Sequential Supply Decision and Market Efficiency: Theory and Evidence

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Sequential Supply Decisions and Market Efficiency: Theory and Evidence

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Abstract

In a homogeneous goods market, due to the lack of the preemption effect, each firm's demand is likely to be proportional to its share of total output. Firms are inclined to supply more to increase their market shares, but should also consider the potential cost from excess supply. Thus, firms should make strategic decisions on how much to supply. We study this topic by considering an oligopoly market in which firms make decisions sequentially under a fixed price. We first provide a theoretical model and find the conditions under which either an efficient supply or oversupply occurs. Our model proposes two practical ways to evaluate the efficiency of a market, specifically regarding excess supply, that do not require information about market demand. Using these, we evaluate the efficiency of the Korean movie theater industry. Our empirical findings indicate oversupply of seating capacity in that industry.

Keywords: Oversupply, First mover advantage, Market efficiency, Movie theater industry

JEL Classification Numbers: L13, L22, L82

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1 Introduction

Oversupply implies a waste of resources that could be used for other economic activities. It is more likely to be present in homogeneous goods markets where goods have little or no differentiation in their features or quality. In such markets, firms are forced to compete on price or availability. Availability is especially important when firms are price takers, since the demand for each firm’s goods is likely to be proportional to its share of total market output. Acknowledging this, firms may be willing to supply more to increase their market shares, resulting in oversupply. Furthermore, if homogeneous goods are non-durable in that the purchase must be made regularly, oversupply may be more common. For example, even when incumbents are already providing more goods than needed, there can still be room for entrants because they can attract customers due to the lack of preemption by incumbents. This new entrance will further exacerbate the oversupply situation. Note that, because of the nature of homogeneous goods, oversupply of this kind occurs even when firms have precise information about market demand.

Although supplying more may help to increase market share, firms should also take into account the potential cost incurred when there is excess supply. The inventory cost and the opportunity cost of unsold items are examples of such costs. Whether or not oversupply occurs depends not only on a firm’s decision, but also on those of other firms. Due to this interdependence, strategic interaction among firms plays an important role in firms’ decisions regarding how much to supply. We study this issue by considering an oligopoly market in which firms supply homogeneous goods.

In particular, we consider a setting in which price is determined exogenously and, given this prevailing price, firms compete to increase market share. The markets of retailers or distributors who supply manufacturers’ products are good examples of this kind of market. As an example, excluding the possibility of price discounts, retailers such as Walmart, Target, and Kmart supply the same item at about the same price. How much they supply does not affect the prevailing list price. In the book market, the list price of a book is determined by the publisher and, given this list price, bookstores decide how many books to supply. Thus, bookstores’ decisions do not affect the list prices of books. The market of music CDs is similar.\(^1\) As another example, in the movie theater market, while ticket price is a part of the theater’s profit, it is uniform across theaters that have different seating capacities and across different market structures.\(^2\) Theaters’ decisions on seating capacity do not affect the predetermined ticket price. Thus, firms in our model can be interpreted as having no control over price.\(^3\)

In the model, how each firm’s demand is determined depends on whether or not there is oversupply in the market. If there is excess supply, each firm’s demand is proportional to its share

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\(^1\) As mentioned in Sorensen (2007), the prices for multimedia goods are determined before they are marketed, and those prices are rigid.

\(^2\) This rigidity of uniform movie ticket prices has been observed by several previous works (e.g. Sorensen (2007), Orbach and Einav (2007), and Gil (2009)). Davis (2005) finds that the effect of local theater competition on admission price is only marginal.

\(^3\) Considering the common observations of price rigidity in oligopoly markets, our setting can also be applied to the case in which firms decide how much to produce given that they are price takers. A regulated industry in which firms behave as price takers is another example.
of total market output. Otherwise, each firm can sell all that it supplies. Given the prevailing price, firms have complete information about market demand. As for the cost side, in addition to the supply cost, there is additional cost incurred when there is oversupply. Hence, the cost of oversupply is internalized, which makes oversupply less likely to occur. Firms decide how much to supply sequentially, with the order given exogenously. Using this model, we characterize the equilibrium of how much is supplied by each firm and explore the conditions under which either efficient supply or oversupply occurs in the market. We first consider a duopoly market to simplify the analysis and then extend the model into an oligopoly in which more than two firms compete with one another.

The efficiency of equilibrium depends on the price. If the price is relatively low, then the equilibrium is efficient in that the firms supply only up to the market demand. On the other hand, if the price is relatively high, even though firms make decisions while recognizing the cost of oversupply, the equilibrium is inefficient and oversupply occurs.

The interesting aspect of the equilibrium is that oversupply can be identified by checking whether or not there is a first-mover advantage. In the efficient equilibrium where the market is cleared, there is a first-mover advantage in that the leader supplies more than the follower. This equilibrium occurs when the benefit of supplying more to increase market share is relatively small and therefore no firm wants to bear the cost incurred when there is oversupply. Taking advantage of this, the leader can preoccupy the demand up to the point at which the residual demand is acceptable to the follower. In contrast, in the inefficient equilibrium where there is excess supply, although firms make decisions sequentially, the leader and the follower supply the same amounts of goods. This equilibrium is derived when marginal revenue is relatively high. The leader, who is concerned with the follower’s aggressive supply, cannot enjoy the first-mover advantage of preoccupying the market. Hence, the leader becomes defensive and the follower can increase the supply up to the level of the leader.

Another interesting proposition of the model is that oversupply can also be identified by considering the profit (revenue) per unit. Given fixed entrance costs, depending on market demand, monopoly and duopoly markets can be identified. If the equilibrium in a duopoly market is efficient, then the profit (revenue) per unit of a firm in a duopoly market is the same as that in a monopoly market. On the other hand, if the equilibrium in a duopoly market is inefficient, then the profit (revenue) per unit of a firm in a duopoly market is less than that in a monopoly market.

In practice, even if firms in the market are well informed, the policy makers or the regulation authorities may not have precise information about market demand. This would make it hard for them to check the current market supply status. The merit of our model is that it proposes two practical ways of identifying inefficiency in such a market. If i) the leader and the follower supply the same amount of goods or ii) the profit (revenue) per unit of a firm in a duopoly market is less than that of a monopolist, then there is an indication of oversupply. The proposed conditions do not require information about market demand. In particular, the first condition is very useful in that data of firms’ supply amounts is easily accessible. Therefore, when the authorities do
not have sufficient information about market demand, the proposed conditions can be useful in identifying the inefficiency in the market. If these conditions are observed, then authorities should pay attention to addressing the inefficiency due to excess supply.

Based on the theoretical analysis, we evaluate the efficiency of the Korean movie theater industry. This industry fits into the framework of our model well. In practice, most theaters in competition have standardized facilities and they play the same movies with a similar ratio of screens. Therefore, consumers may regard equidistant theaters as homogeneous goods. As previously mentioned, ticket price, which is a part of profit, is uniform and rigid. It is not related to seating capacity, which is what theaters control to increase their market shares. In conducting empirical analysis, we use a unique cross-sectional data set covering all Korean movie theaters in 2013. First, using information on theater location, we identify local theater markets. Next, using theaters in the markets identified as monopolies and duopolies, we compare i) the seating capacity of the first and second entrants in the duopoly markets and ii) the audience per seat of theaters in the monopoly and the duopoly markets. As ticket prices are uniform, having more customers implies greater revenue. Our empirical analysis finds that i) there is no statistically significant difference between the seating capacities of the first and second entrants in the duopoly markets, and ii) local monopolists attract approximately 100 more customers per seat on average than theaters in the duopoly markets. According to the prediction of the theoretical model, these findings imply that there is an oversupply of seats, and hence, market inefficiency.

The remainder of the paper is organized as follows: Section 2 provides the literature review. Section 3 provides the model. In Section 4, we characterize the equilibrium. In Section 5, we provide the empirical analysis. Section 6 concludes the paper.

2 Related literature

The most closely related model to ours is Romano (1988). Both models are motivated by the same idea that firms in a homogeneous goods market compete for market share and the demand for each firm is proportional to the share of total supply. His model analyzes how oversupply occurs in an oligopoly market by considering a setting in which firms make decisions simultaneously. As firms are identical, firms’ outputs are symmetric in equilibrium and oversupply occurs when the wedge between price and marginal supply cost is high enough. Our model provides complementary analysis by considering sequential decision making, which is commonly observed in practice. Hence, we can examine how the status of oversupply is related to the presence of the first-mover advantage and symmetry in firms’ choices. The existence of the equilibrium in which firms’ choices are symmetric under sequential decisions is a main finding of our model. Asymmetry in firms’ choices due to the first-mover advantage is also derived. In particular, our model incorporates the cost incurred when oversupply occurs. Hence, oversupply in our model occurs in a setting where it is less likely to be derived.

4His model also considers the endogenous price case in a setting where firms are able to coordinate their price choices.
Our paper is related to the literature on excess entry in homogeneous goods markets in that it deals with the market inefficiency due to oversupply. Perry (1984), Mankiw and Whinston (1986), and Suzumura and Kiyono (1987) propose that, under imperfect competition, excess entry occurs if there are economies of scale and a business-stealing effect. Cabral (2004) explores this issue by considering the entry cost and intensity of competition in a setting of simultaneous entry decisions. Ghosh and Saha (2007) propose that excess entry can occur, even in the absence of economies of scale, if there is cost asymmetry among firms.\footnote{Recent articles such as Ghosh and Morita (2007a,b) and Mukherjee (2010, 2012a,b) provide models in which, even in a homogeneous market, the entry can be less than what is socially optimal.}

The existing empirical literature quantifies the effect of free entry on social welfare. In general, they find evidence that free entry allows excess entry and hence leads to social inefficiency in various industries; for instance, in the radio broadcasting industry (Berry and Waldfogel (1999)), real estate brokerage industry (Hsieh and Moretti (2003), Barwick and Pathak (2015), and Han and Hong (2011)), and liquor industry (Seim and Waldfogel (2013)). However, an increase in consumer surplus due to additional entry may offset its negative business stealing effect, hence improving the total welfare under certain circumstances; for instance, input scarcity (Cutler, Huckman, and Kolstad (2010)) and product differentiation (Dutta (2011) and Dai and Yuan (2013)). We contribute to the literature by empirically showing the existence of excess supply due to competition on capacity in the movie theater market.

3 Model

There are two firms in a market and they supply homogeneous goods produced by a manufacturer. The unit price, $p$, of this good is given exogenously. Firms’ supply decisions do not affect the price. The market demand is determined from a demand function $x(p)$. Given $p$, we denote by $M$ the corresponding market demand. Customers have no preference for a specific firm. Thus, in purchasing goods, they do not consider who the supplier is. Firms decide sequentially how much to supply. We denote the supply amount of the leader by $x$ and that of the follower by $y$. After the leader decides $x$, the follower can observe $x$ before he decides $y$. Given the determined $x$ and $y$, the demand for each firm depends on whether the market supply is greater than the market demand. If $x + y \leq M$, the demand for each firm is $x$ and $y$ respectively. That is, they can sell all they supply. On the other hand, if there is oversupply, i.e., $x + y > M$, the demand for each firm is proportional to its share of total market supply: the demand for the leader is $\left(\frac{x}{x+y}\right)M$ and that for the follower is $\left(\frac{y}{x+y}\right)M$. These can also be interpreted as each firm’s expected demand when oversupply occurs. Each firm’s supply cost function is $c_1x$ and $c_1y$. When there is excess supply, both firms incur an additional cost $c_2$ per unit oversupplied. Thus, the additional cost from oversupply is $c_2\left(x - \left(\frac{x}{x+y}\right)M\right)$ and $c_2\left(y - \left(\frac{y}{x+y}\right)M\right)$ respectively. This can be interpreted as opportunity cost or unrecovered inventory cost for unsold units. We assume that $p > c_1$ to avoid a trivial case.
We define the market efficiency in the following way throughout the paper.

Definition 1 Given $p$ and the corresponding market demand $M$, the market is efficient if $x+y = M$ and inefficient if $x + y > M$.

That is, we say that a market is inefficient if there is oversupply when all customers who are willing to demand goods for given $p$ are served.

The timing of the game is as follows:

T1) Two firms enter the market. They observe the price $p$, the market demand $M$, and the marginal costs $c_1$ and $c_2$.
T2) The leader decides his supply amount, $x$.
T3) The follower observes $x$ and decides his supply amount, $y$.

We use the backward induction to find a subgame perfect Nash equilibrium.

4 Equilibrium

4.1 The follower’s best response

The follower can observe the leader’s choice $x$. The follower’s response depends on whether the leader’s choice is less or greater than the market demand $M$. First, if $x < M$, he can decide whether to supply i) $y = M - x$, which clears the market, or ii) $y > M - x$, which induces oversupply.\(^6\)

If $y = M - x$, the follower’s objective function is

$$\pi_2 = py - c_1 y$$

and his best response function is

$$y = M - x$$

because $p > c_1$.

On the other hand, if $y > M - x$, it is

$$\pi_2 = p \left( \frac{y}{x+y} \right) M - c_1 y - c_2 \left( y - \frac{y}{x+y} M \right)$$

(3)

The first-order condition is

$$\frac{\partial \pi_2}{\partial y} = p M \left( \frac{x}{(x+y)^2} \right) - c_1 - c_2 \left( 1 - \frac{x}{(x+y)^2} M \right) = 0$$

\(^6\)Given that price $p$ is greater than the marginal supply cost $c_1$, the follower has no reason to choose $y < M - x$. Hence, in equilibrium, $x + y \geq M$. 

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The second-order condition says that \( \frac{\partial^2 \pi_2}{\partial y^2} < 0 \). Thus, the follower’s best response function is

\[
y = \left( \sqrt{\frac{M(p + c_2)x}{(c_1 + c_2)} - x} \right)
\]

(4)

Next, if \( x \geq M \), for \( y > 0 \), oversupply always occurs. Thus, the follower’s objective function is (3) and the best response function is (4). Further analysis yields the following result.

**Lemma 1**

Given \( x \), the follower’s best response function \( y \) is as follows. Here, \( M_1 = \frac{M(c_1 + c_2)}{(p + c_2)} \), \( M_2 = \frac{M(p + c_2)}{(c_1 + c_2)} \), and \( M_1 < M < M_2 \).

1) If \( 0 < x \leq M_1 \), \( y = M - x > 0 \). Thus, there is no oversupply, i.e., \( x + y = M \).

2) If \( M_1 < x < M_2 \), \( y = \left( \sqrt{\frac{M(p + c_2)x}{(c_1 + c_2)} - x} \right) > 0 \). In this case, oversupply occurs, i.e., \( x + y > M \).

3) If \( x \geq M_2 \), \( y = 0 \). In this case, oversupply occurs, i.e., \( x > M \).

**Proof of Lemma 1**

In the appendix.

### 4.2 The leader’s choice and the equilibrium

From Lemma 1, the leader knows that if he supplies \( x \) such that \( 0 < x \leq M_1 \), the follower’s best response is (2) and so market is cleared without excess supply. Then, the revenue is \( px \) and the cost is \( c_1 x \). Next, if he supplies \( x \) such that \( M_1 < x < M_2 \), the follower’s best response is (4) and \( y > 0 \). In this case, \( x + y > M \). Then, the revenue is \( p \left( \frac{x}{x + y} \right) M \). The supply cost is \( c_1 x \) and the additional cost is \( c_2 \left( x - \left( \frac{x}{x + y} \right) M \right) \). Finally, if \( x \geq M_2 \), \( y = 0 \), but \( x > M \). So, the revenue is \( pM \), the supply cost is \( c_1 x \) and the additional cost is \( c_2 (x - M) \). Then, the leader’s objective function for each case is as follows.

1) For \( 0 < x \leq M_1 \),

\[
\pi_1 = px - c_1 x
\]

(5)

2) For \( M_1 < x < M_2 \),

\[
\pi_1 = p \left( \frac{x}{x + y} \right) M - c_2 \left( x - \frac{x}{x + y} M \right) - c_1 x
\]

(6)

3) For \( x \geq M_2 \),

\[
\pi_1 = pM - c_2 (x - M) - c_1 x
\]

(7)

where \( M_1 = \frac{M(c_1 + c_2)}{(p + c_2)} \) and \( M_2 = \frac{M(p + c_2)}{(c_1 + c_2)} \).

Comparing the profits in each case after updating the follower’s best response function when appropriate yields the leader’s optimal choice \( x \). The subgame perfect Nash equilibrium can be described as follows.
**Proposition 1**

1) If \( c_1 < p \leq 2c_1 + c_2 \), \((x^*, y^*) = \left( \frac{M(c_1+c_2)}{p+c_2}, \frac{M(p-c_1)}{p+c_2} \right) \) and \( x^* + y^* = M \).

2) If \( p > 2c_1 + c_2 \), \((x^*, y^*) = \left( \frac{M(p+c_2)}{4(c_1+c_2)}, \frac{M(p+c_2)}{4(c_1+c_2)} \right) \) and \( x^* + y^* > M \).

**Proof of Proposition 1**

In the appendix.

The parameter \( p \) determines how intensely firms are willing to compete with each other to increase market share. As \( p \) increases, firms have a greater incentives to attract more customers and therefore supply more. However, due to the additional cost incurred when oversupply occurs, supplying more is not always beneficial. Thus, there exists a price threshold, which is a function of \( c_1 \) and \( c_2 \), that determines the equilibrium. If price is relatively high, they are biased toward supplying more, which results in oversupply. This shows how intense the competition can be in a homogeneous goods market even with the additional cost from oversupply. If not, their concerns about the potential cost from oversupply outweighs the revenue from greater market share, resulting in the efficient equilibrium in which the market is cleared. While the consideration of the cost of oversupply decreases the parameter set of \( p \) under which oversupply occurs, the inefficient equilibrium always exists if \( p \) is sufficiently high.

The interesting aspect of the equilibrium is that it is strongly related to the concept of the first-mover advantage. Note that while firms make decisions sequentially, when oversupply occurs, the supply amounts of the leader and the follower are identical. The leader enjoys the advantage of preoccupying the market only when the equilibrium is efficient.

**Proposition 2**

1) The market is cleared, i.e., \( x^* + y^* = M \) if and only if there is a first-mover advantage, i.e., \( x^* > y^* \).

2) There is oversupply, i.e., \( x^* + y^* > M \) if and only if there is no first-mover advantage, i.e., \( x^* = y^* \).

The efficient equilibrium is derived when the benefit of aggressive supply is not large enough to outweigh the cost from oversupply. Given this condition, the follower intends to avoid oversupply whenever possible. Knowing this, the leader can preoccupy the market up to the point at which the residual demand is acceptable to the follower. In our case, \( y^* = \frac{M(p-c_1)}{n(p+c_2)} \) is the reservation residual demand of the follower. The leader, who is also concerned about the cost from oversupply, cannot preoccupy the market more than \( M - y^* = x^* = \frac{M(c_1+c_2)}{(p+c_2)} \). If \( x > x^* \), the follower supplies more than \( y^* \), resulting in oversupply. In this way, both leader and follower are constrained by the fact that oversupply is beneficial to neither of them. This constraint is advantageous to the leader who makes decision first. Therefore, the first-mover advantages emerges, i.e., \( x^* > y^* \).

In contrast, the inefficient equilibrium takes place when attracting more customers is beneficial due to high marginal revenue. The leader should expect that, in this case, the follower is less
Figure 1: Stackelberg equilibrium

Concerned about the cost from oversupply, and hence is willing to supply more aggressively. Thus, he cannot enjoy the leader’s advantage of preoccupying the market because it will result in excessive oversupply due to the follower’s aggressive response. Hence, the leader becomes defensive and the follower can increase supply up to the level of the leader. Thus, there is no first-mover advantage, i.e., $x^* = y^*$.

This inefficient equilibrium with no first-mover advantage can be explained using the iso-profit function and the best response functions. In Figure 1, our Stackelberg equilibrium is a tangency point A where the leader’s profit is maximized given the follower’s best response function. Note that this point A is the intersection point of the two firms’ best response functions. Therefore, point A also represents the Cournot-Nash equilibrium, derived when they make decisions simultaneously. As firms are symmetric, they supply the same amount in the Cournot-Nash equilibrium. Our model predicts that, even in a sequential decision case, firms supply the same amount if price is sufficiently high.\(^7\)

The merit of this result is that it proposes a practical way of identifying market inefficiency, that is, comparing firms’ supply amounts. It is very useful in that we only need firms’ supply amounts, which are easily accessible, while information about market demand, which is practically difficult to assess and obtain, is not required.

4.3 Comparative statics

In this subsection, we analyze how the parameters, $p$, $c_1$, and $c_2$, affect the equilibrium.

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\(^7\)It has been recognized in the literature on contest that, depending on some conditions of the contest success function, a Stackelberg equilibrium to a symmetric contest is identical to a Cournot-Nash equilibrium. (See Dixit (1987) and Baye and Shin (1999)) The terms $\frac{x}{x+y}$ and $\frac{y}{x+y}$ of our model, which explain how the demand is allocated when oversupply occurs, correspond to the contest success function. Those satisfy the conditions under which a Stackelberg equilibrium is identical to a Cournot-Nash equilibrium.
4.3.1 Analysis on the efficient equilibrium

We first check how a change in price $p$ affects the asymmetry between firms’ choices and profits.

**Corollary 1**

*In the efficient equilibrium in which $x^* > y^*$,

1) As the price $p$ increases (decreases), the first-mover advantage decreases (increases).

2) As $p \rightarrow 2c_1 + c_2$, $x^* - y^*$ converges to 0.*

**Proof of Corollary 1**

In the appendix.

Given the parameter set of $p$ under which there is no excess supply, as $p$ becomes lower, the follower has less incentive to increase market share because the benefit of attracting more customers decreases. Knowing this, the leader can increase his supply $x$ using the first-mover advantage, resulting in a decrease in $y$. Thus, as $p$ becomes lower, the supply differential between leader and follower increases. On the other hand, as $p$ becomes higher, the follower is more willing to increase the market share and therefore his reservation residual demand increases. Knowing this, the leader should decrease $x$ because he knows that oversupply is not beneficial to him. Thus, the first-mover advantage decreases. Figure 2 shows that the threshold price above which the first-mover advantage is dissipated is $p^* = 2c_1 + c_2$.

**Remark**

*In the efficient equilibrium in which $x^* > y^*$, as $p$ increases, the first-mover advantage in terms of profit decreases because the follower’s profit increases faster than the leader’s profit, not because the leader’s profit decreases.*
The increase in $p$ compensates the decrease in the demand for the leader. Actually, the decrease in the supply differential between leader and follower does not mean that the leader’s profit decreases. In the equilibrium, the profit functions of the leader and the follower are respectively

$$\pi^*_l = \frac{M (c_1 + c_2)(p - c_1)}{p + c_2} \text{ and } \pi^*_f = \frac{M (c_1 - p)^2}{p + c_2}$$

Then,

$$\frac{\partial \pi^*_l}{\partial p} > 0, \quad \frac{\partial^2 \pi^*_l}{\partial p^2} < 0 \text{ and } \frac{\partial \pi^*_f}{\partial p} > 0, \quad \frac{\partial^2 \pi^*_f}{\partial p^2} > 0$$

Note that, although $x^*$ decreases when $p$ increases, the leader’s profit increases. Thus, in terms of profit, the first-mover advantage dissipates as $p$ increases because the follower’s profit increases faster than the leader’s profit, not because the leader’s profit decreases. Figure 3 points this out graphically.

**Remark**

*In the efficient equilibrium in which $x^* > y^*$, an increase in $c_1$ or $c_2$ works to the leader’s advantage and the follower’s disadvantage. Therefore, the asymmetry in the firms’ supply amounts (first-mover advantage) increases.*

The marginal supply cost $c_1$ also affects the choices of the leader and the follower asymmetrically as follows.

$$\frac{\partial x^*}{\partial c_1} > 0, \quad \frac{\partial \pi^*_l}{\partial c_1} < 0 \text{ and } \frac{\partial y^*}{\partial c_1} < 0, \quad \frac{\partial \pi^*_f}{\partial c_1} < 0$$

An increase in $c_1$ increases the leader’s supply but decreases the follower’s supply. Therefore, the
asymmetry in the firms’ supplies increases.

\[ \frac{\partial x^*}{\partial c_2} > 0, \quad \frac{\partial \pi_i^*}{\partial c_2} > 0 \text{ and } \frac{\partial y^*}{\partial c_2} < 0, \quad \frac{\partial \pi_f^*}{\partial c_2} < 0 \]

An increase in the marginal cost \( c_2 \) also increases the asymmetry in both firms’ supply amounts. However, while the increase in \( c_1 \) decreases both firms’ profits, the increase in \( c_2 \) helps the leader. This implies that, when \( c_2 \) is considered, the leader supplies more and the follower supplies less than the case in which \( c_2 \) is not considered. This can also be verified from that

\[ x^*|_{c_2>0} > x^*|_{c_2=0} \text{ and } y^*|_{c_2>0} < y^*|_{c_2=0} \]

\[ x^*|_{c_2>0} - y^*|_{c_2>0} > x^*|_{c_2=0} - y^*|_{c_2=0} \]

That is, the degree of the first-mover advantage increases when \( c_2 \) is considered. This confirms that the cost from oversupply works to the leader’s advantage and the follower’s disadvantage. In other words, if firms do not consider the cost from oversupply, the leader is not fully utilizing the leader’s advantage and the follower benefits more.

### 4.3.2 Analysis on the inefficient equilibrium

In the inefficient equilibrium in which firms’ supply amounts are identical, we observe that \( \frac{\partial x^*}{\partial p} > 0, \quad \frac{\partial \pi_i^*}{\partial p} > 0, \quad \frac{\partial x^*}{\partial c_1} < 0, \text{ and } \frac{\partial \pi_i^*}{\partial c_1} = 0 \) where \( i = l, f \). These are intuitive except that firms’ profits do not depend on the marginal supply cost \( c_1 \). The interesting observation is the effect of a change in \( c_2 \). In equilibrium,

\[ x^* = y^* = \frac{M(p + c_2)}{4(c_1 + c_2)} \text{ and } \pi_i^* = \frac{M(p + c_2)}{4} \]

Then,

\[ \frac{\partial x^*}{\partial c_2} < 0 \text{ and } \frac{\partial \pi_i^*}{\partial c_2} > 0 \]

The result that \( \frac{\partial \pi_i^*}{\partial c_2} > 0 \) seems counter-intuitive in that the profit increases as the marginal cost increases. The intuition is as follows: Given that excess supply always occurs in this equilibrium, as \( c_2 \) increases, firms are more concerned about the cost from oversupply and therefore supply less. That is, compared to the case in which \( c_2 \) is not considered, firms supply more efficient amounts by supplying less, which increases the profit. Considering that it also decreases the excess supply, an increase in \( c_2 \) yields a more individually and socially desirable situation.

### 4.4 Entry and market structure

Market size is an important factor that determines the market structure. In bigger markets, more entrants would be willing to join and so the market is more likely to be competitive. In particular,

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8This is due to the facts that i) the market share, which is the demand for each firm, is independent of \( c_1 \) because firms’ supplies are symmetric and ii) the cost functional form is linear.
in a homogeneous goods market, the business-stealing effect should be more common. Then, a
level of market demand large enough to dominate such a negative competition effect is necessary
to induce new entrances. Thus, we attempt to characterize the threshold of market demand that
determines the market structure. For this section, we introduce a fixed market entry cost $F$. Firms
are assumed to enter the market sequentially.

**Corollary 5**

Suppose there is a fixed entry cost $F$.

1) Suppose that $c_1 < p \leq 2c_1 + c_2$. If \( \frac{F}{p - c_1} < M < \frac{F(p + c_2)}{(c_1 - p)^2} \), the market is a monopoly and if
\( M > \frac{F(p + c_2)}{(c_1 - p)^2} \), it is a duopoly.

2) Suppose that $p > 2c_1 + c_2$. If \( \frac{F}{p - c_1} < M < \frac{4F}{p + c_2} \), the market is a monopoly and if \( M > \frac{4F}{p + c_2} \), it is a duopoly.

**Proof of Corollary 5**

In the appendix.

Given parameters values, firms can foresee the market structure. The duopoly market, consid-
tered in our model, corresponds to the case in which \( M > \frac{F(p + c_2)}{(c_1 - p)^2} \) or \( M > \frac{4F}{p + c_2} \) depending on
$p$. From Corollary 5, it can be checked that the minimum level of market demand for the second
entrant to join the market is more than twice as high as that for the first entrant. This implies
that the business-stealing effect is present under competition, and a level of market demand high
enough to dominate it is necessary for the market to become a duopoly market.

**Corollary 6**

Let's denote by $M_i$ the threshold above which $i$-th entrant joins the market for $i = 1, 2$. Then,
$M_2 > 2M_1$.

**Proof of Corollary 6**

In the appendix.

If $c_1 < p \leq 2c_1 + c_2$, efficiency is guaranteed in any market structure. On the other hand, if
$p > 2c_1 + c_2$, although efficiency is guaranteed in a monopoly market, the second firm’s entrance
always causes inefficiency. Note that, in this case, the threshold of the second entrance is $M_2 = \frac{4F}{p + c_2}$.
Then, \( \frac{\partial M_2}{\partial c_2} < 0 \), which is related to the result that \( \frac{\partial x^*_i}{\partial c_2} < 0 \) in the inefficient equilibrium. As $c_2$
increases, each firm supplies less and therefore less market demand is needed for a duopoly market.
This implies that the parameter set of $M$ under which the market becomes a duopoly increases and
therefore the inefficient equilibrium can occur with lower market demand.

**4.5 Profit per unit in monopoly and duopoly markets**

Previously, we suggest that market efficiency can be evaluated by comparing firms’ supply amounts.
In this subsection, we show that profits (revenues) per unit can also be used as good measures of
evaluating the market efficiency.
Depending on market demand, monopoly and duopoly markets can be identified. In a duopoly market, given the optimal \( x^* \) and \( y^* \), the leader’s profit function is

\[
\pi_l^* (x^*, y^*) = p \left( \frac{x^*}{x^* + y^*} \right) M_d - c_1 x^* - c_2 \left( \frac{x^*}{x^* + y^*} M_d \right)
\]

where \( M_d \) is the demand in a duopoly market. The follower’s profit function is analogous. Then, each firm’s profit function per unit is

\[
\frac{\pi_l^* (x^*, y^*)}{x^*} = \frac{\pi_f^* (x^*, y^*)}{y^*} = p \left( \frac{M_d}{x^* + y^*} \right) - c_1 - c_2 \left( 1 - \frac{M_d}{x^* + y^*} \right)
\]

In a monopoly market, we have

\[
\pi_m^* (M_m) = p M_m - c_1 M_m \quad \text{and} \quad \frac{\pi_m^* (M_m)}{M_m} = p - c_1
\]

where \( M_m \) is the monopoly market demand. Then,

\[
\frac{\pi_l^* (x^*, y^*)}{x^*} - \frac{\pi_m^* (M_m)}{M_m} = (p + c_2) \left( \frac{M_d}{x^* + y^*} - 1 \right)
\]

Thus, \( \frac{\pi_l(x^*, y^*)}{x^*} \leq \frac{\pi_m(M_m)}{M_m} \) if and only if \( M_d \leq x^* + y^* \). Revenue can also be used instead of profit and we find a similar relationship. In (8), the supply cost \( c_1 \) does not matter and by setting \( c_2 = 0 \),

\[
\frac{TR_l^* (x^*, y^*)}{x^*} - \frac{TR_m^* (M_m)}{M_m} = p \left( \frac{M_d}{x^* + y^*} - 1 \right)
\]

Therefore, \( \frac{TR_l(x^*, y^*)}{x^*} \leq \frac{TR(M_m)}{M_m} \) if and only if \( M_d \leq x^* + y^* \).

**Proposition 3**

1) The profit (revenue) per unit of firms in a duopoly market is identical.
2) The profit (revenue) per unit of a firm in a duopoly market is equal to that in a monopoly market if and only if the duopoly market is efficient, i.e., \( x^* + y^* = M_d \).
3) The profit (revenue) per unit of a firm in a duopoly market is less than that in a monopoly market if and only if the duopoly market is inefficient, i.e., \( x^* + y^* > M_d \).

In practice, the policy makers or the regulation authorities may not have precise information about market demand, whereas firms in the market are well informed about it. This would make it difficult for them to evaluate whether there is excess supply or not in the market. Our model suggests two practical ways to evaluate the efficiency of a duopoly market. Proposition 2 says that a duopoly market is inefficient (efficient) if and only if the leader’s supply is identical to (greater than) that of the follower. Proposition 3 says that the profit or revenue per unit of a firm in a duopoly market is less than (identical to) that of a monopolist if and only if a duopoly market is inefficient (efficient). In practice, information about the supply amounts, profits, and revenues are more accessible than information about market demand. Our suggested conditions do not require
information about the market demand. Hence, the proposed conditions can be useful in evaluating the market efficiency.

### 4.6 Oligopoly market case

In this subsection, we extend our analysis to the case in which there are more than two firms in the market. We denote by \( x_i \) each firm’s supply amounts and by \( k \) the number of firms. We first assume that price \( p \) is relatively high and therefore oversupply is expected. Note that, in a duopoly market, the equilibrium is inefficient if and only if there is no first-mover advantage and firms supply identical amounts. This result is derived from the structure of the best response functions and iso-profit function, which should be the same even when there are \( k \geq 2 \) firms. Thus, \( x_1 = x_2 = \cdots = x_k \). We use this symmetry during the analysis.

Each firm’s objective function is

\[
\pi_i(x_i, x_{-i}) = p \left( \frac{x_i}{\sum_{i=1}^{k} x_i} \right) - c_2 \left( x_i - \left( \frac{x_i}{\sum_{i=1}^{k} x_i} \right) M \right) - c_1 x_i
\]

Then,

\[
\frac{\partial \pi_i}{\partial x_i} = p \left( \frac{\sum_{i=1}^{k} x_i - x_i}{\left( \sum_{i=1}^{k} x_i \right)^2} \right) M - c_2 \left( 1 - \frac{\sum_{i=1}^{k} x_i - x_i}{\left( \sum_{i=1}^{k} x_i \right)^2} \right) M - c_1 = 0
\]

and \( \frac{\partial^2 \pi_i}{\partial x_i^2} < 0 \). From the symmetry that \( x_1 = x_2 = \cdots = x_k \),

\[
x_i^* = \frac{M (p + c_2) (k - 1)}{k^2 (c_1 + c_2)} \quad \text{and} \quad \sum_{i=1}^{k} x_i^* = \frac{M (p + c_2) (k - 1)}{k (c_1 + c_2)}
\]

From this, the threshold of \( p \) that determines the equilibrium can be derived indirectly. In Proposition 1, if \( x^* = y^* \), there is oversupply by \( (x^* + y^*) - M = M \frac{(p-2c_1-c_2)}{2(c_1+c_2)} \) from which the threshold of \( p \) above which oversupply occurs, \( p = 2c_1 + c_2 \), is derived. This reasoning can be applied to the case of \( k \geq 2 \) firms. The amounts of oversupply is \( \sum_{i=1}^{k} x_i^* - M = M \frac{(kp-kc_1-c_2-p)}{k(c_1+c_2)} \).

Then, the threshold of \( p \) above which oversupply occurs is \( p_k^* = \frac{kc_1+c_2}{k-1} \).

**Proposition 4**

Let \( p_k^* = \frac{kc_1+c_2}{k-1} \). Suppose that there are \( k \geq 2 \) firms and they decide \( x_i \) sequentially. Assume that \( x_1 \) is the first leader and \( x_k \) is the last follower.

1) If \( c_1 < p \leq p_k^* \), then \( x_1^* > x_2^* > \cdots > x_k^* \) and \( \sum_{i=1}^{k} x_i^* = M \).
2) If \( p > p_k^* \), then \( x_1^* = x_2^* = \cdots = x_k^* \) and \( \sum_{i=1}^{k} x_i^* > M \).

Note that \( \frac{\partial p_k^*}{\partial k} < 0 \), implying that, as the number of firms increases, the inefficient equilibrium is more likely to occur. This is also true when \( p > p_k^* \), \( \frac{\partial x_i^*}{\partial k} < 0 \) but \( \frac{\partial (\sum_{i=1}^{k} x_i^*)}{\partial k} > 0 \). Thus, in the inefficient equilibrium, as the number of firms increases, while each firm’s supply \( x_i \) decreases, oversupply increases.
The proposition that profit and revenue per unit is another good measure of evaluating the market efficiency can also be applied to this case.

Proposition 5

1) The profit (revenue) per unit of a firm in an oligopoly market is equal to that of a monopolist if and only if the market is efficient, i.e., \( \sum_{i=1}^{k} x_i = M_d \).

2) The profit (revenue) per unit of a firm in an oligopoly market is less than that of a monopolist if and only if the market is inefficient, i.e., \( \sum_{i=1}^{k} x_i > M_d \).

Proof of Proposition 5

In the appendix.

Finally, when the market is inefficient, \( \sum_{i=1}^{k} x_i = k x_i \) from the symmetry that \( x_i = x_{-i} \). Then,

\[
\frac{\pi^*_m}{x^*_m} - \frac{\pi_i(x^*_i, x^*_{-i})}{x^*_i} = n \left( p + c_2 \right) \left( 1 - \frac{M}{k x_i} \right) \quad \text{and} \quad \frac{TR^*_m}{x^*_m} - \frac{TR_i(x^*_i, x^*_{-i})}{x^*_i} = np \left( 1 - \frac{M}{k x_i} \right)
\]

Thus, as there are more firms, the difference in profit (revenue) per unit of firms in a monopoly market and an oligopoly market increases.

5 Empirical analysis: movie theater industry

In this section, based on the theoretical analysis of the previous section, we empirically evaluate the efficiency of the Korean movie theater industry. This industry fits into the framework of our model well. Most theaters in competition play the same movies with a similar ratio of screens in standardized facilities. Therefore, theaters are more or less homogeneous. The ticket price is rigid and uniform across theaters within each market. Given uniform ticket price, each theater decides seating capacity, which affects its market share. In practice, theaters open sequentially and therefore their decisions on seating capacity are made sequentially.

Note that the validity of our theoretical model can be confirmed depending on whether we observe two empirical findings that are consistent with each other regarding the market efficiency: i) the theaters’ capacities in duopoly markets are identical if and only if the revenue per seat of monopolists is greater than that of theaters in duopoly markets, ii) the first entrant’s capacity is greater than that of the second entrant in a duopoly market if and only if the revenue per seat of theaters is identical across different market structures. The first case indicates oversupply of seats, while the second case suggests that the market is efficient.

Consequently, by exploring the seating capacity variation within duopoly markets, and also comparing the revenue per seat between monopolists and theaters in duopoly markets, we evaluate the market efficiency and test the validity of our model.

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9The initial decision on the seating capacity is critical because, once it is built, the responses to a change in demand cannot be made promptly. Moreover, when there is oversupply of seats, theaters incur the cost from the idle seats for a period of time. Thus, theaters should be concerned about oversupply of seats in their initial decisions.
5.1 Data description and market identification

The cross-sectional data set used in the empirical analysis is obtained from the Korean Film Council and covers all movie theaters in Korea. Theater information such as number of seats, opening date, and location as of December 2013 is downloaded from its website, whereas the data on theater audience size for 2013 is confidential. Art theaters dedicated to screening art films are dropped from the data set in order to focus our attention on commercial theaters only.

For our empirical analysis, we first need to identify markets. The previous works on retailer entry and spatial competition (e.g. Bresnahan and Reiss (1990), Bresnahan and Reiss (1991), Mazzeo (2002), and Gowrisankaran and Krainer (2011)) focus only on isolated areas so that markets can be easily defined. However, since we analyze theaters located not only in isolated markets but also in densely populated metro areas, their approaches are not applicable in our case. Recently, Kim, Lee, and Yoon (2015) proposed to identify markets such that a cluster of theaters is regarded as in the same market if each theater has one or more competitors within a 1 mile radius. That is, if theaters $a$ and $b$ and theaters $b$ and $c$ are located within 1 mile from each other, then all three of them are assumed to be in the same market, even if the distance between $a$ and $c$ is greater than 1 mile. This approach guarantees that the market size is proportional to the degree of market concentration. That is, the more theaters there are in a market, the larger the market is.

Following this procedure, we identify 131 monopoly and 59 oligopoly theater markets in Korea. The longest distance between theaters within a market is 2.5 miles. Figure 4 shows that in the north region of Seoul, this strategy identifies three theater markets. The largest market, with 9 theaters, is indeed one of the major downtown areas in Seoul. The second largest market, where

Figure 4: Theater Markets Example

Note: This figure shows three identified markets in the north region of Seoul.

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10 The Korean Film Council is accessible at http://www.kofic.or.kr

11 The 1 mile radius criterion is based on the preliminary estimation results of Kim, Lee and Yoon (2015) that competitors located farther than 1 mile from a theater have no statistically significant effect on its revenue.

12 We change this 1 mile threshold radius to different values and conduct robustness checks in Section 5.4.
Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Seats</th>
<th></th>
<th></th>
<th>Audience Per Seat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monopoly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,096</td>
<td>514</td>
<td>629</td>
<td>282</td>
</tr>
<tr>
<td>Duopoly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Mover</td>
<td>1,158</td>
<td>458</td>
<td>591</td>
<td>263</td>
</tr>
<tr>
<td>Second Mover</td>
<td>1,156</td>
<td>565</td>
<td>533</td>
<td>280</td>
</tr>
<tr>
<td>Overall</td>
<td>1,118</td>
<td>513</td>
<td>607</td>
<td>279</td>
</tr>
</tbody>
</table>

there are 4 theaters, is also one of the main streets in Seoul. Hence, the market size appears to be proportional to the number of theaters located within the market, which indicates that our approach serves our purpose of defining concentration-weighted markets in the data well: In small markets, there are local monopolies, whereas in large markets there are clusters of theaters. Among the 190 identified markets, we analyze capacity choice of 70 theaters in the 35 duopoly markets and compare their customers per seat with those of the 131 monopolists.

Table 1 presents the descriptive statistics of the sample data. Two observations are noticeable. First, there is not much difference in the average capacities of the first and second entrants in the 35 duopoly markets. Second, as for the revenue, local monopolists have more customers per seat on average than theaters in the duopoly markets. In the following analyses, we examine whether these findings are statistically significant, controlling for other factors.

Finally, in our data set, there are markets where one theater chain holds multiple theaters. The capacity decision of theaters of the same chain is likely to be jointly determined, thus potentially complicating the analysis. Excluding such markets, we are left with 30 duopoly markets, which we call “single chain theater markets”. In the subsequent sections, we conduct analysis using i) all markets and ii) single chain theater markets only.

5.2 Within market capacity analysis

In order to examine whether theater capacity depends on entry order in a duopoly market, we consider the following model:

$$Seats_{im} = \alpha + \beta SecondMover_i + \psi_{ic} + \psi_m + \varepsilon_{im}, \quad i = 1, 2, \quad (9)$$

where subscripts $i \in \{1, 2\}$ and $m$ represent the theater of the $i$-th entry in market $m$, respectively. The dependent variable $Seats$ is the number of seats. $SecondMover$ is the indicator for the second mover in the market. The coefficient $\beta$ measures the difference in the number of seats between the first and second entrants within the market. We also control for theater chain and market fixed
Table 2: Difference in theater capacity in the duopoly market

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Markets (1)</th>
<th>All Markets (2)</th>
<th>Single Chain Theaters Markets (3)</th>
<th>Single Chain Theaters Markets (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SecondMover</td>
<td>-1.600</td>
<td>13.373</td>
<td>-0.433</td>
<td>17.128</td>
</tr>
<tr>
<td></td>
<td>(81.248)</td>
<td>(76.502)</td>
<td>(93.434)</td>
<td>(88.575)</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chain</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Market</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>R squared</td>
<td>0.000</td>
<td>0.183</td>
<td>0.000</td>
<td>0.189</td>
</tr>
<tr>
<td>Observations</td>
<td>35</td>
<td>35</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Note: The table presents OLS estimates using \( \tilde{\text{Seats}} \) as the dependent variable. Single chain theater markets are those markets where one theater chain runs one theater at most. Robust standard errors (clustered by market) are in parentheses. The notation *** indicates significance at 1% level, ** at 5% level, * at 10% level.

We first eliminate the market fixed effect \( \psi_m \) by subtracting \( \text{Seats}_{1m} \) from \( \text{Seats}_{2m} \). Let \( \tilde{\text{Seats}}_m = \text{Seats}_{2m} - \text{Seats}_{1m} \), and define \( \tilde{\psi}_c \) and \( \tilde{\varepsilon}_m \) similarly. By rewriting (9) in terms of the transformed variables, we have

\[
\tilde{\text{Seats}}_m = \beta + \tilde{\psi}_c + \tilde{\varepsilon}_m, \tag{10}
\]

which does not include the market fixed effect \( \psi_m \).

Table 2 reports OLS estimation results of (10). For comparison, we estimate the model i) with and without the chain fixed effect, and ii) using theaters in all duopoly markets and in the single chain markets only. The estimated coefficients of the second entrant dummy \( \text{SecondMover} \) are not significant under any specification, suggesting that there is no statistically significant difference between capacities of the first and the second entrants in the duopoly markets. That is, no statistically significant first mover advantage is observed. According to the prediction of the theoretical analysis, this implies that there is oversupply of seating capacity in this industry.

5.3 Across markets revenue per seat analysis

In this subsection, we compare the revenue per seat of theaters in monopoly and duopoly markets using the following model:

\[
\text{APS}_i = \alpha + \gamma \text{Duopoly}_m + \mathbf{X}_i^\prime \lambda + \varepsilon_i, \tag{11}
\]

where the dependent variable \( \text{APS}_i \) is the number of audiences per seat of theater \( i \), and \( \text{Duopoly}_m \) is a binary variable that takes 1 if market \( m \) where theater \( i \) is located is a duopoly market and zero otherwise (i.e., a monopoly market). Since the admission price is constant within a market, the revenue per seat is directly proportional to the audiences per seat. \( \mathbf{X} \) is a vector including the...
Table 3: Difference in audience per seat across markets: OLS

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Markets (1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duopoly</td>
<td>-110.519</td>
<td>-101.461</td>
<td>-105.517</td>
<td>-78.751</td>
</tr>
<tr>
<td></td>
<td>(40.467)**</td>
<td>(36.937)**</td>
<td>(44.379)**</td>
<td>(38.535)**</td>
</tr>
<tr>
<td>New</td>
<td>-245.538</td>
<td>-277.296</td>
<td>-260.477</td>
<td>-296.616</td>
</tr>
<tr>
<td></td>
<td>(65.611)**</td>
<td>(56.591)**</td>
<td>(69.437)**</td>
<td>(59.384)**</td>
</tr>
<tr>
<td>Constant</td>
<td>533.380</td>
<td>576.985</td>
<td>532.129</td>
<td>580.371</td>
</tr>
<tr>
<td></td>
<td>(36.133)**</td>
<td>(40.011)**</td>
<td>(36.615)**</td>
<td>(40.837)**</td>
</tr>
</tbody>
</table>

Fixed Effects

<table>
<thead>
<tr>
<th></th>
<th>All Markets</th>
<th>Single Chain Theaters Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chain</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Region</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

| R squared        | 0.285           | 0.468                         |
| Observations     | 201             | 201                           |

Note: The table presents OLS estimates using APS as the dependent variable. Single chain theater markets are those markets where a theater chain runs one theater at most. Robust standard errors (clustered by market) are in parentheses. The notation *** indicates significance at 1% level, ** at 5% level, * at 10% level.

following control variables that may affect the audiences per seat: i) a dummy variable for new theaters that opened in 2013, ii) the theater chain fixed effect, and iii) the region fixed effect. Thus, in (11), the coefficient $\gamma$ measures the difference in the audience per seat between the monopoly and duopoly markets, after controlling for the variables in $X$.

We estimate (11) using OLS first, assuming that all regressors are exogenous. The estimation results are reported in Table 3. Note that estimates of the coefficient $\gamma$ are all negative and significant. This implies that the audience per seat is smaller in a duopoly market than in a monopoly market. Specifically, when all markets are analyzed, the results show that local monopolists attract approximately 100 more customers per seat on average annually than theaters in duopoly markets. In addition, new theaters have lower audience per seat due to the shorter operation period in the sample period.

We recognize that the binary variable $Duopoly$ may be influenced by theater revenue and therefore potentially be endogenous. To deal with this issue, we estimate the model by the instrumental variables (IV) estimation method. As an instrumental variable, we consider the indicator for the second mover, $SecondMover$. First of all, it is correlated with the market structure because the second mover exists only in the duopoly market. While the exogeneity of $SecondMover$ cannot be directly tested, it implies that the entry order should not directly affect the audience per seat but only through $Duopoly$. Thus, we check if the entry order within a duopoly market has no effect on audience per seat through the following model:

$$APS_{im} = \alpha + \delta SecondMover_i + X'_i \lambda + \varepsilon_{im}, \quad i = 1, 2,$$

(12)

where the region fixed effect is replaced with the market fixed effect in $X$. The coefficient $\delta$ measures the difference in the audience per seat between the first and second entrants in the market. The
Table 4: Difference in audience per seat across markets: 2SLS

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Markets</th>
<th></th>
<th></th>
<th>Single Chain Theaters Markets</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>Second</td>
<td>First</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duopoly</td>
<td>-127.949</td>
<td>(54.714)**</td>
<td>-133.753</td>
<td>(51.535)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>-0.085</td>
<td>(0.085)</td>
<td>-275.342</td>
<td>(53.573)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SecondMover</td>
<td>0.730</td>
<td>(0.042)***</td>
<td>0.752</td>
<td>(0.044)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.193</td>
<td>(0.131)</td>
<td>585.114</td>
<td>(41.573)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.163</td>
<td>(0.128)</td>
<td>594.852</td>
<td>(41.303)***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The table presents 2SLS estimates using APS as the dependent variable. Duopoly is instrumented by the instrument variable, SecondMover. Standard errors (clustered by market) are in parentheses. The notation *** indicates significant at 1% level, ** at 5% level, * at 10% level.

estimation results, reported in Table A2 in the Appendix, show that the difference is not statistically significant under all specifications. This finding suggests that the entry order is uncorrelated with the audience per seat in duopoly markets. Therefore, its effect on the audience per seat in general would be only indirectly through the market structure. Consequently, the entry order’s correlation with the market structure, while not directly affecting the audience per seat, assures the validity of SecondMover as an instrument variable.

The 2SLS estimates of a just identified model are presented in Table 4. While the Durbin Wu Hausman (DWH) test of endogeneity does not reject the null hypothesis of exogeneity of Duopoly in either specification, all the estimated coefficients have effects similar to the previous OLS estimation results. Thus, we find empirical evidence that the theaters in duopoly markets have a lower audience per seat than those in monopoly markets. According to the theoretical analysis, this indicates that there may be oversupply of seats and thus that the market is inefficient. This is consistent with the previous finding of no first mover advantage, implying the validity of the theoretical model. This also suggests that the ticket price $p$ is set high enough to induce oversupply of seating capacity.

5.4 Robustness

Note that we used 1 mile (1.61 kilometers) as the basis threshold radius in the identification of local markets. That is, we regard a group of theaters as being in the same market if each of them has at least one competitor within 1 mile. As a robustness check, we consider a range of basis threshold
Note: The upper panel of this figure plots OLS estimates of $\hat{\beta}$ in (10) and its 95 percent confidence band for the basis threshold radii from 1.5 to 2 kilometers. The bottom panel plots OLS estimates of $\hat{\gamma}$ in (11) and its 95 percent confidence band for the same basis threshold radii as above.

The upper and lower panels of Figure 5 show the estimated coefficients $\hat{\beta}$ from (10) and $\hat{\gamma}$ from (11) respectively along with their 95 percent confidence bands using all markets. They show that, under different basis threshold radii, i) there is no statistically significant difference between the first mover’s capacity and the second entrant’s capacity in a duopoly market, and ii) the average audience per seat is lower for theaters in duopoly markets compared to that of the local monopolists.

In sum, our empirical findings in the previous section that there exists oversupply of seating capacity and thus the market is inefficient are robust to the changes in the local market definition.

6 Conclusion

In this article, we explore firms’ strategic decisions regarding how much to supply in a homogeneous goods market. Firms in our model can be interpreted as retailers who compete with each other under a given fixed price. In homogeneous goods markets, oversupply may be common because there is no preemption effect and therefore, firms are inclined to supply more to increase their

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14 When we use 2 kilometers as a threshold radius, the longest distance between theaters within a market is approximately 5 kilometers. We believe that this is the largest reasonable size which can be identified as one market.

15 The results are similar when only single chain theater markets are used, and thus omitted.
market shares. However, due to the potential cost incurred from oversupply, supplying more is not always beneficial. Thus, firms should make strategic decisions. We study this topic in a setting where firms make decisions sequentially. Our main result is that, even in a setting in which the cost from oversupply is considered, each firm’s rational choice can result in excess supply which is socially inefficient.

Our model also proposes two practical ways to evaluate market efficiency. If i) the supply levels of the leader and the follower are identical and ii) the profit (revenue) per unit of a firm in a duopoly market is less than that in a monopoly market, then there is excess supply. On the other hand, if i) the supply level of the leader is greater than that of the follower and ii) firms’ profits (revenues) per unit are identical across different market structures, then the market is efficient. These conditions are useful in that information about market demand, which is practically difficult to assess and obtain, is not required.

Based on the prediction of the theoretical analysis, we conduct an empirical analysis evaluating the market efficiency in the Korean movie theater industry. This industry fits into the framework of our model well, especially in that the rigid ticket price, which is a part of the profit, is given exogenously and is not related to theaters’ choices on seating capacity. The empirical analysis provides evidence that there is an oversupply of seating capacity, and thus, the market is inefficient.

We conclude by presenting a possible extension of the current model. Our model crucially depends on the assumption that the price is given exogenously. This assumption works well in the retail market or the multimedia goods market, in which the rigid list prices are determined before the goods are marketed. However, if we consider firms that produce goods, we can think of a setting where the price would be related to output levels. Another direction would be to consider a vertical setup in which retail prices are determined by the strategic interaction among downstream retailers, rather than being fixed by the list price. The strategic decisions of firms under these settings will be different. We plan to extend the current model in that direction in the future.
References


Appendix

Proof of Lemma 1

Case 1) When \( x < M \).

If the follower wants to induce the efficient supply, i.e., \( x + y = M \), the follower’s best response function is

\[
y = M - x
\]  
(A1)

If the follower wants to induce oversupply, i.e., \( x + y > M \), from (4), the follower’s best response function is

\[
y = \left( \sqrt{\frac{M(p + c_2)x}{c_1 + c_2}} - x \right)
\]  
(A2)

From the condition that \( y > M - x \), \( \sqrt{\frac{M(p + c_2)x}{c_1 + c_2}} > M \implies x > \frac{M(c_1 + c_2)}{p + c_2} \) where \( \frac{M(c_1 + c_2)}{p + c_2} < M \). Therefore, (A2) is the follower’s best response only for \( \frac{M(c_1 + c_2)}{p + c_2} < x < M \). For \( 0 < x < \frac{M(c_1 + c_2)}{p + c_2} \), if (A2) is the follower’s best response, undersupply occurs, i.e., \( x + y < M \). However, given that \( p > c_1 \), the follower has no reason not to cover the remaining demand \( M - (x + y) \). Hence, for \( 0 < x \leq \frac{M(c_1 + c_2)}{p + c_2} \), (A1) is the best response.

For \( \frac{M(c_1 + c_2)}{p + c_2} < x < M \), the follower should decide whether to respond with (A1) which induces \( x + y = M \) or (A2) which induces \( x + y > M \). If (A1) is his best response, the follower’s profit as a function of \( x \) is

\[
\pi_2^{A1} = (M - x)(p - c_1)
\]

and if (A2) is his best response, it is

\[
\pi_2^{A2} = x(c_1 + c_2) + M(c_2 + p) - \sqrt{4Mx(c_2 + p)(c_1 + c_2)}
\]

Then,

\[
\pi_2^{A1} - \pi_2^{A2} = -(c_2 + p)\left(\sqrt{x}\right)^2 + 2\sqrt{M(c_1 + c_2)(p + c_2)}\sqrt{x} - M(c_1 + c_2)
\]

This is a concave function of \( \sqrt{x} \) which attains the maximum value 0 at \( \sqrt{x} = \sqrt{\frac{M(c_1 + c_2)}{c_2 + p}} \implies x = \frac{M(c_1 + c_2)}{c_2 + p} \). Hence, for \( \frac{M(c_1 + c_2)}{p + c_2} < x < M \), \( \pi_2^{A1} < \pi_2^{A2} \), implying that responding with (A2) is better for \( \frac{M(c_1 + c_2)}{p + c_2} < x < M \).

Case 2) When \( x \geq M \)

For \( y > 0 \), oversupply occurs always. Then, the follower’s objective function is (3), and the corresponding best response function is (A2). From (A2), for \( y > 0 \), it should be the case that

\[
\sqrt{\frac{M(p + c_2)x}{c_1 + c_2}} > x \implies x < \frac{M(p + c_2)}{c_1 + c_2}.
\]

So, (A2) is the follower’s best response only if \( x < \frac{M(p + c_2)}{c_1 + c_2} \). If \( x \geq \frac{M(p + c_2)}{c_1 + c_2} \), the follower’s best response is \( y = 0 \). \( \square \)

Proof of Proposition 1

First, if the leader intends to supply \( x \) such that \( 0 < x \leq \frac{M(c_1 + c_2)}{p + c_2} \), his objective function is

\[
\pi_1 = px - c_1 x
\]
As $\frac{\partial y}{\partial x} = p - c_1 > 0$, for $0 < x \leq \frac{M(c_1 + c_2)}{p + c_2}$, the optimal choice is $x = \frac{M(c_1 + c_2)}{p + c_2}$. Then, $y = \frac{M(p - c_1)}{p + c_2}$ from (2).

Second, if the leader intends to supply $x$ such that $\frac{M(c_1 + c_2)}{p + c_2} < x < \frac{M(p + c_2)}{c_1 + c_2}$, the leader’s objective function is

$$\pi_1 = p \left( \frac{x}{x + y} \right) M - c_2 \left( x - \frac{x}{x + y} M \right) - c_1 x$$

If we update (6),

$$\pi_1 = - (c_1 + c_2) \left( \sqrt{x} \right)^2 + \sqrt{M (p + c_2) (c_1 + c_2)} \sqrt{x}$$

This is a concave function of $\sqrt{x}$ which is maximized at $x = \frac{M(p + c_2)}{4(c_1 + c_2)} \left( \frac{M(p + c_2)}{c_1 + c_2} \right)$. Given that $\frac{M(c_1 + c_2)}{p + c_2} < x < \frac{M(p + c_2)}{c_1 + c_2}$, depending on whether $\frac{M(p + c_2)}{4(c_1 + c_2)} \geq \frac{M(c_1 + c_2)}{p + c_2}$, the optimal $x$ is determined.

Here, $\frac{M(p + c_2)}{4(c_1 + c_2)} - M \left( \frac{c_1 + c_2}{p + c_2} \right) = \frac{M(2c_1 + 3c_2 + p)}{4(p + c_2)(c_1 + c_2)} (-2c_1 - c_2 + p)$. So, if $p > 2c_1 + c_2$, $\frac{M(p + c_2)}{4(c_1 + c_2)} > \frac{M(c_1 + c_2)}{p + c_2}$. Then, the optimal point is $x^* = \frac{M(p + c_2)}{4(c_1 + c_2)}$. If $p \leq 2c_1 + c_2$, $\frac{M(p + c_2)}{4(c_1 + c_2)} \leq \frac{M(c_1 + c_2)}{p + c_2}$. Then, the optimal point is inf $A$ where $A$ is the set of $x$ such that $x > \frac{M(c_1 + c_2)}{p + c_2}$.

Third, if the leader intends to supply $x$ such that $x \geq \frac{M(p + c_2)}{c_1 + c_2} (> M)$, the leader’s objective function is

$$\pi_1 = pM - c_2 (x - M) - c_1 x$$

From $\frac{\partial (\pi_1)}{\partial x} = -(c_1 + c_2) < 0$, $x = \frac{M(p + c_2)}{c_1 + c_2}$. Then, $\pi_1 \left( x = \frac{M(p + c_2)}{c_1 + c_2} \right) = 0$. Hence, as long as other choices yield positive profit, $x = \frac{M(p + c_2)}{c_1 + c_2}$ is strictly dominated.

The above can be summarized as follows:

1) Suppose that $p \leq 2c_1 + c_2$. If the leader intends to produce $0 < x \leq \frac{M(c_1 + c_2)}{p + c_2}$, $x = \frac{M(c_1 + c_2)}{p + c_2}$,
if
$\frac{M(c_1 + c_2)}{p + c_2} < x < \frac{M(p + c_2)}{c_1 + c_2}$, $x = \inf A$ where $A$ is the set of $x$ such that $x > \frac{M(c_1 + c_2)}{c_1 + c_2}$, and if $x \geq \frac{M(p + c_2)}{c_1 + c_2} (> M)$, $x = \frac{M(p + c_2)}{c_1 + c_2}$.

2) Suppose that $p > 2c_1 + c_2$. If the leader intends to produce $0 < x \leq \frac{M(c_1 + c_2)}{p + c_2}$, $x = \frac{M(c_1 + c_2)}{p + c_2}$,
if
$\frac{M(c_1 + c_2)}{p + c_2} < x < \frac{M(p + c_2)}{c_1 + c_2}$, $x = \frac{M(p + c_2)}{c_1 + c_2}$, and if $x \geq \frac{M(p + c_2)}{c_1 + c_2} (> M)$, $x = \frac{M(p + c_2)}{c_1 + c_2}$.

In each case, the leader chooses the strategy that yields the greatest profit.

1) When $p \leq 2c_1 + c_2$, if $x_1 = \frac{M(c_1 + c_2)}{p + c_2}$, from (A3), $\pi_1 (x_1) = \frac{M(c_1 + c_2)}{p + c_2} (p - c_1)$. If $x_2 = \inf A$, from (A4), $\pi_1 (x_2) < \frac{M(p + c_2)}{c_1 + c_2} (p - c_1)$. If $x_3 = \frac{M(p + c_2)}{c_1 + c_2}$, from (A5), $\pi_1 (x_3) = 0$. Hence, the leader’s choice is $x_1 = \frac{M(c_1 + c_2)}{p + c_2}$.

2) When $p > 2c_1 + c_2$, if $x_1 = \frac{M(c_1 + c_2)}{p + c_2}$, from (A3), $\pi_1 (x_1) = \frac{M(c_1 + c_2)}{p + c_2} (p - c_1)$. If $x_4 = \frac{M(p + c_2)}{4(c_1 + c_2)}$, from (A4), $\pi_1 (x_4) = \frac{M(p + c_2)}{4}$. If $x_3 = \frac{M(p + c_2)}{c_1 + c_2}$, from (A5), $\pi_1 (x_3) = 0$. Here, $\pi_1 (1) - \pi_1 (x_3) = - \frac{1}{4} M \left( \frac{2c_1 - c_2 + p}{p + c_2} \right)^2 < 0$. Thus, the leader’s choice is $x_3 = \frac{M(p + c_2)}{4(c_1 + c_2)}$.

Finally, given $p > c_1$, the leader’s choice is as follows: if $c_1 < p \leq 2c_1 + c_2$, $x^* = \frac{M(c_1 + c_2)}{p + c_2}$ and if $p > 2c_1 + c_2$, $x^* = \frac{M(p + c_2)}{4(c_1 + c_2)}$. Given conditions, if $x^* = \frac{M(c_1 + c_2)}{p + c_2}$, $y^* = \frac{M(p - c_1)}{p + c_2}$ from (A1). If $x^* = \frac{M(p + c_2)}{4(c_1 + c_2)}$, $y^* = \frac{M(p + c_2)}{4(c_1 + c_2)}$ from (A2). □
Proof of Corollary 1

i) \( \frac{\partial x^*}{\partial p} = -M \frac{c_1 + c_2}{(p + c_2)^2} < 0 \) and \( \frac{\partial^2 x^*}{\partial p^2} = 2M \frac{c_1 + c_2}{(p + c_2)^3} > 0 \), ii) \( \frac{\partial y^*}{\partial p} = M \frac{c_1 + c_2}{(p + c_2)^2} > 0 \) and \( \frac{\partial^2 (y^*)}{\partial p^2} = -2M \frac{c_1 + c_2}{(p + c_2)^3} < 0 \), and iii) \( \frac{\partial(x^* - y^*)}{\partial p} = -2M \frac{c_1 + c_2}{(p + c_2)^2} < 0 \) and \( \frac{\partial^2 (x^* - y^*)}{\partial p^2} = 4M \frac{c_1 + c_2}{(p + c_2)^3} > 0. \)

Proof of Corollary 5

If the first entrant joins the market, his net profit is \( \pi = pM - c_1 M - F \). Thus, the threshold of a market demand above which at least one firm operates in the market is \( M = \frac{F}{p-c_1} \). If the second entrant joins the market, when \( x + y > M \), the follower’s net profit is

\[
\pi_2 = p \left( \frac{y}{x+y} \right) M - c_1 y - c_2 \left( y - \frac{y}{x+y} M \right) - F
\]

In particular, if \( x + y = M \),

\[
\pi_2 = py - c_1 y - F
\]

From Proposition 1, if \( c_1 < p < 2c_1 + c_2 \), the profit function is \( \pi_2 = \frac{M(c_1-p)^2}{p+c_2} - F \) and if \( p > 2c_1 + c_2 \), it is \( \pi_2 = \frac{1}{2} M (p + c_2) - F \). Given that there is already an incumbent, when \( c_1 < p < 2c_1 + c_2 \), the market remains a monopoly if \( \frac{M(c_1-p)^2}{p+c_2} < F \). Therefore, the threshold of market demand above which there is a new entrant is \( M = \frac{F(p+c_2)}{(c_1-p)^2} \). If \( p > 2c_1 + c_2 \), it is \( M = \frac{4F}{p+c_2} \).

Proof of Corollary 6

When \( c_1 < p < 2c_1 + c_2 \), \( M_1 = \frac{F}{p-c_1} \) and \( M_2 - M_1 = F \frac{c_1 + c_2}{(-c_1 + p)^2} \). Then, \( M_1 - (M_2 - M_1) = F \frac{2c_1 - c_2 + p}{(-c_1 + p)^2} < 0 \implies 2M_1 < M_2 \). When \( p > 2c_1 + c_2 \), \( M_2 - M_1 = F \frac{-4c_1 - c_2 + 3p}{(p+c_2)(-c_1 + p)} \). Then, \( M_1 - (M_2 - M_1) = -2F \frac{-2c_1 - c_2 + p}{(p+c_2)(-c_1 + p)} < 0 \implies 2M_1 < M_2 \).

Proof of Proposition 4

Given the optimal seating capacities \( x_i^* \), each firm’s profit per unit is

\[
\frac{\pi^*_i(x_i^*, x_{i-1}^*)}{x_i^*} = p \left( \frac{M}{\sum_{i=1}^{k} x_i^*} \right) - c_2 \left( 1 - \left( \frac{M}{\sum_{i=1}^{k} x_i^*} \right) \right) - c_1
\]

The profit per unit in a monopoly market is \( \frac{\pi^*_m}{x_m^*} = np - c_1 \). Then,

\[
\frac{\pi^*_m}{x_m^*} - \frac{\pi^*_i(x_i^*, x_{i-1}^*)}{x_i^*} = (p + c_2) \frac{\sum_{i=1}^{k} x_i - M}{\sum_{i=1}^{k} x_i}
\]

Thus, \( \frac{\pi^*_m}{x_m^*} \geq \frac{\pi^*_i(x_i^*, x_{i-1}^*)}{x_i^*} \) if and only if \( \sum_{i=1}^{k} x_i \geq M \). Similarly, comparison of revenue per unit in each market structure yields that

\[
\frac{TR^*_m}{x_m^*} - \frac{TR^*_i(x_i^*, x_{i-1}^*)}{x_i^*} = p \frac{\sum_{i=1}^{k} x_i - M}{\sum_{i=1}^{k} x_i}
\]

Thus, \( \frac{TR^*_m}{x_m^*} \geq \frac{TR^*_i(x_i^*, x_{i-1}^*)}{x_i^*} \) if and only if \( \sum_{i=1}^{k} x_i \geq M. \)
Table A1: Difference in theater capacity: without market fixed effect

<table>
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<th>Variable</th>
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<th>All Markets (2)</th>
<th>Single Chain Theaters Markets (3)</th>
<th>Single Chain Theaters Markets (4)</th>
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<td>-0.433</td>
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<td></td>
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<td>(102.852)**</td>
<td>(87.914)**</td>
<td>(110.579)**</td>
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Fixed Effects

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<td>Observations</td>
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Note: The table presents OLS estimates using Seats as the dependent variable. Single chain theater markets are those markets where a theater chain runs one theater at most. Robust standard errors (clustered by market) are in parentheses. The notation *** indicates significant at 1% level, ** at 5% level, * at 10% level.

Table A2: Difference in audience per seat in the duopoly market

<table>
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<th>All Markets (1)</th>
<th>All Markets (2)</th>
<th>Single Chain Theaters Markets (3)</th>
<th>Single Chain Theaters Markets (4)</th>
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<td>(223.029)</td>
<td>(149.675)**</td>
<td>(169.680)**</td>
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Fixed Effects

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<tr>
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<tr>
<td>Observations</td>
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Note: The table presents OLS estimates using APS as the dependent variable. Single chain theater markets are those markets where a theater chain runs one theater at most. Robust standard errors (clustered by market) are in parentheses. The notation *** indicates significant at 1% level, ** at 5% level, * at 10% level.