MARKETING SCIENCE
Vol. 33, No. 3, May–June 2014, pp. 353–363
ISSN 0732-2399 (print) | ISSN 1526-548X (online)
http://dx.doi.org/10.1287/mksc.2013.0827
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A Dynamic Model of Competitive Entry Response

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I develop a dynamic investment game with a "memoryless" research and development process in which an incumbent and an entrant can invest in a new technology, and the entrant can also invest in the old technology. I show that an increase in the probability of successfully implementing a technology can cause the incumbent to *reduce* its investment. Under certain conditions, if the success probability is high, the incumbent allows the entrant to win the new technology so that firms reach an equilibrium in which they use different technologies, and threats of retaliation prevent attacks; but if the success probability is low, such an equilibrium cannot be sustained, and both firms eventually implement both technologies.

Keywords: new product development; defensive strategy, Markov perfect equilibrium
History: Received: October 21, 2012; accepted: October 24, 2013; Preyas Desai served as the editor-in-chief and Miguel Villas-Boas served as associate editor for this article. Published online in *Articles in Advance* December 9, 2013.

1. Introduction

When a new entrant attacks an incumbent, the incumbent typically has many advantages such as established retail locations and expertise in current technology. The entrant might then try to develop its own advantages, for example, by investing in a new distribution channel such as the Internet, a new technology, or a lower-cost business model. The incumbent must then decide how to respond to this threat.

Firms facing this problem have used a variety of entry-response strategies. For example, following E*TRADE's early success with online trading technology, Charles Schwab invested in its own online trading platform. Now both firms offer online trading. By contrast, when BestBridalPrices.com launched an online wedding dress store, many traditional wedding shops such as Priscilla of Boston decided to stay focused on their traditional business and *not* sell dresses online. Other approaches include delayed response or responding only if the entrant directly attacks the incumbent's traditional business. For example, after easyJet's entry as a "no-frills" airline, British Airways initially continued to focus on the traditional full-service format; however, when easyJet began moving upscale and serving more business passengers, British Airways retaliated by adopting a no-frills model for some of its short-haul European routes.

This paper develops a dynamic investment model that derives conditions in which these various entry-response strategies are optimal. The model assumes an incumbent with expertise in an old business "format" faces competition from a new entrant. Both firms can invest in a new business format, which might represent a new technology or, more generally, a new business approach, which is now possible as a result of exogenous technological progress or changes in customer preferences. Either firm can potentially use both formats; for example, they can distribute a product through traditional retail stores and over the Internet.

A firm has some random probability of successfully implementing a format in which it makes a positive investment. If a firm fails to implement a format in a given period, it can try again in the following period. For example, an airline trying to adopt a lower-cost business model might need to renegotiate contracts with its union and train employees to spend less time handling each customer complaint. If these negotiations and organizational changes fail one year, the airline can try them again the next year.

Although many factors could affect firms' investment decisions, I focus on three key parameters. The first is the strength of preemption effects, which tend to prevent a firm from investing in a format its competitor is already using. I operationalize this parameter by allowing customers to have uniformly distributed brand preferences; when brand preferences are weak, if two firms use the same format, intense price competition ensues, and profits generated from that format are low. Therefore, preemption effects are strong; that is, once one firm has implemented a format, the other firm has little incentive to do so.

The second key parameter is the strength of cannibalization effects across formats. I operationalize this parameter by allowing for three groups of customers: those who consider only the old format, those who consider only the new format, and those who consider both formats. If the number of customers

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who will consider both formats is large, a firm that is already using one format has little incentive to implement a second format, because doing so would mostly cannibalize sales from its existing format rather than attracting new customers.

The third key parameter is the probability that a firm that invests in a format will successfully implement this format at an operational or organizational level. In some cases, implementing a new format is fairly straightforward, and firms that make the necessary investments are almost certain to implement the format successfully; in other cases, even a firm that makes substantial investments in a format might fail to implement it. I use a general functional form for success probability that makes exploring both cases possible.

I show that interesting interactions occur among these three parameters. In particular, when preemption and cannibalization effects are strong, an increase in success probability causes the incumbent to invest *more* in the new format in an attempt to deter the entrant from investing. This result is consistent with previous theoretical research on innovation (Gilbert and Newbery 1982, Reinganum 1983). More surprisingly, when preemption and cannibalization effects are weak, an increase in success probability causes the incumbent to invest *less* in the new format to avoid the threat that the entrant will retaliate by investing in the old format. Thus, I show that an increase in the ease (or expected speed) with which firms can implement formats might *discourage* the incumbent's investment in the new format.

As an illustrative example, consider the contrast between the airline industry and the package-shipping industry. For a traditional full-service airline, implementing a no-frills format (or for a no-frills airline, implementing a full-service format) is a major organizational challenge, requiring firms to invest in retraining employees, renegotiating union contracts, and developing new pricing skills, all of which have a fairly high chance of failure (Sanchez 1994, Dutta et al. 2003). By contrast, in the package-shipping industry, for primarily ground-based carrier UPS to acquire more airplanes (or for primarily air-based carrier FedEx to acquire more trucks) is a more straightforward investment, because both firms have the logistical expertise to manage both ground and air shipping (Composit and Speckman 2004).

We might expect that the difficulty of implementing new formats would compel airlines to stay focused, whereas the ease of implementing new formats would compel package-shipping firms to diversify, but in fact, the opposite has occurred. Over time, traditional airlines have improved aircraft turnaround times, renegotiated labor contracts, and stopped offering free meals and free checked bags, whereas the no-frills airlines have added additional routes, improved customer service, and started offering optional services such as early boarding to attract business passengers. The two types of airlines have become similar, with both offering an efficient no-frills level of service and better service at a higher price (Cowell 2002, McCartney 2011, Jacobs 2013). By contrast, UPS and FedEx remain more differentiated, with UPS focusing heavily on ground transportation and FedEx focusing heavily on air transportation (Darell 2011).

Of course, competitive outcomes in these industries depend on many complex forces beyond those in this paper's theoretical model. Nonetheless, this model provides one potential explanation for why traditional airline incumbents (faced with the threat from no-frills airlines) have invested continuously in the difficult task of developing low-cost no-frills expertise, whereas package-shipping incumbent UPS (faced with the threat from FedEx) has largely avoided the easier task of expanding its air-shipping service.

The rest of this papers is as follows. Section 2 discusses related literature. Section 3 presents the formal model and results. Section 4 presents two model extensions that study asymmetric formats. Section 5 concludes. A supplemental online appendix (available as supplemental material at http://dx.doi.org/10.1287/mksc.2013.0827) contains all proofs.

2. Related Literature

Previous theoretical literature in economics and marketing has studied optimal defensive strategies (Schmalensee 1978, Hauser and Shugan 1983, Reinganum 1983, Fudenberg and Tirole 1984, Katz and Shapiro 1987, Purohit 1994, Balasubramanian 1998, Kalra et al. 1998) and entry strategies (Gelman and Salop 1983, Carpenter and Nakamoto 1990, Narasimhan and Zhang 2000, Joshi et al. 2013). The current paper contributes to this literature by incorporating competition between an entrant and an incumbent into a dynamic investment game in which firms make repeated investments over a theoretically infinite number of periods. Because successful investment can lead to a series of reactions and counterreactions, this model generates new insights into how threats of strategic retaliation influence investment behavior.

Previous theoretical research has also shown that multimarket contact in a repeated game can help firms sustain high prices (Bernheim and Whinston 1990) or sustain an arrangement in which they focus on different markets (Karnani and Wernerfelt 1985, Bronnenberg 2008). The current paper differs in two key respects. First, I show how preemption effects, cannibalization effects, and the difficulty of implementing a format interact to determine whether firms can sustain an equilibrium in which they stay focused on different formats. Second, I show that multiformat

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contact can create an asymmetry in the investment incentives of an incumbent and an entrant; for example, in some cases, the entrant invests heavily in the new format, whereas the incumbent invests nothing.

Another related stream of research has developed dynamic investment models involving increasing returns (Athey and Schmutzler 2001, Rob and Fishman 2005), which implies that firms invest more in areas of current strength than in areas of current weakness (Selove 2013). By contrast, the current paper does not involve increasing returns. Instead, concerns over cannibalization and competitive retaliation sometimes compel firms to stay focused.

Empirical literature has studied factors that determine whether incumbents invest in new technologies (e.g., Christensen 1997; Chandy and Tellis 1998, 2000; Debruyne and Reibstein 2005) or lower-cost business formats (e.g., Ritson 2009). These papers have identified concerns over cannibalization and preemption as key factors that determine whether firms adopt new technologies and whether defensive strategies are successful. This paper uses a formal game-theoretic model to clarify how these factors determine firms' optimal investment strategies.

3. Model

Assume two firms, indexed by $i \in \{A, B\}$, can compete using two possible business formats, indexed by $j \in \{1, 2\}$. At any time t, the formats used by each firm are given by $X_t = (X_{A,1,t}, X_{A,2,t}; X_{B,1,t}, X_{B,2,t})$, where

$$X_{i,j,t} = \begin{cases} 1 & \text{if firm } i \text{ uses format } j \text{ at time } t, \\ 0 & \text{otherwise.} \end{cases}$$

The game begins in state $(1, 0; 0, 0)$, with firm A (the incumbent) using only format 1 and firm B (the entrant) not using either format. Assume firms cannot exit a format (or equivalently, exit costs are sufficiently high), so that once a firm starts using a format, it always continues to do so. If firm i did *not* use format j at time $t-1$, the probability that it will successfully implement (and begin using) this format at time t is the following (as long as this function is not greater than 1):

$$F(e_{i,j,t}) = \frac{z}{d}\ln(de_{i,j,t} + 1), \quad (1)$$

where $z > 0$, $d > 0$, and $e_{i,j,t}$ is the amount firm i invests in format j at time t. This success function is memoryless in the sense that past failed investments have no effect on the current state.

Taking the first derivative, we have

$$F'(e_{i,j,t}) = \frac{z}{de_{i,j,t} + 1}. \quad (2)$$

Note that $F'(0) = z$, and the parameter d determines how rapidly the marginal value of investment decreases.

Figure 1 **Investment Success Function Examples**

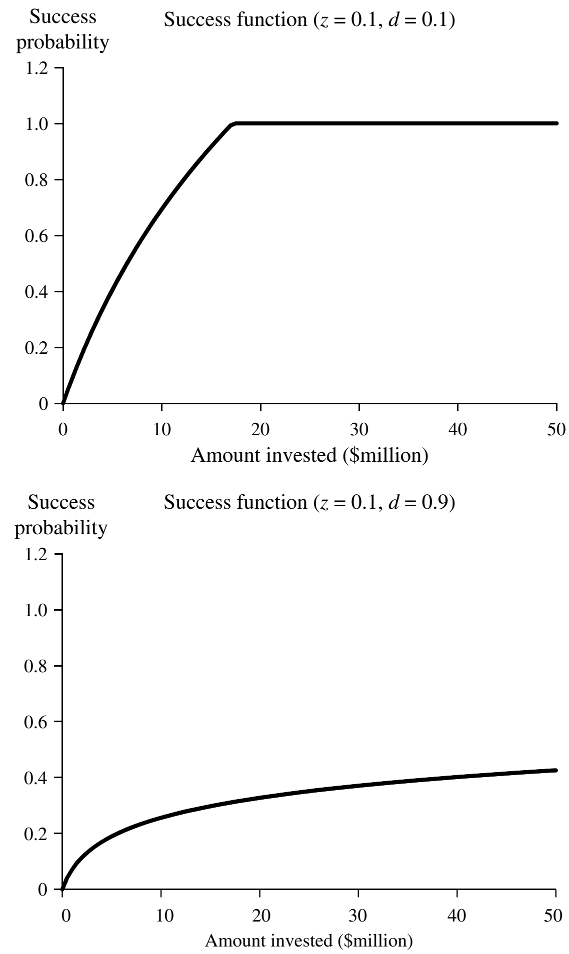

Figure 1 gives examples of this investment success function for two different sets of parameter values. For both examples, $z = 0.1$, so the marginal impact of the first dollar invested is the same. However, for the first example, $d = 0.1$, which means each additional dollar invested continues to have a large impact on the probability of success, whereas for the second example, $d = 0.9$, which means the marginal impact of each additional dollar rapidly decreases. A key point of this paper is to explore how these two different types of success functions affect the equilibrium outcome of the game.

I assume a firm cannot simultaneously invest in both formats in a given period.[1] I also assume firms alternate their investments, so firm A invests only in odd-numbered periods and firm B invests only in even-numbered periods.[2] These assumptions simplify

[1] Intuitively, because of limitations on managerial time and attention or other internal resource constraints, there are often diseconomies of scope to investment during a given time period.

[2] For another example of a dynamic model in which firms alternate moves, see Maskin and Tirole (1988).

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the analysis by ensuring that only one state variable can change in any given period.

Let $\pi^A_{(X_t)}$ and $\pi^B_{(X_t)}$ represent firm A's and firm B's profits, respectively, as a function of the current state X_t. Each firm has discount factor δ and maximizes expected discounted profits. Firm A's objective is to maximize

$$E\left[\sum_{t=0}^{\infty}\delta^t(\pi^A_{(X_t)} - e_{A,1,t} - e_{A,2,t})\right]. \tag{3}$$

Firm B has an analogous objective function. I assume firms play a Markov perfect equilibrium (MPE) of this dynamic investment game.

In principle, we could make the model more realistic by relaxing some of these assumptions. For example, we could allow firms to exit formats, and similar results would still hold if we also restricted the profit functions in such a way that exit is never optimal.[3] We could also allow for multiple discrete states of success (and "partially successful" investment) or allow for simultaneous investment by both firms in both formats. Such changes would complicate the analysis technically, but the same basic forces described in §3.3 would still determine whether firms can sustain an equilibrium in which they stay focused on different formats.

However, one key assumption cannot be relaxed. The restriction to Markov strategies implies that a firm can retaliate only in response to a change in the game's state; that is, a firm can react to its competitor's successful investment but *cannot* react to a failed investment. In fact, Proposition 1 (in §3.3) depends on the possibility that each firm could have a long string of investment failures without facing retaliation for these failed investments. This assumption is reasonable if companies can keep their investments secret until they reach some level of technical or operational success. For example, the technology firm Apple is famous for keeping its new product strategies secret, preventing competitive reaction, until it is ready for product launch (Lashinsky 2012).

If each firm *can* observe and react to its competitor's failed investments, Proposition 1 does not hold. However, Proposition 2 (in §3.3) still holds, and the equilibria described in Propositions 3–5 (in §§3.4, 4.1, and 4.2, respectively) still exist. More generally, allowing firms to react to failed investments would not rule out any of the equilibria identified in this paper; it would, however, permit additional equilibrium outcomes.[4]

3.1. Product Market Competition

I now introduce a model of product market competition that gives rise to a profit function for each firm at each possible state.

Assume a unit mass of customers varies along two dimensions. First, their brand preferences are represented by a Hotelling line with length 1 and per-unit transportation cost β. Firm A is fixed at the left side of the line and firm B is fixed at the right side.[5] Customers also vary in their format preferences. A fraction α will buy only using format 1, another α will buy only using format 2, and the remaining $1-2\alpha$ are indifferent between the two formats, where $\alpha \in [0, \frac{1}{2}]$. One can think of customers who will use only the new format as having a latent preference they do not realize until at least one firm implements the new format, at which point these customers enter the market.

In each period, a customer buys at most one product. Suppose a customer is located a distance ψ from the left side of the line. If this customer has either a preference for format 1 or no format preference, he derives utility $V - \beta\psi - P_{A,1}$ if he purchases from firm A using format 1 at price $P_{A,1}$. However, if he has a preference for format 2, he derives utility $-\infty$ from any transaction using format 1. The utility of purchasing from firm B or with format 2 can be computed in a similar manner.

Without loss of generality, assume marginal production costs are zero. Throughout the paper, I also assume the following.

Assumption 1. $2\beta < V < 2\beta((1-\alpha)/(1-2\alpha))$.

This assumption ensures the market is covered in equilibrium and that, when firms use different formats (at state $(1,0;0,1)$), they each set the monopoly price.[6]

[3] For the profit functions used in this paper, if there are no exit costs, and if firms reach state $(1,1;1,1)$, an equilibrium could exist in which they both retreat, so the game goes back to state $(1,0;0,1)$. After these "retreats" occur, if we assume firms can immediately reenter any format they have exited in the past, then neither firm would resume using both formats, because its competitor could immediately retaliate by doing the same. The assumption that firms cannot exit a format is a simple way to rule out this type of equilibrium. Alternatively, we could modify the profit functions so mutual retreat *decreases* profits, or we could assume firms face exist costs.

[4] Allowing firms to react to failed investments implies permitting all subgame perfect equilibria, which contains the set of Markov perfect equilibria considered here (see Maskin and Tirole 1988). Note that Proposition 1 states conditions in which both firms implement both formats in *all* equilibria; allowing for additional equilibria can overturn this result. By contrast, Proposition 2 states only that a particular equilibrium exists.

[5] Other theoretical papers have also assumed firms are exogenously located at opposite sides of a Hotelling line in order to focus on other firm decisions (e.g., Simester 1995, Ellison 2005).

[6] If the second inequality in Assumption 1 did not hold, in some cases, state $(1,0;0,1)$ would have a pure strategy price equilibrium in which firms set prices *below* the monopoly level. In other cases, this state would have a mixed strategy price equilibrium in which firms randomize over prices.

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Given this setup, the online appendix proves that an equilibrium exists in which prices are as follows. If a firm is the only one that uses a format, it sets price $V-\beta$ in that format; if both firms use a format, they each set price β in that format. Intuitively, Assumption 1 guarantees each format has enough loyal customers that a firm sets the monopoly price whenever it is the only one to use a format; on the other hand, firms set the standard competitive price from the Hotelling model in any format used by both firms. Table 1 reports equilibrium profits for each firm in each possible state.

The profits in Table 1 arise from the one-shot equilibrium of the pricing game. Note that this equilibrium *does* allow for competitive price reaction when a firm implements a new format. For example, at state $(1,0;0,1)$, the firms are using different formats, and both firms set a monopoly price. If the incumbent then implements the new format, so that the state moves to $(1,1;0,1)$, the entrant immediately cuts its price. This threat of immediate price retaliation helps discourage the incumbent from making this investment. On the other hand, if we allowed collusive pricing at all states, this could remove the threat of price retaliation and *encourage* firms to attack each other's format. More generally, we could allow firms to price collusively at some states and competitively at others, which would encourage investment behavior that leads to the states with collusive pricing. However, I leave the topic of collusive pricing for future research; the current paper focuses on the one-shot price equilibrium.

To summarize, this model captures two key aspects of multiformat competition. First, new formats vary in the degree to which they expand the market as opposed to cannibalizing from the old format (which is determined in this model by α). Second, formats vary in the degree to which they can support multiple profitable firms (which is determined in this model by β). One could also use more realistic and complicated models of product market competition, for example, with asymmetries between firms and formats. Section 4 gives examples of how such asymmetries can affect dynamic investment competition.

Table 1 Equilibrium Profits at Each State

State	Firm A's profits	Firm B's profits
$(1,0;0,0)$	$(V-\beta)(1-\alpha)$	0
$(1,1;0,0)$	$(V-\beta)$	0
$(1,0;0,1)$	$(V-\beta)\frac{1}{2}$	$(V-\beta)\frac{1}{2}$
$(1,0;1,0)$	$\beta(1-\alpha)\frac{1}{2}$	$\beta(1-\alpha)\frac{1}{2}$
$(1,1;0,1)$	$(V-\beta)\alpha+\beta(1-\alpha)\frac{1}{2}$	$\beta(1-\alpha)\frac{1}{2}$
$(1,1;1,0)$	$(V-\beta)\alpha+\beta(1-\alpha)\frac{1}{2}$	$\beta(1-\alpha)\frac{1}{2}$
$(1,0;1,1)$	$\beta(1-\alpha)\frac{1}{2}$	$(V-\beta)\alpha+\beta(1-\alpha)\frac{1}{2}$
$(1,1;1,1)$	$\beta\frac{1}{2}$	$\beta\frac{1}{2}$

3.2. Equilibrium Existence

The online appendix proves the following lemma.

Lemma 1. *A pure strategy Markov perfect equilibrium exists.*

This result holds for any $z>0$, $d>0$, and any V, α, and β satisfying Assumption 1 (refer to Table 2 for notation). Lemma 1 does *not* guarantee equilibrium uniqueness. For example, in some cases, there is an MPE in which both firms invest nothing at state $(1,0;0,1)$ and another MPE in which both firms make a positive investment at this state. The next section derives conditions in which firms can (or cannot) sustain an equilibrium with no investment at this state.

3.3. Weak Preemption and Cannibalization Effects

I first explore the case in which preemption and cannibalization effects are relatively weak (α and β are large). I show that when the success probability is high, there is an equilibrium in which the incumbent allows the entrant to win the new format, and firms then perpetually use different formats. However, if the success probability is low, such an equilibrium does not exist, and both firms eventually implement both formats. The results in this section are the key new insights of the paper.

Define a state as *absorbing* if neither firm invests once that state is reached. Based on the setup of the game, state $(1,1;1,1)$ is obviously absorbing. We can then use backward induction to find equilibrium investment levels for all other states.

Consider what happens at state $(1,0;1,1)$. At this state, as the incumbent decides whether to invest in the new format, it faces both the problem of cannibalizing its existing sales and the problem of potentially entering a format that the entrant is already using. If the following condition holds, neither of these effects

Table 2 Variables in the Model

$i\in\{A,B\}$	Index of firms
$j\in\{1,2\}$	Index of formats
$t\in\{0,1,2,\ldots\}$	Index of time
$X_{i,j,t}\in\{0,1\}$	Indicator of whether firm i uses format j at time t
$e_{i,j,t}$	Firm i's investment in format j at time t
F	Function that maps investment into success probability
z	Rate of increase in success probability for the first dollar invested
d	Determines how rapidly the marginal impact of investment decreases
δ	Each firm's discount factor
$\pi^A_{(X_t)}$, $\pi^B_{(X_t)}$	General profit functions for each firm
V	Value of the product to a customer who is zero distance from the firm
α	Fraction of customers loyal to each format
β	Per-unit transportation cost

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is strong enough to stop the incumbent from investing at this state:

$$\left(\frac{1}{1-\delta}\right)\frac{\alpha\beta}{2} > \frac{1}{z}. \qquad (4)$$

This condition ensures the discounted gains from entering the new format are enough to justify investing the first marginal dollar. In this case, state $(1,0;1,1)$ is not absorbing, because the incumbent makes a positive investment at this state, and therefore the game will eventually move to state $(1,1;1,1)$.

Table 1 implies that the smallest incremental profits from adding a new format occur when firm A (for example) implements format 2 and moves the state from $(1,0;0,1)$ to $(1,1;0,1)$. Generating these incremental profits over an infinite number of periods would be enough to justify the first marginal dollar of investment if the following condition holds.[7]

Condition 1. $\frac{1}{1-\delta}\left[\frac{\alpha\beta}{2} - (V-2\beta)\left(\frac{1}{2}-\alpha\right)\right] > \frac{1}{z}$.

When this condition holds, any state at which one firm (but not the other) is using both formats cannot be absorbing, because the other firm would always make a positive investment until it also implements both formats.

On the other hand, state $(1,0;0,1)$ could be absorbing. At this state, each firm must worry that implementing another format will lead to retaliation by its competitor. For example, if firm A implements the new format, its profits will temporarily increase; however, once firm B successfully retaliates, the game moves to state $(1,1;1;1)$, at which point increased competition in each format causes firm A's profits to drop below their initial level. This threat of retaliation can prevent investment at state $(1,0;0,1)$ if and only if the following inequality holds (for notational convenience, this condition is stated in terms of the general profit function π^A):

$$\frac{\pi^A_{(1,1;0,1)}[1+\delta(1-F(e^*))]+[\delta/(1-\delta)]F(e^*)\pi^A_{(1,1;1,1)}}{1-\delta^2(1-F(e^*))} - \frac{1}{1-\delta}\pi^A_{(1,0;0,1)} \le \frac{1}{z}, \qquad (5)$$

where e^* denotes firm B's optimal investment level in the old format at state $(1,1;0,1)$. The first term on the left side of this inequality represents the expected discounted profits to firm A just after reaching state $(1,1;0,1)$, accounting for firm B's eventual retaliation; the second term represents the expected discounted profits to firm A of staying permanently at state $(1,0;0,1)$.

[7] Moving from state $(1,0;0,1)$ to state $(1,1;0,1)$ allows the incumbent to capture an additional $\alpha/2$ customers, who each pay price β. However, it also causes a fraction $(\frac{1}{2}-\alpha)$ of the firm's customers to move from format 1, at which they paid price $V-\beta$, to format 2, at which they pay the lower price β.

Whether this inequality holds depends on how quickly firm B is expected to retaliate following a successful attack by firm A. If the parameter d is very large, each additional dollar spent has a rapidly decreasing effect on the probability of success, so once state $(1,1;0,1)$ is reached, in each period firm B will simply make a small "exploratory" investment that gives it a small chance of success. On the other hand, if d is small, each incremental dollar continues to have a large effect on the success probability, so firm B will invest enough to give it a large chance of success in any given period.

Formally stated, as $d \to \infty$, $F(e^*) \to 0$, which implies that the expected time required for successful retaliation grows without bound, and the left side of inequality (5) approaches $(1/(1-\delta))(\pi^A_{(1,1;0,1)} - \pi^A_{(1,0;0,1)})$. When we insert the values from Table 1, this expression is the same as the left side of Condition 1, which implies (5) does not hold, and the threat of retaliation *cannot* prevent investment at state $(1,0;0,1)$.

Intuitively, when implementing a format is sufficiently difficult (d is sufficiently large), the expected time required to retaliate becomes so long that firms do not worry about retaliation. Rather, they each invest a small amount in the other's format because Condition 1 guarantees that the expected discounted profits of a successful attack are enough to justify investing the first marginal dollar. Although each firm's expected success probability in any given period is low, one firm eventually succeeds in its attack, and its competitor eventually succeeds in retaliating; thus both firms end up using both formats (see Figure 2). The online appendix proves this result formally.

Proposition 1. *If Condition* 1 *holds and d is sufficiently large, then in any equilibrium, both firms implement both formats in the long run* (*with probability one*).

I now consider the case in which implementing a format is easy. When d is sufficiently small, $F(e^*) = 1$, and retaliatory investments are guaranteed to succeed in the next period after an attack. Inequality (5) then becomes

$$\left(\pi^A_{(1,1;0,1)} - \pi^A_{(1,0;0,1)}\right) - \frac{\delta}{1-\delta}\left(\pi^A_{(1,0;0,1)} - \pi^A_{(1,1;1,1)}\right) \le \frac{1}{z}. \qquad (6)$$

Thus, unless firms have very low discount factors, inequality (5) holds when d is sufficiently small, in which case the threat of immediate retaliation can prevent investment at state $(1,0;0,1)$.

The following condition is sufficient to ensure (6) holds. This condition also ensures that if d is small enough, an equilibrium exists in which the incumbent

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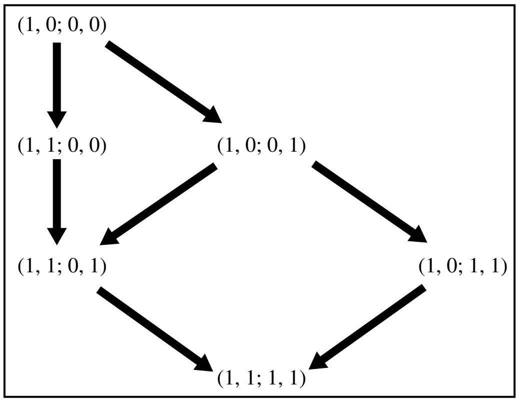
Figure 2 When Implementing a Format Is Difficult (d Is Large), Both Firms Implement Both Formats



Note. Arrows indicate possible paths the game state can follow.

invests nothing at the initial state $(1, 0; 0, 0)$, guaranteeing that the industry reaches the absorbing state $(1, 0; 0, 1)$.

Condition 2. $\alpha V - \frac{\delta^3}{1-\delta}\frac{V-2\beta}{2} < \frac{1}{z}$.

The first term on the left side of this condition is an upper bound on the short-term benefits the incumbent gains from implementing the new format (moving the game from state $(1, 0; 0, 0)$ to state $(1, 1; 0, 0)$), and the second term is the cost of provoking the entrant to implement both formats (given that d is small enough that the entrant will immediately implement any format in which it invests). Condition 2 ensures that, at the initial state, the sum of these two effects is not great enough to justify the incumbent investing the first marginal dollar in the new format.[8] Note that Conditions 1 and 2 are both more likely to hold when δ is large. By choosing δ sufficiently close to 1, it is straightforward to find parameter values for which both conditions hold.

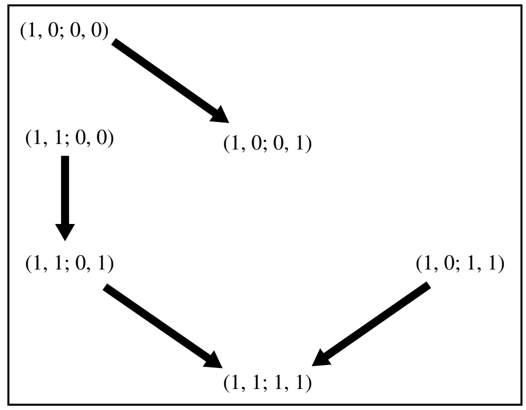
The online appendix proves the following proposition.

Proposition 2. *If Conditions 1 and 2 hold, and d is sufficiently small, there is an equilibrium in which firm B is the only one that invests in the new format; once it successfully implements this format, neither firm makes further investment.*

Note that if either firm ever implements both formats, the other firm keeps investing until it also implements both formats. For example, at state $(1, 1; 0, 1)$, the entrant invests in the old format, knowing the incumbent has no way to retaliate. On the other hand, at state $(1, 0; 0, 1)$, the entrant does *not* invest in the old format because the incumbent would then retaliate by investing in the new format. Thus,

[8] This condition is somewhat stronger than necessary, but it is more notationally succinct than the weakest possible condition would be.

Figure 3 When Implementing a Format Is Easy (d Is Small), a Firm Will Not Implement a Second Format Because Doing So Would Lead to Swift Retaliation



Note. Arrows indicate possible paths the game state can follow.

the game progresses as follows (see Figure 3). At the initial state $(1, 0; 0, 0)$, the incumbent avoids investing in the new format so that it retains a credible way to retaliate against the entrant. Once the entrant implements the new format, and the game reaches state $(1, 0; 0, 1)$, neither firm encroaches on the other's format, because neither firm wants to end up at state $(1, 1; 1, 1)$.

To summarize, Proposition 1 states that when the success probability is *low*, both firms must eventually implement both formats, whereas Proposition 2 states that when the success probability is *high*, there is an equilibrium in which firms reach an absorbing state where they use different formats.

3.4. Strong Preemption and Cannibalization Effects

The previous section showed that an increase in success probability can make the incumbent less willing to invest in the new format. This section shows that this effect can be reversed.

Intuitively, the previous section assumed preemption and cannibalization effects were weak, and so the incumbent primarily faced a trade-off between the short-term gains from adopting the new format and the long-term loss that results from competitive retaliation. In that case, an increase in success probability made the threat of retaliation more immediate, which made the incumbent *less* willing to invest in the new format to increase its short-term profits. By contrast, the current section assumes preemption and cannibalization effects are strong. In this case, an increase in success probability makes the relative benefits of preempting the potential entrant more immediate, which makes the incumbent *more* willing to cannibalize its existing sales by investing in the new format. Because the results in this section are similar

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to results from previous theoretical research on innovation (Gilbert and Newbery 1982, Reinganum 1983), I keep the exposition of these results relatively brief.

The current section assumes the following conditions hold.

Condition 3. $\frac{1}{1-\delta}(V-\beta)\alpha < \frac{1}{z}$.

Condition 4. $\frac{1}{1-\delta}\frac{\beta(1-\alpha)}{2} < \frac{1}{z}$.

Condition 3 implies that cannibalization effects are strong (α is small), whereas Condition 4 implies that preemption effects are strong (β is small). The online appendix shows that these conditions guarantee all states except the initial state are absorbing (see proof of Proposition 3).

I also assume the following condition holds.

Condition 5. $(V-\beta)\alpha + \frac{\delta}{1-\delta}\frac{V-\beta}{2} > \frac{1}{z}$.

This condition is sufficient to ensure that the entrant invests in the new format at the initial state. As $d \to \infty$, the expected time for the entrant to successfully implement the new format grows without bound, and Condition 3 ensures the incumbent invests nothing at the initial state because it is concerned about cannibalizing its existing sales (see Figure 4).

On the other hand, as $d \to 0$, the entrant is guaranteed to successfully implement the new format the first time it moves. In this case, Condition 5 guarantees that the incumbent also invests in the new format at the initial state (see Figure 5). The first term in that condition represents the incumbent's immediate profit impact from implementing the new format, whereas the second term reflects the long-term benefit of preventing the entrant from implementing the new format.

The online appendix formally proves the following.

Proposition 3. *If Conditions 3–5 all hold, then all states except the initial state are absorbing. If d is sufficiently large, then at the initial state, the incumbent makes zero investment and the entrant is guaranteed to win the new format in the long run. However, if d is sufficiently small, then at the initial state, both firms make a positive investment in the new format.*

Figure 4 **When Cannibalization and Preemption Effects Are Strong and Implementing a Format Is Difficult (d Is Large), the Incumbent Allows the Entrant to Win the New Format**

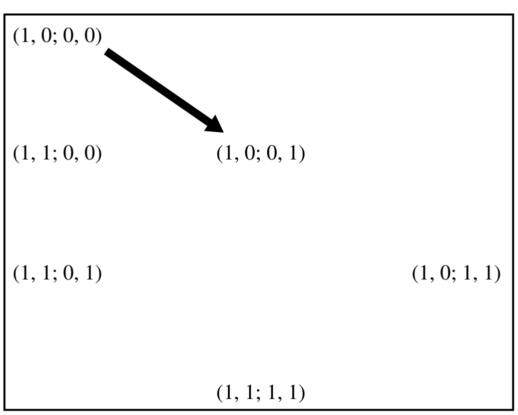
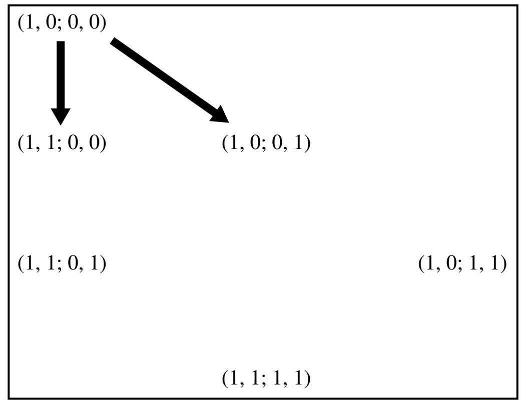


Figure 5 **When Cannibalization and Preemption Effects Are Strong and Implementing a Format Is Easy (d Is Small), the Incumbent Is Willing to Cannibalize Its Sales to Try to Preempt Investment by the Entrant**



Survey data show that high-tech firms vary substantially in how much their managers say they are willing to cannibalize existing sales (Chandy and Tellis 1998). When a new technology has a winner-take-all property (preemption effects are strong), Proposition 3 implies that incumbents should be willing to cannibalize existing sales if the probability that an entrant can quickly implement the new technology is high, but incumbents should not be willing to cannibalize existing sales if this probability is low.

3.5. Other Regions of the Parameter Space

Previous sections have studied cases in which preemption and cannibalization effects are either both weak or both strong. I do not present detailed results for other combinations of these parameter values, because the results are more straightforward and less interesting than those in the previous sections. If preemption effects are weak and cannibalization effects are strong, the incumbent allows the entrant to win the new format; if preemption effects are strong and cannibalization effects are weak, the two firms race to enter the new format. These results do not depend on the parameter d that determines how quickly the marginal impact of investment diminishes.

4. Extensions: Asymmetric Formats

Until now, I have assumed profit functions are symmetric across formats. To illustrate how large asymmetries can change investment incentives, I now present two model extensions. The first assumes formats differ in terms of fixed costs, and the second

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assumes either firm's use of the new format eliminates profits from the old format.

4.1. Fixed Expense in the Old Format

Many Internet-based business models allow firms to avoid fixed expenses (e.g., physical retail locations) that are associated with traditional business models. I now show that such fixed expenses in the old format can allow the incumbent to attack the new format without fear of retaliation.

Assume there is a recurring fixed expense f to operating the old format, which is avoided in the new format. For example, at state $(1, 0; 0, 1)$, firm A's profits are now $(V-\beta)\frac{1}{2}-f$, whereas firm B's profits are still $(V-\beta)\frac{1}{2}$. Also assume Condition 1 holds, so cannibalization and preemption effects alone are too weak to prevent investment. If the fixed expense is large enough that the following condition holds, the entrant will never invest in the old format (see Figure 6).

Condition 6. $\frac{1}{1-\delta}\left[(V-\beta)\alpha - f\right] < \frac{1}{z}$.

The online appendix proves the following result formally.

Proposition 4. *If Conditions* 1 *and* 6 *hold*, *in equilibrium*, *both firms eventually implement the new format*, *but the entrant never invests in the old format*.

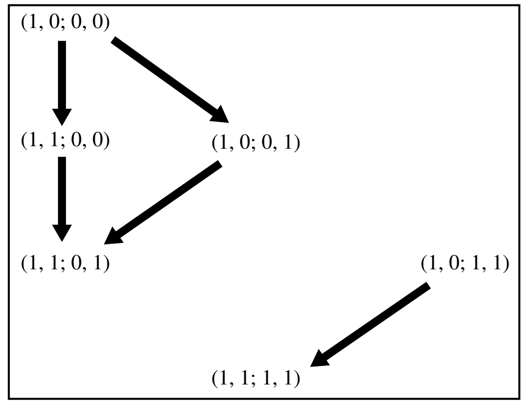
As an example in which the incumbent could attack the new format without fear of retaliation, when incumbent Charles Schwab invested in its online trading platform, it would have been unprofitable for E*TRADE to retaliate by building a large network bricks-and-mortar locations. Schwab now offers both online and in-person investment formats, whereas E*TRADE focuses on the online format.[9]

4.2. Delayed Entry Response

Online stores often free ride on customer service provided by traditional stores, making traditional stores much less profitable (Anderson et al. 2010). To illustrate how this type of asymmetric channel conflict can affect investment decisions, I make the extreme assumptions that either firm's use of the new format eliminates profits from the old format, but either firm's use of the old format does *not* affect the profits from using the new format.[10]

Under these new assumptions, if implementing a format is difficult enough, at first the incumbent

Figure 6 Large Fixed Expenses in the Old Format Allow the Incumbent to Invest in the New Format Without Fear of Retaliation



Note. Arrows indicate possible paths the game state can follow.

avoids investing in the new format, because implementing this format would entirely cannibalize its existing profits. However, once the entrant finally succeeds in implementing the new format, destroying all profits in the old format, the incumbent starts investing in the new format as well (see Figure 7). This result is similar in spirit to previous results by Katz and Shapiro (1987), who study whether an incumbent or an entrant innovates first, if firms can imitate each other's innovations.[11]

The online appendix proves the following proposition formally.

Proposition 5. *If either firm's use of the new format eliminates profits in the old format*, *Condition* 1 *holds*, *and* d *is sufficiently large*, *then the incumbent initially makes no investment*; *after the entrant successfully implements the new format*, *the incumbent begins investing in the new format until it also implements this format*.

As an example of delayed entry response, a wedding dress shop faces the potential threat that a bride could spend several hours in its store trying on dresses—and in the process utilize the shop's customer service staff—until she finds a dress she likes, and then proceed to buy a similar dress online at a much lower price.[12] Most new brides are reluctant to buy a dress online (Bertagnoli 2011), so for now

[9] According to their respective company websites, Schwab has over 300 physical branches, whereas E*TRADE has only 30.

[10] In the case of free riding, the new format might benefit from the existence of the old format. To allow this benefit to occur, we could make the alternative assumption that the use of the new format leaves the old format just profitable enough that the incumbent will continue to use the old format.

[11] Using the terminology of Katz and Shapiro (1987), the conditions of Proposition 5 imply the entrant has stronger "stand-alone incentives" (defined as the increase in a firm's profits if it innovates and its competitor does nothing) than the incumbent, and firms have equal "preemption incentives" (defined as the difference in profits from innovating first rather than second). As a result, the entrant innovates first.

[12] For example, a recently married woman blogged that she visited several traditional wedding stores and found a dress she liked priced at $2,800 but instead bought a similar dress online for $350 (Fong 2013).

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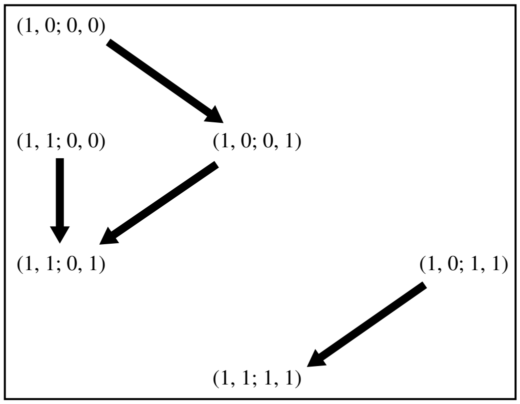
Figure 7 If Either Firm's Use of the New Format Eliminates Profits in the Old Format, and Implementing a Format Is Difficult, the Incumbent Does Not Invest in the New Format Until the Entrant Has Successfully Adopted This Format



Note. Arrows indicate possible paths the game state can follow.

the best strategy for the traditional shops may be to stick with their current format; however, if an online retailer ever builds a strong-enough reputation that free riding on customer service becomes a major problem in this market, traditional wedding shops might want to start investing in the online channel as well.

4.3. Other Possible Asymmetries

This section has introduced two possible types of asymmetry into the model. One could imagine other possible asymmetries as well. For example, if the new format is more difficult to implement than the old, the entrant might start by investing in the old format. On the other hand, if the entrant has a weaker brand than the incumbent, then the entrant might no longer be able to make a credible threat of attacking the old format (undermining the equilibrium of Proposition 2), or the entrant might avoid entering the market altogether. I leave such model extensions for future research.

5. Conclusion

This paper has developed a model in which an incumbent and an entrant compete in a market where a new business format has become available. If implementing a format is difficult, firms can attack each other without worrying about swift retaliation, so each firm continually invests a small amount in the other's format until they both implement both formats. By contrast, if implementing a format is easy, the incumbent allows the entrant to win the new format, and firms can then sustain an equilibrium in which they stay focused on different formats.

These results hold when preemption and cannibalization effects are weak. On the other hand, when both of these effects are strong, an increase in the ease of implementing formats makes the incumbent more willing to cannibalize its sales by investing in the new format.

The paper includes two model extensions that illustrate how asymmetric formats can affect investment incentives. Future research could further extend the model, for example, to allow firms to differ in how easily they can implement new formats or to allow customer preferences to change over time.

Future research could also empirically investigate the predictions of the model, looking for evidence that incumbents tend to avoid investing in new formats in industries where all of the following hold: (1) entry barriers keep the number of firms small; (2) conditional on entry, implementing a format is relatively easy; and (3) multiple firms could profitably implement both formats (preemption and cannibalization effects are weak). In such industries, this model implies incumbents should retain the threat of implementing the new format later as a form of retaliation.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mksc.2013.0827.

Acknowledgments

Helpful comments were provided by the anonymous reviewers and by Anthony Dukes, Shantanu Dutta, Bob Gibbons, Chakravarthi Narasimhan, Jiwoong Shin, Gerry Tellis, Birger Wernerfelt, and seminar participants at Duke, the Massachusetts Institute of Technology, the University of California at Davis, the University of California at Los Angeles, the University of Southern California, the 2011 Marketing Science Conference, and the 2012 Summer Institute in Competitive Strategy Conference.

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