Radical or Incremental Innovations under Competition and Imitator's Project Lags

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Abstract:

Firms engaging in innovations not only face high investment costs but also tremendous R&D expenditures to develop a new product. Success in the R&D phase enables a firm to bring the new product to market. However, all prosperous products attract competitors and motivate product imitations. These imitations alter the market power of the innovator and thus the product life cycle of the innovation after the imitator optimally imitates and overcomes its project lag. We model the innovation competition of two firms of innovator and imitator type. The successful firm starts the market competition becoming the leader while the other firm gets an option to imitate the innovation as a market follower. We derive the optimal investment strategy for both competitors as well as the expected profitability for the both firms under innovation competition.

Keywords: Radical and Incremental Innovations, Innovators and Imitators, Imitator's Project Lag

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Abstract:

Firms engaging in innovations not only face high investment costs but also tremendous R&D expenditures to develop a new product. Success in the R&D phase enables a firm to bring the new product to market. However, all prosperous products attract competitors and motivate product imitations. These imitations alter the market power of the innovator and thus the product life cycle of the innovation after the imitator optimally imitates and overcomes its project lag. We model the innovation competition of two firms of innovator and imitator type. The successful firm starts the market competition becoming the leader while the other firm gets an option to imitate the innovation as a market follower. We derive the optimal investment strategy for both competitors as well as the expected profitability for the both firms under innovation competition.

1. Introduction

Innovators typically face great challenges to launch a new product into a new market. These include high investment costs for R&D and the innovation process, high operating costs and an uncertain success rate for their innovations. Furthermore, they face great threats of imitators, which might copy their product idea if the innovation is successful. An imitator simply copies the product or strategy of the innovator which means the implement, but do not invent. Imitators typically face a cost advantage with lower investment and operating costs. However, they imitators face an adoption lag. They need some time to copy the product and launch it into the market.

But innovators and innovators in the market must not be separated into these roles by their own choice, but can rather by their success in the innovation phase. That is, both firms may compete in an innovation process to launch a new product into a new market.[1] In this innovation competition, the firms differ by their innovation type of the product, which may be radical or incremental, and their innovativeness, being more or less likely to be successful in R&D. It is thus better to discuss types of firms: innovator and imitator types. An innovator type of firm has a higher probability to innovate than an imitator type. Furthermore, an innovator spends more on R&D which may indicate are more radical than incremental innovation.

While both innovator and imitator types of firm may compete in innovation, it is likely that only one is successful in R&D and market entry. This firm now becomes the market leader. Thus, it is recognized as the innovator for this special innovation. The other firm becomes the follower in the market with an option to enter the market later by imitating the original product. Thus, it will be called an imitator. Both firms additionally face the choice of investment size. They can both commit more or less resources to their product, which influences their market power and expected revenue streams from product sales. Overall, even imitators may innovate and even innovators may wish to copy successful products. Therefore, it is important to differentiate between general types of firms, i.e. innovator or imitator types, and the order of product introduction for a special innovation, i.e. the innovator or imitator for this product.

[1] They do not necessarily have to strive for the same product. Their products just have to compete in the same market later on, i.e. because they offer a similar customer benefit.

2. Literature Review

The decision problem of the two firms regarding their investment size and timing in the innovation and market competition require a real option analysis. Flexibility in R&D using real options has always of interest in the literature (e.g. Lint & Pennings, 1998, Jägle, 1999, Huchzermeier & Loch, 2001). There have been different approaches on how to model product innovation. New product innovations in new markets have been the core of this analysis (see e.g. Grenadier & Weiss, 1997, Kulatilaka & Perotti, 1998, Chevalier‐Roignant et al., 2019).

Some authors focus on the product life cycle of such innovations. Hagspiel et al. (2016) consider the case where a single company can innovate with a new product to exit and switch from a declining market. Others have focused on cyclical cash flow of innovations (Bollen, 1999, Lukas et al., 2017) or assumed a finite project life such as Gryglewicz et al. (2008). Their approach is most similar to ours, although the other way around. In contrast to a finite project life, we assume that the project does not start right away but after a lag. This lag is driven by the need for the follower to imitate the product before it can be launched into the market. This project lag is a completely new approach to model product life cycles.

Another important stream of literature connected to our decision problem is the one on market competition. Firms that compete in a market may choice their investment size and choose an optimal quantity, which they want to sell. Their quantity competition effects both their own and the competitors revenue stream. Chevalier-Roignant et al. (2011) give a good literature review on this topic. Close to our approach to model market competition is the paper of Huisman & Kort, (2015). They model such a strategic capacity investment in duopoly and derive leader and follower strategies. They derive a leader/follower structure, which is endogenous and derived from the market competition. In contrast, we assume that the successful company always invests immediately and becomes the market leader. However, are able to link the leader/follower structure to the outcome of an innovation competition.

The project lag of the follower to model product life cycles in the market phase and the analysis of radical or incremental innovations in the innovation phase are new to the literature. We derive optimal strategies for the leader and follower for the market competition and the expected profitability of different types of firms for radical or incremental innovations under innovation competition. We show that investment incentive of the follower in the market competition as measured by the investment threshold is U-shaped over the project lag. Under innovation competition, we show how a higher innovation proability of the innovator may be offset by too much innovation efforts, i.e. too high investment costs. Furthermore, we derive in which cases the imitator type of firm profits from the efforts and success probability of the innovator.

The rest of the paper is as follows. Section 3 discribes the model setup in the innovation and market competition. We illustrate the optimal strategies and expected profitability of the two firms in section 4. Section 5 has our conclusion.

3. The Model

Two firms compete over an innovation in R&D to launch this innovation into a new market. The first successful company will enter the market first and right away as the leader. The defeated company will receive an option to copy the product from the leader to become a follower in the market. However, the sales and operation of the follower will not start after an adoption lag L after its optimal investment timing. After sales start, the firms will produce up to their capacity q_n with $n = L$ for the leader and $n = F$ denoting the follower. The market price of the product will follow a linear demand function following Dawid et al. (2010), where the leader receives a monopoly price

$$p_{mon} = x(1 - \gamma q_L) \tag{1}$$

and after market entrance of the follower the companies will receive

$$p_L = x(1 - \gamma q_L - \eta q_F) \tag{2}$$

and

$$p_F = x(1 - q_F - \eta q_L) \tag{3}$$

respectively, where $0 < \eta < \gamma < 1$. That is, both products are vertically and horizontally differentiated from each other. In this case γ describes the vertical differentiation and η the horizontal differentiation of the products. The stochastic demand shift parameter X is governed by a geometric Brownian motion

$$dx = \alpha x dt + \sigma x dW \tag{4}$$

where dW is the increment of a Wiener process and α is the drift parameter and σ is a measure for uncertainty.

The temporal structure and model setup is as follows:

1. Both firms compete over R&D and product launch success. They have a probability p_n that their product will be successful and have exogenous investment costs I_n for the innovation phase.
2. The first successful firm becomes the leader and launches the product right away receiving a monopoly revenue $q_L p_{mon} - c_L$ for paying a price k_L per installed capacity q_L, totaling $k_L q_L$. The leader will chose an optimal quantity q_L^* depending on the optimal strategy of the competitor.

3. The competitor becomes the follower and is not in the market but receives an option to imitate the original product. Upon investing $k_F q_F$ for the imitation the follower needs a time L to copy the product. Only after that time period the follower will receive a duopoly revenue $p_F q_F - c_F$ leading to a decreased duopoly revenue $q_L p_L - c_L$ of the leader. The follower will chose an optimal quantity q_F^* depending on the previous decisions of the leader.

The temporal structure of the model is illustrated in Figure 1.

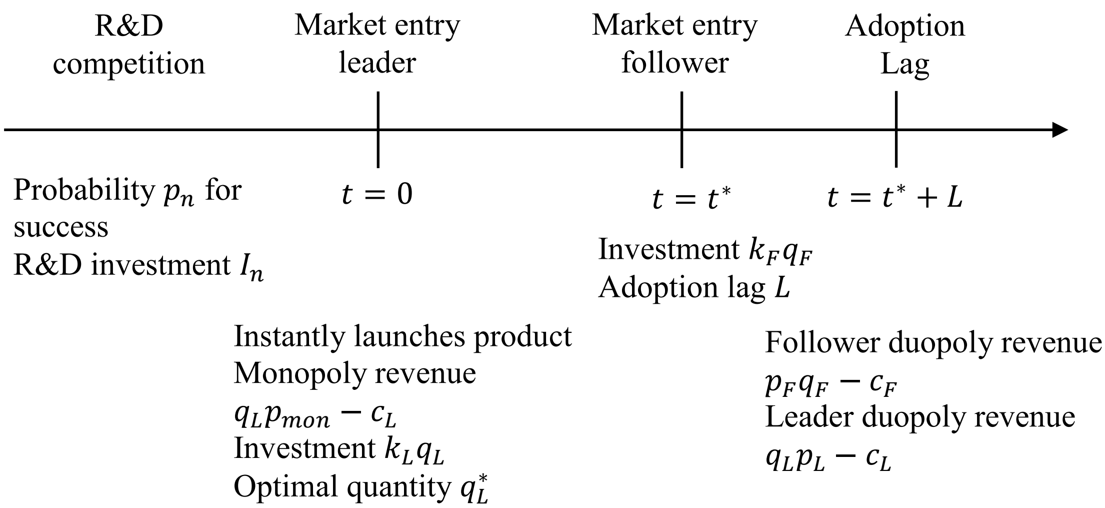

Figure 1: Firm and product innovativeness.

We solve the strategic games and investment decisions recursively, starting from follower's investment decision in the market phase.

3.1 Market Competition

The follower has observed the investment and quantity choice of the leader. The follower can invest at any time afterwards. After the investment the followers cash flows and operating costs will start after a lag L and will create a product value

$$V_F = \mathrm{E}\left[\int_L^{\infty} (x(1-q_F-\eta q_L)q_F - c_F)e^{-rs}ds\right] \tag{5}$$

or

$$V_F = \frac{p_F q_F}{r-\alpha} e^{-(r-\alpha)L} - \frac{c_F}{r} e^{-rL} \tag{6}$$

and an investment payoff

$$\pi_F = V_F - k_F q_F. \tag{7}$$

To maximize this payoff the imitator will chose an optimal capacity

$$q_F^*(x, q_L) = \frac{1}{2}(1 - \eta q_L - \frac{k_F(r-\alpha)}{xe^{-(r-\alpha)L}}) \tag{8}$$

The imitator holds an option on this investment. The option value is

$$F_F = A_1 x^{\beta_1} \tag{9}$$

where

$$\beta_1 = \frac{1}{2} - \frac{(\alpha)}{\sigma^2} + \sqrt{\left(\frac{(\alpha)}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} > 0 \tag{10}$$

and

$$A_1 = \frac{k_F r q_F + c_F e^{-rL}}{(\beta_1 - 1)r}\left(\frac{\beta_1(r-\alpha)\left(\frac{c_F}{r}e^{-rL} + k_F q_F\right)}{(\beta_1 - 1)p_F}\right)^{-\beta_1} e^{-\beta_1(r-\alpha)L} \tag{11}$$

Proposition 1: *The imitator will optimally invest at the investment threshold*

$$x_F^*(q_L, q_F) = \frac{\beta_1}{\beta_1 - 1}\frac{\left(\frac{c_F}{r}e^{-rL} + k_F q_F\right)(r-\alpha_d)e^{-(r-\alpha)L}}{p_F} \tag{12}$$

which gives an optimal capacity $q_{F,d}^*\left(q_L, x_{F,d}^*\right)$

$$q_F^*(q_L) = \frac{(1-\eta q_L)rk_F - 2e^{-rL}\beta_1 c_F}{2kr(\beta_1+1)} + \frac{\sqrt{4\beta_1^2 c_F^2 e^{-2rL} + 4\beta_1^2 c_F e^{-rL} k_F r(1-\eta q_L) + k^2 r^2 (1-\eta q_L)^2}}{2kr(\beta_1+1)} \tag{13}$$

which yields the optimal investment threshold

$$x_F^*(q_L) = x_F^*\left(q_L, q_{F,d}^*\right). \tag{14}$$

The leader knows the optimal reaction to its strategy and has to determine its optimal quantity q_L^*. If the imitator would never invest, the innovator would earn an perpetual monopoly revenue which would generate a project value

$$V_{mon} = \mathrm{E}\left[\int_0^{\infty} (x(1-\gamma q_L)q_L - c_L)e^{-rs}ds\right] = \frac{p_{mon}q_L}{r-\alpha} - \frac{c_L}{r}. \tag{15}$$

However, as soon as the follower invests, this project value would change to that of a company in a duopoly: The leader would still earn monopoly revenues until the lag of the follower is over and duopoly revenues from there on. The project value would be

$$\begin{aligned} V_{duo} &= \mathrm{E}\left[\int_0^{L} (x(1-\gamma q_L)q_L - c_L)e^{-rs}ds\right] \\ &\quad + \mathrm{E}\left[\int_L^{\infty} (x(1-\gamma q_L - \eta q_F)q_L - c_L)e^{-rs}ds\right] \\ &= \frac{p_{mon}q_L}{r-\alpha}\left(1-e^{-(r-\alpha)L}\right) + \frac{p_L q_L}{r-\alpha_d}e^{-(r-\alpha)L} - \frac{c_L}{r}. \end{aligned} \tag{16}$$

Note that the second term is similar to the duopoly revenue from the follower.

The leader has to give up its monopoly project value V_{mon} in exchange for the duopoly project value V_{duo} at a random future time T at which the follower chooses to invest. Thus, the difference is discounted to today by the stochastic discount factor $\mathrm{E}(e^{-rT}) = \left(\frac{x}{x_F^*(q_L)}\right)^{\beta_1}$. We can state the complete payoff of the innovator from investing $k_L q_L$ into the product as

$$\begin{aligned} \pi_L = V_{mon}(x) &- \left(\frac{x}{\max(x_F^*(q_L), x)}\right)^{\beta_1}\left(V_{mon}\left(x_F^*(q_L)\right) - V_{duo}\left(x_{F,d}^*(q_L)\right)\right) \\ &- \frac{c_L}{r} - k_L q_L \end{aligned} \tag{17}$$

or

$$\begin{aligned} \pi_L = \frac{p_{mon}q_L}{r-\alpha} &- \left(\frac{x}{\max(x_F^*(q_L), x)}\right)^{\beta_1}\left(\frac{x_F^*(q_L)q_L\eta q_F^*(q_L)e^{-(r-\alpha)L}}{r-\alpha}\right) - \frac{c_L}{r} \\ &- k_L q_L. \end{aligned} \tag{18}$$

From this project value the optimal quantity of the leader q_L^* can be obtained and the optimal threshold for the imitator $x_F^*(q_L^*)$ can be derived.

In the case where the follower decides to copy the innovation directly in $t = 0$ because $x > x_F^*(q_L^*)$, the leader would receive the duopoly project value V_{duo} right away and would optimize its payoff

$$\pi_{duo} = \frac{xq_L\left(1 - \gamma q_L - \eta q_F e^{-(r-\alpha)L}\right)}{r - \alpha} - \frac{c_L}{r} - k_L q_L \quad (19)$$

again choosing an optimal quantity $q_{L,d}^*$ based on the optimal quantity $q_F = q_F^*(x, q_L)$ given by Eq. (8).

3.2 Innovation Competition

In the innovation phase, two firms compete over the success in an R&D project. Both firms In this phase it is unknown which of the two firms will become the leader or follower in the later market phase. The structure in the market competition depends on the individual success of the both firms in their R&D project. We assume that each firm $i \in (1,2)$ commit exogenous fixed investment costs I_i to their project.[2] Furthermore, each firm has an individual success probability p_i with which the R&D project will be successful and thus unsuccessful with a probability $1 - p_i$. The payoff of each firms R&D project depends on the R&D outcome of both firms. Table 1 provides the payoff structure.

Table 1: Payoff structure of the innovation competition.

		Firm 2	
		success p_2	failure $1 - p_2$
Firm 1	success p_1	$\pi_{1,Duo} - I_1$ $\pi_{2,Duo} - I_2$	$\pi_{1,L} - I_1$ $F_{2,F} - I_2$
	failure $1 - p_1$	$F_{1,F} - I_1$ $\pi_{2,L} - I_2$	$-I_1$ $-I_2$

[2] We assume that both firms commit these costs irrespectively of their success rate or expected innovation outcome. This is true in many R&D situations where firms face a great pressure to innovate in order to stay in the market or choose a certain level in their R&D spending with respect to their sales. Furthermore, we assume that in order to be able to imitate a product later on if own R&D was unsuccessful a company must constantly invest in R&D nevertheless in order to stay capable to understand and apply new technologies.

We assume that if both firms are successful with probability p_1 and p_2 respectively they will both launch a new product into the market, leading to an instant duopoly where both firms receive a duopoly payoff $\pi_{\mathrm{i},Duo} - I_i$ as given by Eq. (19). If only firm one is successful and firm two is not successful with probability $1 - p_2$ firm one launches its new product into the market directly, becoming the market leader in the market competition phase receiving the market leader payoff $\pi_{1,L} - I_1$. Even though firm two was unsuccessful in the innovation competition, it receives the option to imitate the product in the market phase. It thus receives the option payoff of the market follower $F_{2,F} - I_2$ with

$$F_{2,F} = \begin{cases} A_1 x^{\beta_1} & if\ x_F^*(q_L) < x \\ \pi_{duo} & if\ x_F^*(q_L) > x \end{cases} \tag{20}$$

with $x_F^*(q_L)$ determined by Eq. (14), π_{duo} by Eq. (19), and A_1 by Eq. (11) respectively.

The same holds similarly if firm two is successful and firm one is unsuccessful with swapped payoff functions. If both firms are unsuccessful with probability they will not be able to launch any product into the market and will face their innovation investment I_i.

We can now calculate the expected payoff of this innovation competition for each firm. The expected payoff $\mathrm{E}[\Delta G_i]$ for each firm is

$$\mathrm{E}[\Delta G_1] = p_1\left(V_{1,L} - I_1 - p_2\left(V_{1,L} - V_{1,Duo}\right)\right) + (1 - p_1)(p_2 F_{F,1} - I_1) \tag{21}$$

and

$$\mathrm{E}[\Delta G_2] = p_2\left(V_{2,L} - I_2 - p_1\left(V_{2,L} - V_{2,Duo}\right)\right) + (1 - p_2)\left(p_1 F_{F,2} - I_2\right). \tag{22}$$

4. Results

The payoffs of the strategies of the leader and follower in the market competition phase crucially depend on the optimal capacity q_L^* of the leader, which must be solved numerically. To better understand the forces driving market competition, we first analyze the optimal strategies of the leader and follower in the market phase irrespective of which firm won the innovation competition. After that, we assume two types of firms competing in the innovation phase and analyses their expected payoffs.

4.1 Market Competition

We assume the following base case parameter values: r = 0.1, α = 0.05, σ = 0.2, k_F = 1, k_L = 2, c_F = 0.05, c_L = 1, I_F = 1, I_L = 1, η = 1, γ = 1, L = 5 and x_0 = 0.5. First, we focus on the evolutions of the optimal investment threshold of the follower x_F^*, of the optimal capacity for leader q_L^* and follower q_F^* and payoffs for leader π_L and follower π_F for different levels of x in Figure 2. Coming from small levels of x, we observe a constant threshold. This is due to the model set up. Since the leader is obliged to be active immediately, he chooses a zero capacity for

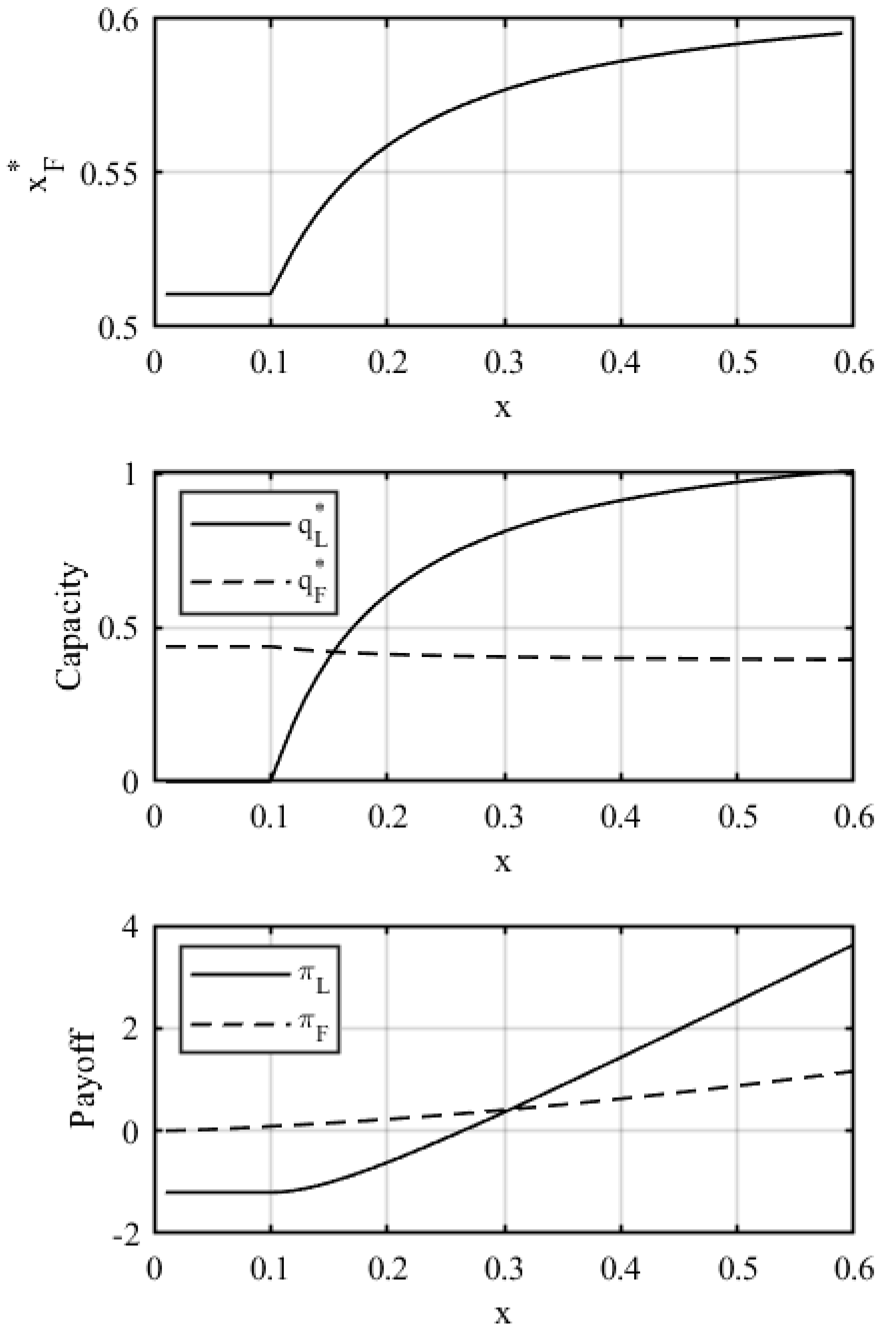

Figure 2: Optimal investment threshold of the follower x_F^*, optimal capacity for leader q_L and follower q_F and payoffs for leader π_L and follower π_F for different levels of x.

low levels x. At some point, however, the leader starts choosing a capacity $q_L > 0$ place himself better with regard to his payoff, which is still negative. With further increasing x the leader increases his capacity steadily, while the follower corrects his capacity slightly downwards. As soon as $x \geq x_F^*$ (which is around x = 0.58) the follower gets active alongside the leader.

Next, we study the impact of σ on the above studied measures x_F^*, q^* and π in Figure 3 on the left side. We observe a common real options result in an increasing threshold x_F^* with increasing σ. Hence, the incentive to invest decreases for the follower as uncertainty increases. Despite that, both follower and leader only slightly increase their capacity. The payoffs stay almost unaffected, however, also slightly increase alongside the corresponding capacities.

On the right side of Figure 3 we study the impact of the lag L on x_F^*, q^* and π. We observe a u-shape in x_F^* over the lag. Hence, the follower has an increased incentive to invest for certain levels of L and, at a certain point, this effect reverses and the x_F^* once again increases with L. This can be traced back to the operating costs c_F and is a new insight regarding Huisman & Kort (2015). While the incentive to invest increases at lower L the capacity q_F^* is steadily adjusted downwards. On the contrary, the leader increases his capacity. Accordingly, the payoff of the follower steadily decreases with L as the discounting of his' possible future profits becomes more significant.

Next, we focus on the effect of the horizontal product differentiation η on x_F^*, q^* and π on the left side of Figure 4. As η increases, x_F^* increases as well. Hence, the investment incentive for the follower decreases. While capacity of the follower decreases with increasing η, the capacity of the leader q_L^* exhibits a u-shape. As η increases q_L^* starts to decrease first, finds its minimum and then increases steadily.

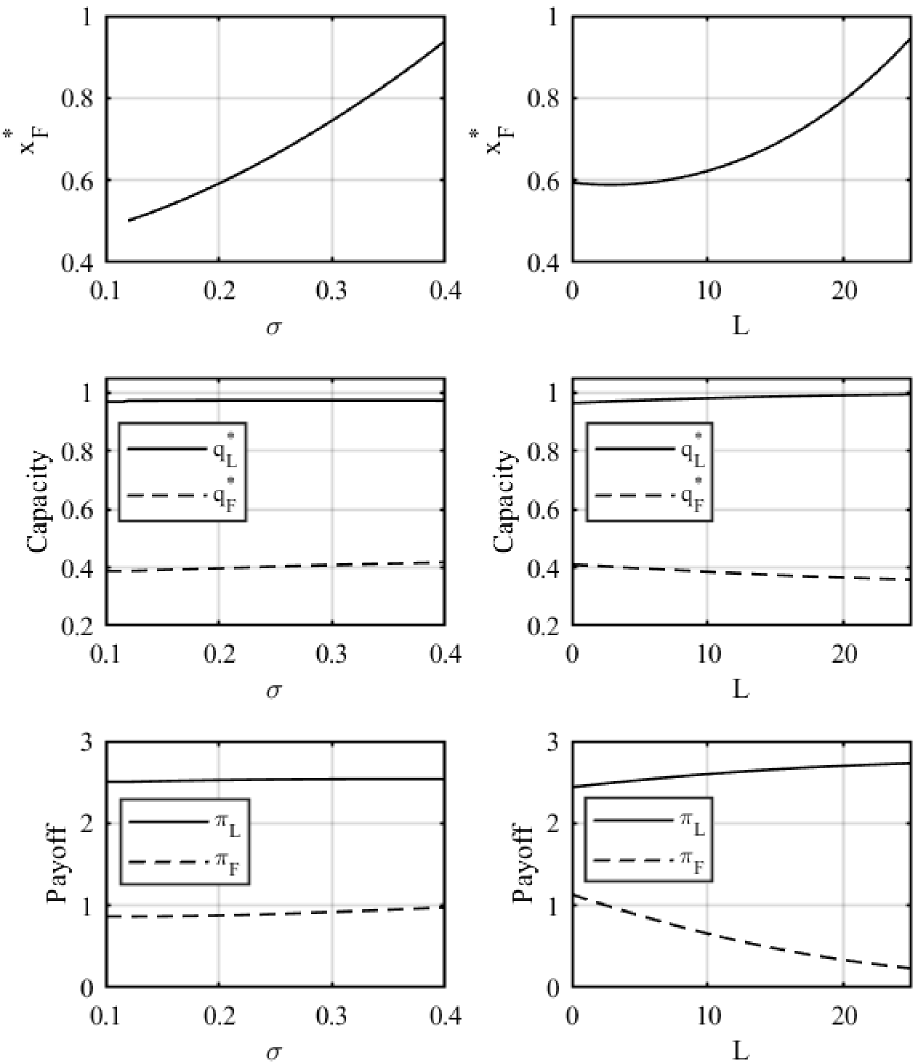

Figure 3: Optimal investment threshold of the follower x_F^*, optimal capacity for leader q_L and follower q_F and payoffs for leader π_L and follower π_F for different levels of σ (left column) and L (right column).

However, both payoffs decrease with a higher horizontal product differentiation, since the prices that follower and leader can charge for the products decrease.

Last, we study the impact of vertical product differentiation γ on x_F^*, q^* and π. As γ increases, the threshold x_F^* decreases. Hence, the follower profits from high γ. Accordingly, the follower chooses a higher capacity alongside with γ. On the contrary, the leader is less privileged for high γ. Hence, he chooses a lower capacity q_L^* as γ increases. Hence, the payoff for the leader decreases and the payoff of the follower increases with γ. For very high γ the payoff of the follower can get even better than that of the leader.

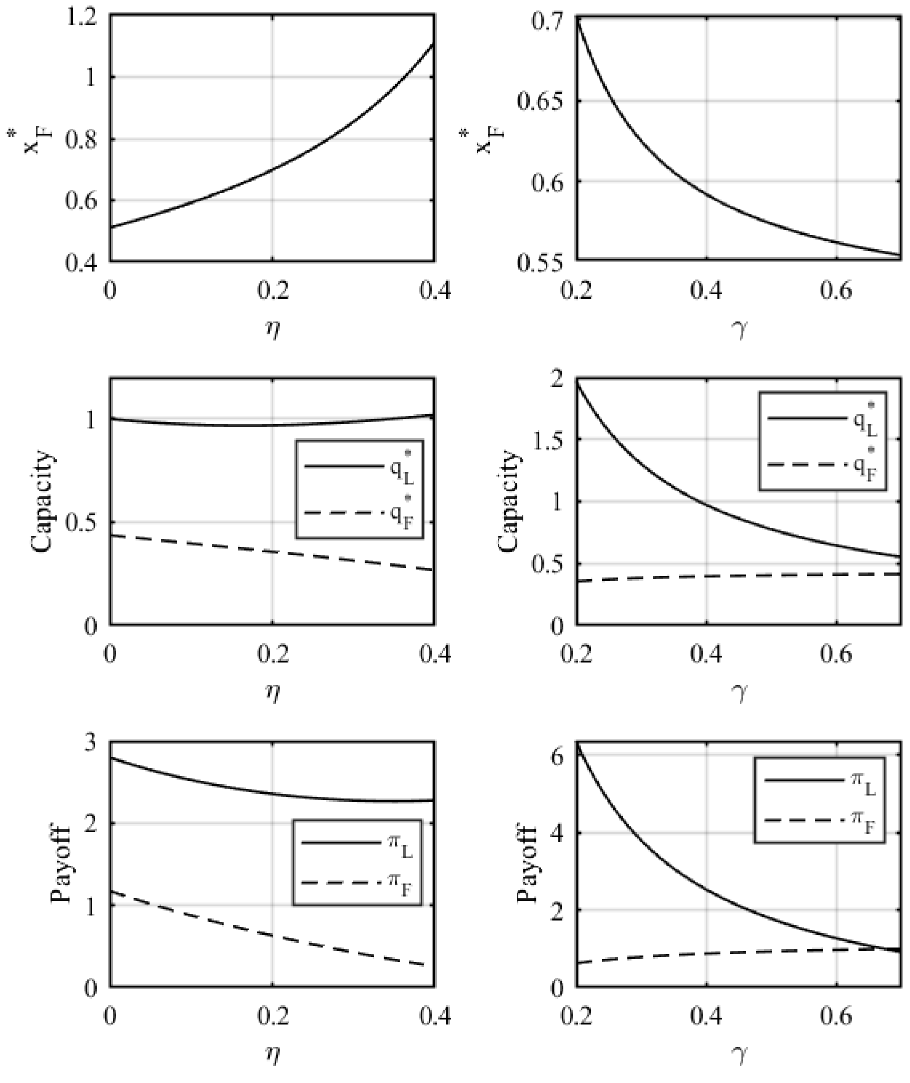

Figure 4: Optimal investment threshold of the follower x_F^*, optimal capacity for leader q_L and follower q_F and payoffs for leader π_L and follower π_F for different levels of η (left column) and γ (right column).

4.2 Innovation Competition

Innovation is a long-term success factor for companies. Most firms engage in R&D to innovate new products or business models. However, all firms differ by their innovation strategy or innovation type and innovation capability or innovativeness. The possible combination innovation typ and innovativeness of the firm are illustrated in Figure 5.

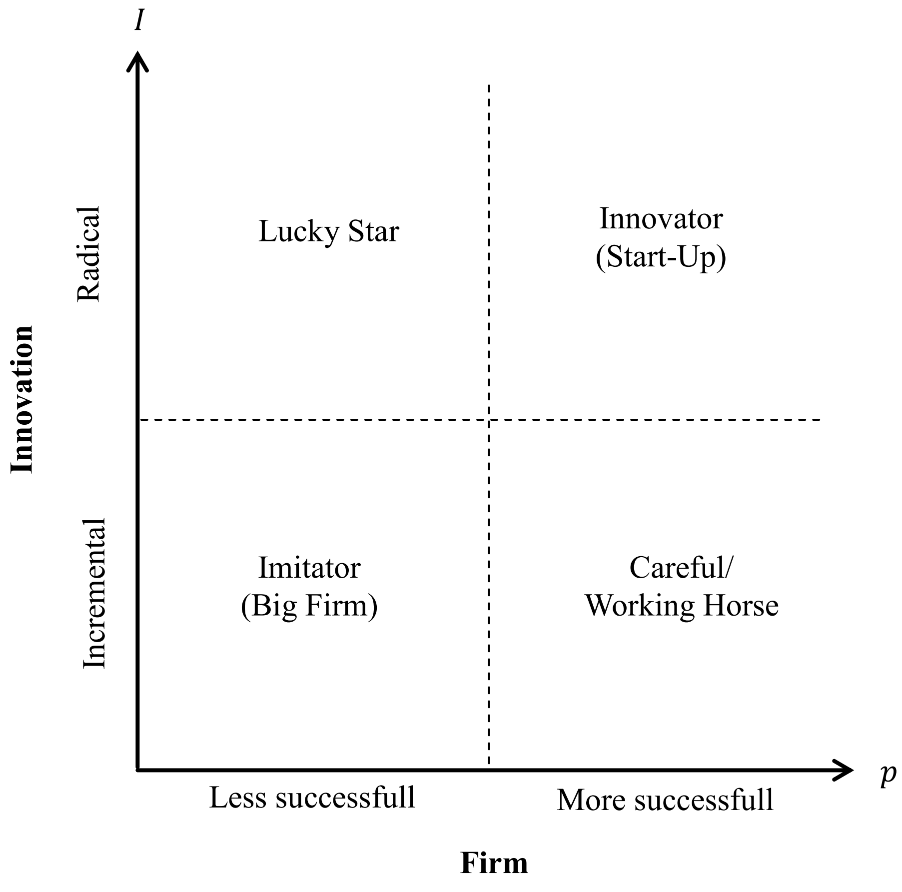

Figure 5: Firm and product innovativeness.

The literature broadly differentiates between two types of possible innovations: incremental or radical.[3] While there is no direct link between innovation type and R&D spending, we assume that a radical innovation is typically linked to higher

[3] These are at best two extremes of a possible spectrum of innovation types. However, they capture the idea that some innovations be more complex and lead to higher competitive advantage than others.

R&D investment costs I_i. This may be true because a company constantly spending smaller amounts on R&D over long time horizon or a company spending large amounts on R&D at home might be more likely to create an innovation that is more radical.

At the same time, firms may be more or less successful in R&D and their innovation management. That is, no matter how much investment takes place some firms have a better capability to adapt their whole firm, i.e. R&D, production and sales, to new products than others. Furthermore, firms may specialize themselves to create radical or incremental innovations. In the first case they prepare themselves create large changes and discover completely new products or markets. In the second case firms may rather constantly improve their products or try to adapt to product variations introduced by their competitors. We assume that a higher innovativeness of the firm is connected to a higher innovations probability p_i.

While lucky stars and working horses do exist, we focus on the interaction of an imitator and innovator time of firm, which compete against each other. According to our interpretation, an innovator is more agile and innovative and thus has a high probability achieve an innovation. At the same time this firm has high efforts in its R&D process which likely leads to an radical innovation. That is, the firm, i.e. a start-up, spends relatively high investment costs for its R&D. On the other hand, the imitator may be a large firm, which specializes into constant product innovations leading to rather incremental innovations. At the same time this firm focuses on existing markets and has a more rigid firm structure which is difficult to adapt to necessary changes and flexibility connected and required for innovations. That is, this firm is less innovative and thus likely to be successful in innovating. Hence, we assume that the innovator has higher operating costs with $c_{In} = 0.12 > c_{Im} = 0.05$, higher capacity costs $k_{In} = 2.5 > k_{Im} = 1$, a higher success rate $p_{In} > p_{Im} = 0.3$, and has a higher R&D investment $I_{In} > I_{Im} = 0.34$ than the imitator. Furthermore, we assume that $\eta = 0.1$, $\gamma = 0.4$, and $x_0 = 1$.

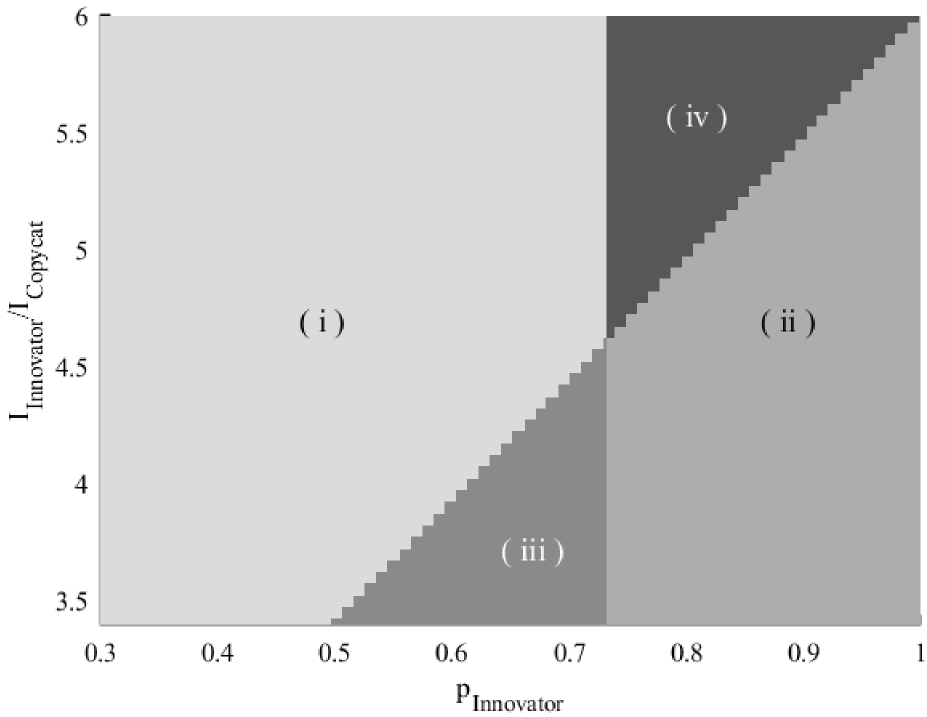

Figure 6: Firm and product innovativeness.

The expected payoffs for both firms according to Eq. (21) and Eq. (22) are illustrated in Figure 6. We identify four cases, in which either none of the two firms is expected to be profitable (case I), only the innovator is expected to be profitable (case II), only the imitator is expected to be profitable (case III) or both firms are expected to be profitable (case IV).

In case I, the innovator as a low innovation probability and spends a lot in the R&D competition phase leading to no expected profitability. Even if the success probability increases, the innovator remains unprofitable for higher investment costs. The imitator may is not expected to be profitable because of the low success probability of the leader, leaving the imitator with no option to imitate any products from its competitor.

In case II, the success probability of leader his high enough to give the innovator an expected profit for low investment costs in the innovation competition. However, the high success probability of the innovator does not lead to an expected positive payoff for the imitator, as its expected chances to imitate a product and launch it into the market remain low. In both cases I and II it is remarkable that the imitators expected payoff from an own innovation is very low, leading to an a negative expected profitability in the R&D competition.

If the success probability of the innovator is larger than $p_{In} > 0.73$ the imitator becomes successful in cases III and IV. In these cases, the expected success of the innovator lead to high enough chances for the imitator to become active as a follower in the market competition by imitating the product of the innovator. In case IV the investment costs in the innovation competition are low enough for the innovator to be expected to be profitable from the innovation competition. This changes in case III, where the innovator is not expected to be profitable.

It is thus clear that the expected profitability of the innovator is split between positive and negative along the diagonal line separating cases I and III from cases II and IV as an increases in the innovativeness and success probability $p_{In}$is offset by higher investment costs I_{In} and thus a more radical expected innovation. For the imitator the only driving force of its expected profitability is the success probability p_{In} of the innovator, leading to a more or less likely chance to imitate the innovator.

It is notable that case III leaves no expected profitability for the innovative start-up, which is very likely to be innovative but has to high investment costs in the

R&D competition. This start-up is likely to produce a very radical innovation with a high probability but is not able to capitalize its success enough to compensate its investment costs. The imitator on the other hand is well prepared for an innovation of this type of competitor: The higher the success rate of the innovator the more likely are its chances to follow its prepared imitation strategy, irrespective of the expected profitability of the innovator.

5. Conclusion

Firms innovate to bring new products to the market and thus secure the long-term success of the firm. Most of the time firms compete with others over an innovation. In this innovation competition, the firms may differ by their innovation effort as in their R&D investments as well as their innovation type and thus their success probability. We identify four types of firms and focus on the competition between an innovation and imitator type of firm. While both innovator and imitator types of firm may compete in innovation, the market competition depends on their innovation success. If both companies are successful they launch their products immediately together or not at all, if both fail at innovating. However, if only one firm is successful it becomes the market leader and the other firm gets an option to time an imitation. However, the imitator faces a project lag due to a necessary adoption period.

This imitator's project lag and the innovator and imitator type of firms competing on innovation is new to the literature. We show an U-shaped investment threshold over the project lag for the follower. Furthermore, we explain why imitator types of firms profit form successful innovators and may be expected to be more profitable than they are.

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