investment behaviors

In this section, we use a simple example to illustrate how the game-theory approach can be integrated in the lattice model to explore retailers' investment opportunities and determine their decisions as a decision tree problem.

This example is to illustrate two retailers' behaviors in a competitive, dynamic market. The objective is to show how we can determine retailers' decisions (entry times and optimal quantities) using an integrated game-theory option-based approach.

In this example, we consider a competitive, dynamic retail market, in which both retailers have the options to open stores for a period of one month. Each retailer can open a store either at the beginning of this month (time 0) or waits and delays his investment opportunity to the end of this month (time1). After a retailer opens a store the store remains open for ever.

The following notional values are assumed as typical values for our model parameter: $\alpha = 12\%$ per year, $r = 12\%$ per year, $\delta = 10\%$ per year, $\sigma = 0.1\%$ per year, $\gamma = 1$, $VC_i = \$100.00$, $FC_i = \$100{,}000.00$, and $IC_i = \$200{,}000.00$ where $i = 1,2$ and IC_i is retailer i's constant initial investment outlays to open a store in this market. Note that the estimation procedure to define the values of the above parameters using real market data has left for future research.

It is assumed that the dynamic component of demand model in this retail market $X(t)$ changes according to a Geometric Brownian motion with parameters $\alpha = 12\%$ and $\sigma = 0.1\%$ per year. Figure 3 shows the approximate lattice representation of $X(t)$ over a period of one month. The initial value of $X(t)$ is assumed to be $X_0 = 620$ at time 0. The risk-neutral probabilities and the jump values are calculated using a standard trinomial approximation as described in 3.2 with respective to the above notional values of r, σ, and δ. Hence, at the end of this investment period $X(t)$ may rise to $X_1^+ = 640$ with probability $p_1 = 0.43$, stay constant at $X_1^c = 620$ with probability $p_2 = 0.17$, or drop to $X_1^- = 600.43$ with probability $p_3 = 0.40$.

The described one-period trinomial lattice in Figure 3 can be used as a decision tree to determine the retailers' decisions in this market. At time 0 when $X_0 = 620$ each retailer has a decision to make: invests and opens a store in this market or delays his investment opportunity to time 1. At any of the three levels of $X(t)$ at time 1, each retailer also has a decision to make: invests and opens a store in this market or drops his investment opportunity to open a store in this market. Therefore, to explore a retailer's investment behavior at each lattice node we need to determine at what node in this decision tree a retailer should open a store and what his optimal quantities should be when he has an open store in this market.

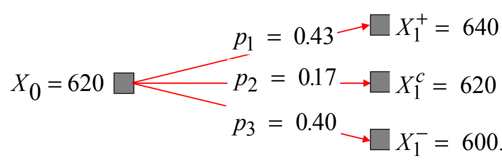

Figure 3. Dynamic changes of the retail market and the risk neutral probabilities of our illustrative example

A retailer should make his entry and optimal quantity decisions with respect to the actions from his competitor. Therefore, we use a game theory approach to address competition between two retailers and determine retailers' decisions in the equilibrium state of the market.

Each retailer has two actions at each node: invest or not to invest. Therefore, there is a two-by-two game between retailers at each node that represents four market structures. The possible market structures are summarized as follows. Both retailers invest, none of the retailers invest, retailer 1 invests and retailer 2 does not invest, and retailer 2 invests and retailer 1 does not invest.

Retailers' outcomes at each node should be determined for any of the above market structures. Retailers' outcomes are retailers' expected NPVs that are derived from retailers' decisions in any of the above market structures. The stable state of the market at each node is the Nash equilibrium [8] of the game between retailers at that node. Figure 4 shows the game between the two retailers in this dynamic market as a decision tree. The details of calculation are summarized below.

Starting from time 1 we determine retailers' expected NPVs under these four market structures at the final nodes. The values are summarized in 2X2 tables as shown in Figure 4. If both retailers do not invest retailers' NPVs become zero for all three levels of X_1 at time 1 as shown in the D-D cells of these tables.

If both retailers invest at time 1 the market structure becomes duopoly. The retailers' optimal quantities of goods in the duopoly market were already calculated in 3.1 and specified in equation (3). The retailers' optimal instantaneous profits were also determined in 3.1 and specified in equation (4). These optimal profits construct retailers' cash flows that must be discounted appropriately to determine retailers' expected NPVs. We must use standard methods of stochastic calculus to compute retailers' expected NPVs since an important part of retailers' profit functions $X(t)$ follows a Geometric Brownian motion. Retailers' expected NPVs are summarized in equation (8) when $X(t) = X_1$. Interested reader can find the details of how we derive this equation in [10]. Based on equation (8) retailers' NPVs are calculated at the three levels of X_1 and the values are shown in the I-I cells of the tables in Figure 4.

$$\begin{cases} (NPV_1)_1 = \dfrac{2X_1^{\,2}}{9\gamma(2\delta-(r+\sigma^2))} \\ +\dfrac{VC_2-2VC_1}{3\gamma\delta}X_1 \\ +\dfrac{1}{r}\left(\dfrac{(VC_2-2VC_1)^2}{9\gamma}-FC_1\right)-IC_1 \\ (NPV_2)_1 = \dfrac{2X_1^{\,2}}{9\gamma(2\delta-(r+\sigma^2))} \\ +\dfrac{VC_1-2VC_2}{3\gamma\delta}X_1 \\ +\dfrac{1}{r}\left(\dfrac{(VC_1-2VC_2)^2}{9\gamma}-FC_2\right)-IC_2 \end{cases} \tag{8}$$

Next, we need to determine retailers' NPVs under the other two market structures: retailer 1 invests and retailer 2 does not, and retailer 2 invests and retailer 1 does not. Since retailers have the same cost parameters we only need to consider one of these market structures for instance, the first condition. The results are reciprocal for the second market structure. If retailer 2 does not invest at time 1 he looses his investment opportunity and does not gain any cash flow after time 1. So retailer 2's NPV becomes zero.

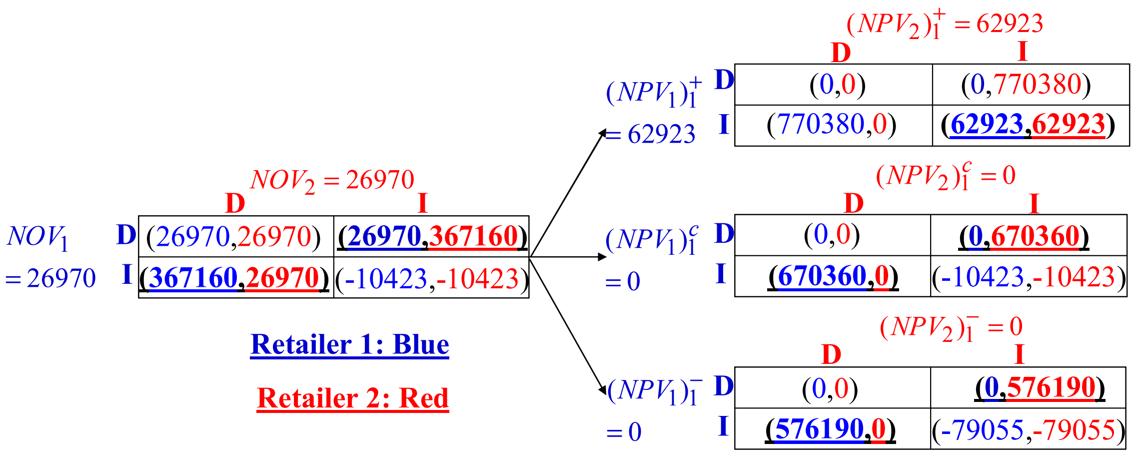

Figure 4. Nash equilibrium market structures and retailers' expected NPVs in our illustrative example

On the other hand, retailer 1 is the only retailer in the market. Therefore, the market structure is monopoly. Retailer 1's optimal quantity was already calculated in 3.1 and specified in equation (5). His optimal instantaneous profits was also determined in 3.1 and specified in equation (6). His optimal profits construct retailer 1's cash flows that must be discounted appropriately to determine his expected NPV. Similar to our calculation for the duopolistic market structure, we apply standard method of stochastic calculus to determine retailer 1's expected NPV. Retailer 1's expected NPV is summarized in equation (9) when $X(t) = X_1$. Interested reader can find the details of how we derive this equation in [10].

Based on equation (9) retailer 1's NPVs are calculated at the three levels of X_1 and the values are shown in the I-D cells of the tables in Figure 4. The reciprocal values are assigned for the D-I cells of the tables in Figure 4.

$$(NPV_1)_1 = \frac{X_1^2}{4\gamma(2\delta - (r + \sigma^2))} + \frac{VC_1}{2\gamma\delta} X_1 + \frac{1}{r}\left(\frac{VC_1^2}{4\gamma} - FC_1\right) - IC_1 \qquad (9)$$

Retailers' NPVs are shown in the two-by-two tables in Figure 4. These values are used to determine the Nash equilibrium of the game between retailers at each node in this dynamic market. The Nash equilibrium strategies are the bold-underlined values in the tables in Figure 4. For instance, invest-invest is the single pure strategy Nash equilibrium when $X_1^+ = 640$ and retailers' NPVs at this stable market structure are $(NPV_1)_1^+ = (NPV_2)_1^+ = 62923$. We use mixed strategy Nash equilibria [8] as the stable market structure for the lattice nodes, in which there are more than one pure Nash equilibrium strategy, for example when $X_1^c = 620$ and $X_1^- = 600.62$. We use the retailers' Nash equilibrium NPVs as their investment values at the lattice nodes in the stable market structures.

Now, we continue our analysis to time 0. Again four market structures must be evaluated. If both retailers decide not to invest they both get the deferral values of their investment opportunities, which are equal to the expected values of their NPVs at time 1 that are discounted back to time 0 using (p_1, p_2, p_3) for expectation and risk free rate r for discounting.

If both retailers decide to invest the market structure becomes duopolistic. Therefore, retailers' optimal quantities and instantaneous profits follow equations (3) and (4), respectively. Retailers' NPVs also follow equation (8) based on the similar discussion that we had earlier for the nodes at time 1. The only difference is to use X_0 instead of X_1 in equation (8).

Next, we need to determine retailers' NPVs under the other two market structures: retailer 1 invests and retailer 2 does not, and retailer 2 invests and retailer 1 does not. Since retailers have the same cost parameters we only need to consider the first market condition. The results are reciprocal for the second market condition. Calculations for this market condition are slightly different from what described above for time 1. Retailer 2 has an investment opportunity to open a store at time 0 or time 1 considering the fact that retailer 1 is in the market. Therefore, first we need to specify retailer 2's investment decisions at different lattice nodes and then determine retailers' NPVs.

Figure 5 shows retailer 2's stable NPVs in this investment opportunity. Retailer 2 has two actions at each lattice node: invest or do not invest. Again we start from time 1. If retailer 2 does not invest his NPV becomes zero for all three levels of X_1 at time 1 as shown in Figure 5. If retailer 2 decides to invest the market structure becomes duopolistic since retailer 1 was in the market. Therefore, retailer 2's NPV follows equation (8) based on what described earlier for the optimal decisions of retailers in a duopolistic market. Thus, retailer 2 only invests when market is large enough at time 1, i.e., $X_1^+ = 640$ where his NPV exceeds zero.

We continue our analysis to time 0. If retailer 2 decides to invest the market structure becomes duopolistic and his NPV follows equation (8). Note that X_0 must be used in this equation instead of X_1. If retailer 2 decides not to invest at time 1 his NPV equals the deferral value, which is the expected values of his NPVs at time 1 that are discounted back to time 0 using (p_1, p_2, p_3) for expectation and risk free rate r for discounting. Since the deferral value exceeds the investment value retailer 2 defers his investment opportunity to time 1 and opens a store only at the upper lattice node at time 1 when $X_1^+ = 640$.

Retailer 2's investment behavior in this market is used to determine retailer 1's investment values at the lattice nodes as shown in Figure 6. Again we start from time 1. When $X_1^+ = 640$ the market structure is duopolistic. Therefore, retailer 1's NPV follows equation (8) based on what described earlier for the optimal retailers' decisions in the duopolistic market.

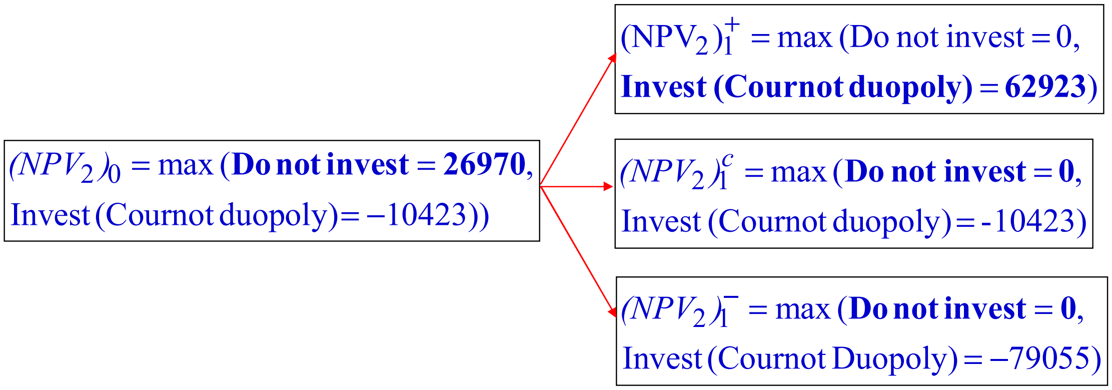

Figure 5. Retailer 2's investment decisions and his expected NPVs in this dynamic market

On the other hand, when $X_1{}^c = 620$ and $X_1{}^- = 600.62$ the market structure becomes monopolistic, in which retailer 1 is the only retailer in the market. Therefore, retailer 1's optimal decisions follow our discussion regarding monopolistic markets and his expected NPV follows equation (9). The only difference is that we must exclude $(-IC_1)$ from equation (9) since retailer 1 already paid his investment cost and opened the store in the market.

Now, we continue our analysis to time 0 for retailer 1. Retailer 1's NPV at time 0 consists of two parts: the expected values of his NPVs at time 1 that are discounted back to time 0 and his first-period profit. Since retailer 2 decides not to open the store at time 0 retailer 1 is the only retailer in this market in the first period. Therefore, retailer 1's optimal quantity and his instantaneous profit follow our discussion regarding monopolistic market summarized in equations (5) and (6), respectively where $i = 1$ and $X_0 = 620$. Retailer 1's profit in the first period is equal to his optimal instantaneous profit based on equation (6) multiplied by one month.

The above calculated NPVs are shown in the I-D cell of the table at the first node in Figure 4. Note that retailer 1's value in this cell is lower by $(-IC_1)$ from his corresponding value in Figure 6 since the calculations in Figure 6 is based on the assumption that retailer 1 already opened a store in this market. The reciprocal values are assigned to the D-I cell of the same table in Figure 4.

The above NPVs are used to determine the Nash equilibrium of the game between retailers at node 1 in this market. The Nash equilibrium strategies are the bold-underlined values in this table in Figure 4. Since there are two pure Nash equilibrium strategies at this node the mixed strategy Nash equilibrium is used to determine the stable market structure and its respective NPVs at time 0. These Nash equilibrium NPVs are called NOVs in Figure 4 since they represent the values of retailers' investment opportunities in this dynamic market $NOV_1 = NOV_2 = 26970$.

Retailers' NOVs specify the maximum amount retailers are willing to spend to acquire these investment opportunities. Note that the NOV approach explicitly addresses the management flexibility to delay investment and determines the optimal investment time as an integrated part of analysis.

$(NPV_1)_0 = 567160$ (Monopoly in the first period + Expected Discounted $(NPV_1^*)_1$)

$(NPV_1)_1^+ = 262920$ (Cournot duopoly)

$(NPV_1)_1^c = 870360$ (Monopoly)

$(NPV_1)_1^- = 776190$ (Monopoly)

Figure 6. Retailer 1's expected NPVs in this dynamic market based on retailer 2's decisions

Through this simple example, it is shown that the described investment model can be used to evaluate retailers' investment behaviors in a competitive, dynamic market. For instance, we notice the only time both retailers open stores in this market is the time that the market becomes large enough for both retailers, i.e., $X_1^+ = 640$.

The described procedure can be extended to explore retailers' behaviors for investment opportunities that are valid for the longer periods of time. Next, we use this integrated approach to explore how differences in retailers' fixed and variable costs impact their investment behaviors in a competitive, dynamic market.

4. Exploring the impact of differences in retailers' fixed and variable costs on their market entry decisions

In this section, a possible application of our model is presented. We set up a case to explore how the differences between retailers' fixed and variable costs impact their investment behaviors in a competitive, dynamic market. We use two retailers for this comparison. The first retailer is a big discount retailer like Wal-Mart who has low variable cost but high fixed and investment costs to open a store. The other retailer is a small discount retailer like Dollar General who has high variable cost but low fixed and investment costs. This cost variations are due to the fact that the large retailers invest heavily in their infrastructure and are so efficient in their supply chains. Therefore, they have low variable cost but high investment and fixed costs.

We assign the following notional values to retailers' cost parameters: $FC_1 = \$200{,}000.00$, $FC_2 = \$100{,}000.00$, $VC_1 = \$50.00$, $VC_2 = \$100.00$, $IC_1 = \$400{,}000.00$, and $IC_2 = \$200{,}000.00$, i.e., retailer 1 is a big retailer and retailer 2 is a small retailer. The other model parameters keep same at their values as our example in section 3.3. However, retailers' investment opportunities last for two hundred months instead of one month since we want to capture retailers' investment behaviors over a longer period of time.

We use the above integrated investment analysis approach to determine retailers' decisions. The objective is to determine when each retailer decides to open a store in this competitive, dynamic market. Retailers' entry decisions are based on the values of X at the time of investment decision as shown in Figure 7. It can be observed that the small retailer invests first and opens a store in the developing market before the big retailer. Since X represents the market potential in the demand model (1) we can conclude that the small retailer targets smaller markets while the big retailer targets larger markets.

Note that the decreasing horizon effects are observed in retailers' investment boundaries since their investment opportunities become expired at the time horizon and retailers' deferral values become disappeared when they get close to the investment horizon.

It is interesting to observe this early investment behavior by the small retailer since the small retailer's marginal profit and consequently his return on investment is low in small markets. However, the small retailer still opens his store in such small markets since he knows he can not compete with the big retailer in large markets due to the big retailer's variable cost advantage, i.e., the small retailer's marginal profit and his return on investment is lower in large markets than small markets since the big retailer opens a store only in large markets due to his substantial investment and fixed costs. In addition, the small retailer's early investment in the evolving market delays big retailer's market entry due to his strategic first-move advantage.

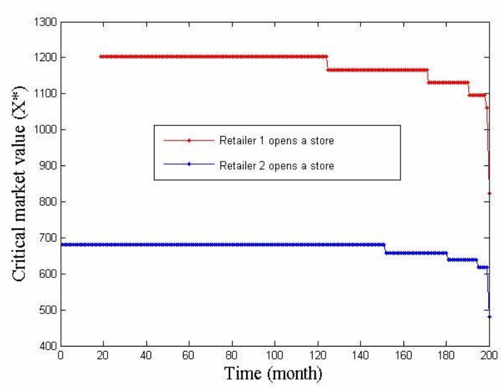

Figure 7. When the big and small retailer, retailer 1 and 2 respectively open stores in the competitive, dynamic market

Thus, use of this model the impression that the small retailer invests earlier in a new market is confirmed. The empirical validation of this impression is under further research and therefore, real validity of the proposed model has left for future research.

5. Conclusions and future work

In this paper, we look at retail market analysis from a theoretical investment perspective. An integrated investment model is presented to explore retailers' behaviors in competitive, dynamic markets. Particularly, by use of this option-based model the impression that the small retailer invests earlier in a new market is confirmed. The real validity of the proposed model should be investigated in future research.

This research should be extended to show how actual retailers could use this model in the investment evaluation process of competitive, dynamic retail markets. The major challenge that should be formally treated is to define an estimation process for the model parameters, particularly, α, σ, and δ. Thus, this option-based investment analysis approach can be useful for retailers that have long been known to take a not formal approach to the evaluation of new markets for store development [11, 12] and frequently make market investment decisions on a combination of hunch, experience and a few rudimentary calculations [13].

In addition, a comprehensive design-of-experiment should be carried out to explore how retailers' investment behaviors are sensitive to the changes of model parameters. This sensitivity analysis is used to prioritize the variables that retailers should pay more attention to in their investment analysis process.

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