Innovation Games - The Impact of Startup's Product Innovation Degree and Competition Intensity on the Incumbent's Acquisition Decision

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Abstract

To study the impact of a startup's product innovation degree and competition intensity on the incumbent's acquisition decision, this dissertation proposes a three-stage game. This is played by two firms: an incumbent and a startup. The startup plays the first stage, in which it decides to invest in R&D or do nothing. In the latter case, it is considered that the startup does not invest in R&D if it does not own the required financial resources. An innovative product arises in case of successful investment in R&D, and the startup files a patent application in the country's Patent Office to protect its IP. In the second stage, the incumbent must choose between merging with the startup, making a killer acquisition, or allowing the startup to enter the market. After the startup's entry, both firms engage in Cournot competition. According to the conclusions obtained, killer acquisitions only occur if the innovator develops a product quality at a maximum of 10% within high levels of competition intensity. When the innovator does not heavily invest in R&D, it spends low financial resources and then requires a financial reward that the acquiring firm can afford. Authority Agencies should then supervise anti-competitive acquisitions based not only on the consumers' welfare harming but also on low acquisition prices. These results only stand for high transaction costs associated with the new product implementation after a genuine acquisition has occurred. For this reason, it is suggested to study the impact of those transaction costs on the incumbent's decision.

Keywords: product innovation, competition intensity, genuine and killer acquisitions

1. Introduction

Nowadays, innovation is a key driver of economic growth. At the beginning of the 1930s, Schumpeter defined three main types of innovation: product innovation, process innovation, and organisational/management innovation. In 2005, the Organisation of Economic Co-operation and Development (OCDE) added a fourth type, marketing innovation. OCDE (2005) then defines the four types of innovation and divides them into two categories: i) Technological innovations are associated with the first two types; ii) Non-technological innovations classify the remaining two types of innovation. Since this article relies on the impact of product innovation on a firm's acquisition decision, the remaining study will focus on technological innovation.

According to Abernathy and Utterback (1975), a firm invests firstly in product innovation. When entering a new market, it is crucial to fulfil the maximum possible demand with greater effectiveness, so its profit can increase. On the other hand, a firm tends to invest in process innovation in the later stages of the competition when it already owns a significant market power. In that case, the innovator intends to benefit from a competitive advantage which arises from maximising its profit at a lower marginal cost. Contrary to the conventional technological innovation approach, Adner and Levinthal (2001) state that the type of innovation developed depends on whether the innovation is *new to the world* (new to the customers) or *new to the market* (an enhanced technology compared to the existing one). Whilst the former leads to product innovation, the latter incentives process innovation.

The scope in which technological innovation is developed also depends on the type of market competition. Aghion et al. (2005) combine two different perspectives and state that the competition intensity and the incentives to innovate follow an inverted u-shape: for low levels of competition (monopoly structure), firms with higher market power have higher financial resources and thus higher incentives to invest in research and development (R&D) (Schumpeter, 1943); for high levels of competition (large firms at the same technology level), firms intend to invest in R&D looking forward escaping to competition and thus, benefiting from higher profit (Arrow, 1962).

To rapidly benefit from financial returns, the innovator mainly decides to sell the rights associated with their intellectual property (IP) (Gans and Stern, 2000). In fact, according to Bryan and Hovenkamp (2020), startups innovate towards the leading firm in the market since it owns a higher market power and is willing to pay a higher financial value when acquiring the innovator. Acquisitions can be divided into two types: i) mergers or genuine acquisitions, where the acquiring firm keeps maintains the technology innovation acquired in the market; ii) killer acquisitions, where the acquiring firm acquires the new technology and keeps it secret, "killing the product/process" even before it has entered the market. Within that context, anti-competitive acquisitions are becoming a central concern to the Authorities Agency because of the competition suppression and resulting in consumer welfare harm. Prohibiting startup acquisitions would positively affect economic growth by 3% per year. Motta and Peitz (2021) conclude that big tech mergers view young startups as a cheap target due to the low acquisition price. On the other hand, Fumagalli et al. (2022) state that Authority Agencies are more prone to intervene in acquisitions with a high transaction cost. For this reason, they suggest supervising the acquisitions based on the acquisition cost instead of the consumers' welfare harming and defining a low acquisition price threshold, so anti-competitive mergers with low acquisition prices are analysed too.

Between 2010 and 2020, the five most dominant firms within the digital market (Google, Apple, Facebook, Amazon and Microsoft) acquired more than 400 firms. The acquired firms did not shut down their operations. Thus, they are described as mergers. On the other hand, acquisitions observed within Google Play Store are described as killer acquisitions since the acquired firms were discontinued (Affeldt and Kesler, 2021). At the beginning of 2022, Adobe acquired its direct competitor, Figma, seeking to prevent the latter from gaining even more value within the digital market. Adobe's willingness to keep its market share was so high that the acquisition price is estimated to be around fifty times the annual Figma profit, translated into 20000 million dollars (Magalhães, 2022).

Regarding the pharmaceutical industry, if the new potential entrant innovation overlaps with the incumbent's product, drug projects are unlikely to be developed in monopolistic markets. Killer acquisitions constitute between 5.3% and 7.4% of acquisitions in the sampled data studied by Cunningham et al. (2021).

Seeking to study the impact of a startup's product innovation degree and competition intensity on the incumbent's acquisition decision, this study suggests a three-stage game played by two firms: an incumbent and a potential entrant described as a startup. The startup plays the first stage, in which it decides to invest in R&D or do nothing. In the latter, it is considered that the startup does not invest in R&D if it does not own the required financial resources. An innovative product arises in case of successful investment in R&D, and the startup files a patent application in the country's Patent Office to protect its IP. It is considered that the startup develops a product innovation because it seeks to obtain a significant market share when entering the market. For this reason, it develops a differentiated and improved product compared with the existing one. The game ends if the startup fails to invest in R&D. In the second stage, the incumbent must choose between merging with the startup, making a killer acquisition, and allowing the startup to enter the market. Both firms engage in Cournot competition in the last stage and after the startup entry.

This article is structured as follows: i) Model setup and description; ii) Profits maximisation and their response to the main variables; iii) Incumbent optimal acquisition solutions; iv) Aggregate results and their limitations; vi) Conclusions and future work.

2. Model

As stated before, this work presents a three-stage game played by two firms: an incumbent (I) and a potential entrant described as a startup (S). The startup plays the first stage, in which it decides to invest in R&D or do nothing. In the latter, it is considered that the startup does not invest in R&D if it does not own the required financial resources. An innovative product arises in case of successful investment in R&D, and the startup files a patent application in the country's Patent Office to protect its IP. After the patent has been approved, the product innovation achieves its maximum value, and the game moves forward to the second stage. The game ends if the startup fails to invest in R&D. In the second stage, the incumbent must choose between merging with the startup, making a killer acquisition, and allowing the startup to enter the market. Both firms engage in Cournot competition in the last stage and after the startup entry.

Following the perspective of Letina et al. (2021), this study describes mergers as genuine acquisitions.

2.1. Model setup

This theoretical model follows the linear demand functions suggested by Singh and Vives (1984). The resulting inverse demands, or, in other words, the prices each firm charges for their quantities sold, are described by equation (1) indexed by $i, j, k = \{S, I\}$ for $i \neq j$: i) If $i = S$, then $k = i$; ii) If $i = I \land \gamma \neq 0$, then $k = i$; iii) If $i = I \land \gamma = 0$, then $k = \{S, I\}$. Henceforth the subscripts I and S refer to the incumbent and the startup, respectively.

$$p_i = a_k - q_i - \gamma q_j \qquad (1)$$

Contrary to Singh and Vives (1984), this model considers a symmetric marginal cost c, which is assumed to be null for simplicity since this study aims to analyse the impact of product innovation on the incumbent's acquisition decision. Therefore, the above equation (1) represents each firm's price net marginal cost, which must be strictly positive ($p_k > 0$, for $k = \{S, I\}$).

Also, since it is not possible to directly measure a product quality, variables a_I and a_S refer to each product's quality proxy, whereby the innovative product has a greater product quality than the existing one ($a_S > a_I$). This perspective follows the interpretation of Bryan and Hovenckamp (2020). The greater the product quality is, the higher consumers' willingness to pay for it. The quantities produced by each firm fulfil each demand, and they are represented by q_I and q_S. To operate in the market, each firm must produce strictly positive quantities ($q_k > 0$, for $k = \{S, I\}$), and therefore, both product qualities are strictly positive too ($a_k > 0$, for $k = \{S, I\}$).

$\gamma \in [0; 1]$ represents the product differentiation degree, or in other words, the impact the output level of firm i has on the demand of firm j, for $i \neq j$. This parameter is widely understood in the literature as representing the product substitutability degree. In this study, it is assumed to be symmetric, which means that the impact caused by the output level of firm i on the demand of firm j is equal to the effect caused by the output level of firm j on the demand of firm i. For a better understanding, in a monopoly, there is no competition intensity because of the high product differentiation degree, where the output level of one firm has no impact on the other's demand ($\gamma = 0$), each market is independent of all the others. There is no substitutability between products. On the other hand, in a market with perfect competition, the competition intensity is very high due to the high product homogeneity. In this case, the output level of one firm heavily impacts the other's demand ($\gamma = 1$).

2.2. Model description

Hereafter, in this article, regarding the superscripts adopted: GA describes the event where the incumbent decides to merge with the potential new entrant; KA is related to a killer acquisition; Da_S and Da_I refer to when the incumbent opts to do nothing in the acquisition. Also, the superscript * refers to the equilibrium state.

For a better understanding and seeking to summarise all possible subgames and the respective outcome combinations, it is presented Table 1. The last subgame may also be described as subgame 2 if the startup fails in the investment stage (first stage). The author of this work describes it as the fourth subgame since this study seeks to study the incumbent optimal solutions in the acquisition stage. The incumbent only faces this decision when the startup invests successfully in R&D and consequently files a patent application to protect its IP. For this reason, subgame 4 will not be studied.

Table 1. Killer acquisition game: Subgames descriptions and their outcomes

Subgames	Description	Outcomes
Subgame 1 (***R&D, NA***)	S invests successfully in R&D, and after that, it files a patent application, which is granted and approved by the country's Patent Office. As in the following stage, I decides not to make an acquisition, S enters the market producing and commercialising its innovative product with quality a_S whilst I keeps producing and commercialising its existing product with quality a_I. The market becomes a duopoly where each firm benefits from profits equal to $\pi_S^{Da_S}$ and $\pi_I^{Da_I}$.	$\left(\pi_S^{Da_S*} ; \pi_I^{Da_I*}\right)$
Subgame 2 (***R&D, KA***)	S invests successfully in R&D, and after that, it files a patent application, which is granted and approved by the country's Patent Office. I makes a killer acquisition, and S gets a financial reward ($Re_S = \pi_S^{Da_S}$). After making the killer acquisition at an acquisition cost equal to the financial reward obtained by the startup, I keeps operating as a monopolistic firm producing and commercialising its existing product quality a_I, thus getting as final profit $\pi_I^{KA} = \pi_I^{Ma_I} - \pi_S^{Da_S}$.	$\left(Re_S{}^*; \pi_I^{KA*}\right)$
Subgame 3 (***R&D, GA***)	S invests successfully in R&D, and after that, it files a patent application, which is granted and approved by the country's Patent Office. I makes a genuine acquisition, and S gets a financial reward ($Re_S = \pi_S^{Da_S}$). After making the genuine acquisition at an acquisition cost equal to the financial reward obtained by the startup, I keeps operating as a monopolistic firm and starts operating only with the new product quality a_S, thus getting a final profit $\pi_I^{GA} = \pi_I^{Ma_S} - \pi_S^{Da_S}$.	$\left(Re_S{}^* ; \pi_I^{GA*}\right)$
Subgame 4 (***NR&D***)	S does not invest successfully in R&D, and therefore, it does not enter the market. It gets then profit equal to zero. I keeps operating as a monopolistic firm producing and commercialising its existing product with quality a_I, thus getting a profit equal to $\pi_I^{Ma_I}$.	$\left(0 ; \pi_I^{Ma_I*}\right)$

Using the 13th version of the mathematical software named "Wolfram Mathematica" allowed the author of this work to simplify the mathematical expressions and plot the relevant graphs in the following sections. As the aim of this article suggests, the equilibrium profits and the incumbent acquisition decision will be studied based on the startup product innovation degree, which can be translated into how much greater is the new product quality comparing with the existing one $\left(\frac{a_S}{a_I}\right)$ versus the product differentiation degree (γ).

3. Profits maximisation

Before proceeding to the following subsections, it is necessary to keep in mind conditions (2)(3)(4) shown below and that have already been mentioned in model setup subsection 2.1:

$$\frac{a_S}{a_I} > 1, a_k > 0 \text{ for } k = I, S \quad (2)$$

$$0 < \gamma < 1 \quad (3)$$

$$q_k > 0 \text{ for } k = I, S \quad (4)$$

Note that condition (2) arises from the fact that the innovative product has a better product quality than the existing one.

3.1. Subgame 1 *(R&D, NA)*

Recalling equation (1), linear inverse demands are $p_S = a_S - q_S - \gamma q_I$; $p_I = a_I - q_I - \gamma q_S$ and the profit functions $\pi_S{}^{Da_S} = p_S q_S = (a_S - q_S - \gamma q_I) q_S$; $\pi_I{}^{Da_I} = p_I q_I = (a_I - q_I - \gamma q_S) q_I$.

Profits maximisation results on the following First-Order-Conditions (FOC), thus leading to each firm's reaction function represented by equations (5)(6):

$$\frac{\partial \pi_S{}^{Da_S}}{\partial q_S} = 0 \Leftrightarrow q_S = \frac{a_S - \gamma q_I}{2} \quad (5)$$

$$\frac{\partial \pi_I{}^{Da_I}}{\partial q_I} = 0 \Leftrightarrow q_I = \frac{a_I - \gamma q_S}{2} \quad (6)$$

Solving the equations system with both reaction functions (5)(6), it is calculated each firm's quantities in equilibrium $q_S{}^* = \frac{2a_S - \gamma a_I}{4-\gamma^2}$; $q_I{}^* = \frac{2a_I - \gamma a_S}{4-\gamma^2}$. In equilibrium, therefore, the prices net marginal costs charged to the downstream customers are $p_S{}^* = \frac{2a_S - \gamma a_I}{4-\gamma^2}$; $p_I{}^* = \frac{2a_I - \gamma a_S}{4-\gamma^2}$, thus resulting in the equilibrium profits functions (7)(8):

$$\pi_S^{Da_S{}^*} = p_S{}^* q_S{}^* = \frac{(2a_S - \gamma a_I)^2}{(2-\gamma)^2(2+\gamma)^2} \quad (7)$$

$$\pi_I^{Da_I{}^*} = p_I{}^* q_I{}^* = \frac{(2a_I - \gamma a_S)^2}{(2-\gamma)^2(2+\gamma)^2} \quad (8)$$

Each output level in equilibrium must be strictly positive. Since the denominator $4 - \gamma^2 > 0$, the output level depends on the numerator to fulfil these conditions. $2a_S - \gamma a_I > 0$; $2a_I - \gamma a_S > 0$ is only true for $\gamma < \min\left\{\frac{2a_I}{a_S}; \frac{2a_S}{a_I}\right\}$. As $\frac{a_S}{a_I} > 1$, the product's differentiation degree must fulfil condition (9) presented below.

$$\gamma < \frac{2a_I}{a_S} \quad (9)$$

There are two scenarios in which condition (9) is fulfilled. **Scenario 1:** If $1 < \frac{2a_I}{a_S}$, the condition is always fulfilled, and γ can assume all the values within the interval $[0; 1]$. From $1 < \frac{2a_I}{a_S}$, it is obtained $\frac{a_S}{a_I} < 2$, which joined to condition (2), results in a new condition (10):

$$1 < \frac{a_S}{a_I} < 2 \quad (10)$$

Scenario 2: When $1 > \frac{2a_I}{a_S}$, the condition is only fulfilled for some values of γ within the interval $[0; 1]$. From $1 > \frac{2a_I}{a_S}$, it is obtained $\frac{a_S}{a_I} > 2$, which being analysed together with condition (2), provides a new condition (11):

$$1 < \frac{a_S}{a_I} < 2 \quad (11)$$

As Bryan and Hovenkamp (2020) state in chapter 2, a leading firm's product quality which is twice greater than the laggard firm's product leads to a monopolistic market. The former desirable demand is not affected by the latter output level. Consequently, the dominant firm keeps getting a significant share of demand, allowing it to continue benefiting from monopoly profit.

Bearing that in mind and following the same reasoning, the startup and the incumbent profits will be studied within scenario 1. Scenario 2 is excluded because it is assumed that developing a product whose quality impacts more than twice the desirable demand requires a high investment level in R&D. It becomes costly to the innovator. For this reason, condition (10) is the one which prevails for the remaining subgames perfect Nash equilibrium study.

As can be easily observed from equations (7)(8), $\pi_S^{Da_S{}^*}$ always increases with a_S and always decreases with a_I. The opposite happens with the $\pi_I^{Da_I{}^*}$, which always increases with a_I and always decreases with a_S. For this reason, the subgame 1 perfect Nash equilibrium is only studied depending on the product differentiation degree γ.

Starting with the startup profits, it is obtained equation(12):

$$\frac{\partial \pi_S^{Da_S{}^*}}{\partial \gamma} = 2a_I{}^2\left(2\frac{a_S}{a_I} - \gamma\right)\frac{(-4 + 4\frac{a_S}{a_I}\gamma - \gamma^2)}{(2-\gamma)^3(2+\gamma)^3} \quad (12)$$

Since all the remaining multiplication factors and the denominator are strictly positive according to conditions (3)(10), the signal of $\frac{\partial \pi_S^{Da_S{}^*}}{\partial \gamma}$ only depends on the numerator. If $-4 + 4\frac{a_S}{a_I}\gamma - \gamma^2 > 0 \Leftrightarrow \frac{a_S}{a_I} > \frac{\gamma^2 + 4}{4\gamma}$, then $\pi_S^{Da_S{}^*}$ increases with γ; Otherwise, it decreases with γ.

It is obtained Figure 1, where it can be observed that the startup benefits from a higher profit for high levels of product innovation degree and for high levels of competition intensity. Under these conditions, it will then require a high financial reward.

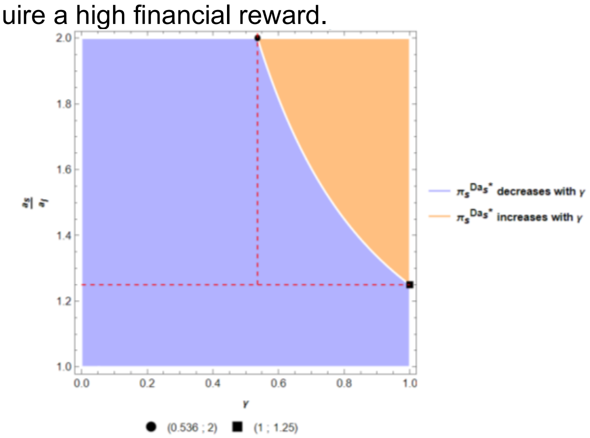

Figure 1. $\pi_S^{Das^*}$ behavior with γ

When it comes to the incumbent's profit, the following equation is obtained:

$$\frac{\partial \pi_I^{Da_I^*}}{\partial \gamma} = 2a_I^2\left(2-\gamma\frac{a_S}{a_I}\right)\frac{\left(-4\frac{a_S}{a_I}+4\gamma-\gamma^2\frac{a_S}{a_I}\right)}{(2-\gamma)^3(2+\gamma)^3} \quad (13)$$

Since all the remaining multiplication factors and the denominator are strictly positive according to conditions (3)(10), $\frac{\partial \pi_I^{Da_I^*}}{\partial \gamma}$ only depends on the numerator: If $-4\frac{a_S}{a_I}+4\gamma-\gamma^2\frac{a_S}{a_I} \Leftrightarrow \frac{a_S}{a_I}(-4-\gamma^2)+4\gamma>0$, then $\pi_I^{Da_I^*}$ increases with γ; Otherwise, it decreases with γ.

It can be easily observed that $\frac{a_S}{a_I}(-4-\gamma^2)+4\gamma$ is always negative within conditions (3)(10). Therefore, $\frac{\partial \pi_I^{Da_I^*}}{\partial \gamma}<0$ and, thus, the incumbent's profit always increases with the product differentiation degree (low γ means high differentiation).

3.2. Subgame 2 *(R&D, KA)*

The incumbent profit will be the one to be studied within this section since the startup does not enter the market.

Within a monopoly $p_I = a_I - q_I$ and hence the following profit function $\pi_I^{Ma_I} = p_I q_I = (a_I - q_I)q_I$.

Since the incumbent operates as a monopolistic firm in this event, its reaction function is equal to the output level in equilibrium. From FOC, the demand in equilibrium is represented by equation (14):

$$\frac{\partial \pi_I^{Ma_I}}{\partial q_I} = 0 \Leftrightarrow q_I^* = \frac{a_I}{2} \quad (14)$$

In equilibrium, therefore, the price net marginal cost charged to downstream customers by the manufacturing firm I is $p_I^* = \frac{a_I}{2}$, thus resulting in the following equilibrium profit (15):

$$\pi_I^{Ma_I^*} = p_I^* q_I^* = \left(\frac{a_I}{2}\right)^2 \quad (15)$$

Since the incumbent makes a killer acquisition in this subgame, its final equilibrium profit considers the acquisition cost related to the new product's purchase. This acquisition cost is represented by startup equation profit (7), and then the total equilibrium incumbent profit after making a killer acquisition is reflected on a new equation profit (16):

$$\pi_I^{KA^*} = (15)-(7) = \left(\frac{a_I}{2}\right)^2 - \frac{(2a_S-\gamma a_I)^2}{(2-\gamma)^2(2+\gamma)^2} \quad (16)$$

Having in mind conditions (3)(10), the incumbent's profit equation in equilibrium (16) will not be studied depending on the three main variables for the following two reasons: i) As it can be observed, $\pi_I^{KA^*}$ always increases with a_I and decreases with a_S; ii) Since I keeps producing and commercialising its old product in a monopoly, the incumbent profit equation (16) does not depend on product differentiation degree. As a result, its profit equation after making a killer acquisition (16) only depends on the acquisition cost. Once the acquisition cost is reflected on the startup profit equation (7), the results are the opposite comparing with the ones obtained from the Figure 1 analysis.

3.3. Subgame 3 *(R&D, A)*

Once more, the incumbent profit will be the one to be studied within this section since the startup does not enter the market.

As mentioned before, within a monopoly, there is no product differentiation. Thus $\gamma = 0$ and recalling equation (1), it is obtained the following I linear inverse demand $p_I = a_S - q_I$ and hence the following profit function $\pi_I^{Ma_S} = p_I q_I = (a_S - q_I)q_I$.

By analogy to the previous subgame, the incumbent profit in equilibrium when operating in a monopoly with its new acquisition is obtained by applying the FOC. It is given by equation (17):

$$\pi_I^{Ma_S^*} = p_I^* q_I^* = \left(\frac{a_S}{2}\right)^2 \quad (17)$$

Since, in this subgame, the incumbent makes a genuine acquisition, its final equilibrium profit takes into account the acquisition cost related to the new product's purchase. This acquisition cost is represented by the startup equation profit (7), and then the total equilibrium incumbent profit after merging with the startup is reflected on a new equation profit (18):

$$\pi_I^{GA^*} = (17)-(7) = \left(\frac{a_S}{2}\right)^2 - \frac{(2a_S-\gamma a_I)^2}{(2-\gamma)^2(2+\gamma)^2} \quad (18)$$

Bearing in mind conditions (3)(10), the incumbent profit in equilibrium after making a genuine acquisition will not be studied depending on the existing product quality a_I and on the product differentiation degree γ due to the following reasons: i) As can be easily observed, $\pi_I^{A^*}$ always increases with a_I; 2) Since I starts producing and commercialising in monopoly its newly acquired product, the incumbent monopoly profit equation (17) before merging with the startup does not depend on product differentiation degree. This means that γ only affects the acquisition cost. Once the acquisition cost is reflected on the startup profit equation (7), the results are the opposite comparing with the ones obtained from the Figure 1 analysis.

In this subgame, by derivating the incumbent profit in equilibrium after merging with the startup in order to a_S it is obtained equation (19):

$$\frac{\partial \pi_I^{GA^*}}{\partial a_S} = \gamma a_I \frac{\left(8-8\frac{a_S}{a_I}\gamma+\frac{a_S}{a_I}\gamma^2\right)}{2(2-\gamma)^2(2+\gamma)^2} \quad (19)$$

Since all the remaining multiplication factors and the denominator are strictly positive based on conditions (3)(10), the signal of $\frac{\partial \pi_I^{GA^*}}{\partial a_S}$ depends on the numerator: If $8-8\frac{a_S}{a_I}\gamma+\frac{a_S}{a_I}\gamma^2>0 \Leftrightarrow \frac{a_S}{a_I}<\frac{8}{8-\gamma^3}$, then $\pi_I^{GA^*}$ increases with a_S; Otherwise, it decreases with the innovative product quality.

Figure 2 is obtained, where it can be easily observed that the incumbent can benefit from higher profit after making a genuine acquisition for high levels of competition intensity and if the startup invests low financial resources in R&D, which means that the startup's product innovation degree is low.

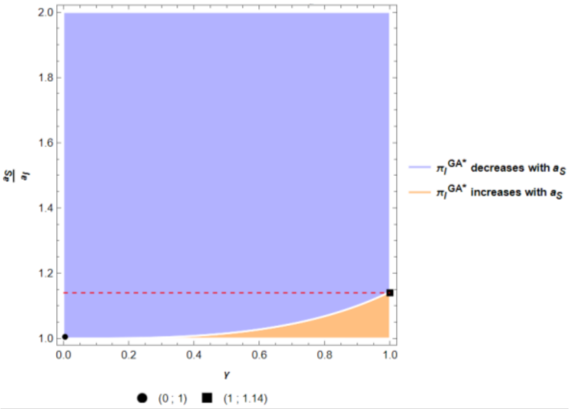

Figure 2. π_I^{GA*}behavior with a_S

4. Incumbent 2nd stage optimal solutions

4.1. KA vs D

When the incumbent is faced with choosing between making a killer acquisition and competing in a duopoly with the new entrant, the results are obtained from the difference between the incumbent profit equations (16) and (8). They are then drawn based on equation (20):

$$\pi_I^{KA*} - \pi_I^{Da_I*} = a_I^2\left(-2\frac{a_S}{a_I} + \gamma\right)\frac{\left(8\frac{a_S}{a_I} - 12\gamma + \gamma^3 + 2\gamma^2\frac{a_S}{a_I}\right)}{4(2-\gamma)^2(2+\gamma)^2} \quad (20)$$

If $\pi_I^{KA*} - \pi_I^{Da_I*} < 0$, then to keep its operations with the old product and hence to compete with the startup is more profitable for I; Otherwise, $\pi_I^{KA*} > \pi_I^{Da_I*}$ and the incumbent prefers to make a killer acquisition. Within conditions (3)(10), $a_I^2\left(-2\frac{a_S}{a_I} + \gamma\right) < 0$ and $4(2-\gamma)^2(2+\gamma)^2 > 0$, thus meaning that the signal of $\pi_I^{KA*} - \pi_I^{Da_I*}$ depends on the numerator: If $8\frac{a_S}{a_I} - 12\gamma + \gamma^3 + 2\gamma^2\frac{a_S}{a_I} > 0 \Leftrightarrow \frac{a_S}{a_I} > \frac{12\gamma - \gamma^3}{8+2\gamma^2}$ then $\pi_I^{KA*} - \pi_I^{Da*} < 0$ which means that to compete in duopoly with S is more profitable for I; Otherwise, making a killer acquisition is more attractive for the existing firm.

It is then obtained Figure 3, where it can be easily observed that a killer acquisition may only occur when the startup invests low financial resources in R&D and thus it requires a low financial reward, and for high levels of competition intensity. Also, it can be stated that under these conditions it is when the startup is cheaper to acquire from the incumbent perspective, since it requires the minimum financial reward possible.

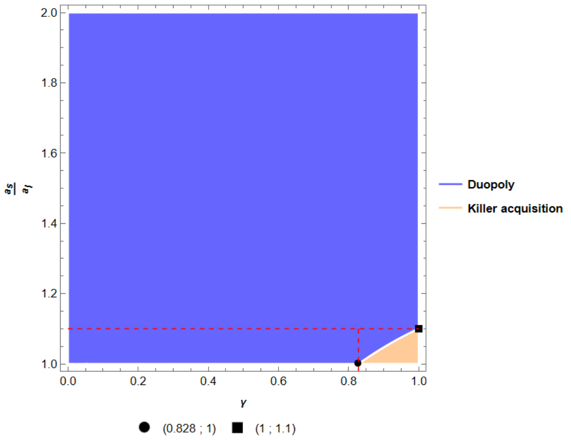

Figure 3. Incumbent's acquisition decision in the 2nd stage: Killer Acquisition vs Duopoly

4.2. GA vs D

When deciding whether to merge with the potential new entrant or to do nothing, the incumbent's acquisition decision relies on the difference between the incumbent profit equations (18) and (8), which is given by equation (21):

$$\pi_I^{GA*} - \pi_I^{Da_I*} = a_I^2\left(-2\frac{a_S}{a_I} + \gamma\right)\frac{\left(8 - 12\frac{a_S}{a_I}\gamma + \frac{a_S}{a_I}\gamma^3 + 2\gamma^2\right)}{4(2-\gamma)^2(2+\gamma)^2} \quad (21)$$

If $\pi_I^{GA*} - \pi_I^{Da_I*} < 0$, to compete with the new entrant is more profitable for the existing firm; Otherwise, $\pi_I^{GA*} > \pi_I^{Da_I*}$ and then the incumbent prefers to make a genuine acquisition. As stated by conditions (3)(10), $a_I^2\left(-2\frac{a_S}{a_I} + \gamma\right) < 0$ and $4(2-\gamma)^2(2+\gamma)^2 > 0$, and therefore, the signal of $\pi_I^{GA*} - \pi_I^{Da_I*}$ depends on the numerator: If $8 - 12\frac{a_S}{a_I}\gamma + \frac{a_S}{a_I}\gamma^3 + 2\gamma^2 > 0 \Leftrightarrow \frac{a_S}{a_I} > \frac{-8-2\gamma^2}{\gamma^3 - 12\gamma}$, then $\pi_I^{GA*} - \pi_I^{Da_I*} < 0$ and therefore, to compete with S is more profitable for I; Otherwise, merging with the potential new entrant is more attractive.

Figure 4 is then obtained, and a genuine acquisition only occurs for low levels of competition intensity. This is to say, when the startup's output level does not heavily impact the incumbent's demand.

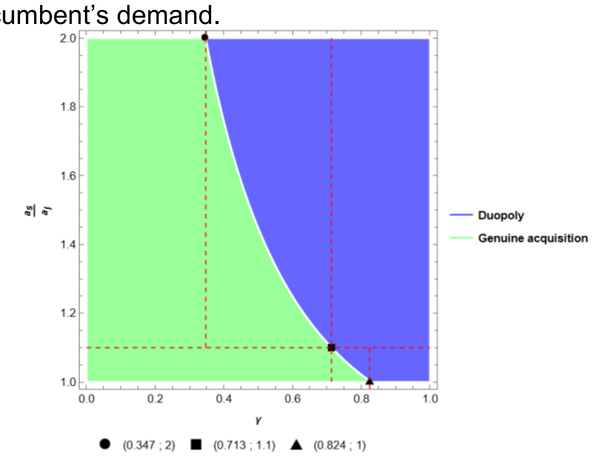

Figure 4. Incumbent's acquisition decision in the 2nd stage: Genuine Acquisition vs Duopoly

4.3. GA vs KA

Finally, to study which solution is the most profitable to the incumbent between merging with the potential entrant described as a startup and making a killer acquisition, the difference is calculated between incumbent profit equations (21) and (16). Since the acquisition cost is the same in both events, it is obtained equation (22):

$$\pi_I^{GA^*} - \pi_I^{KA^*} = \frac{a_S{}^2 - a_I{}^2}{4} \quad (22)$$

If $\pi_I^{GA^*} - \pi_I^{KA^*} > 0$ to make a genuine acquisition is more profitable; Otherwise, a killer acquisition is the best option for the existing firm.

$\pi_I^{GA^*} - \pi_I^{KA^*}$ is strictly positive (> 0) since $\frac{a_S}{a_I} > 1$, as stated by condition (2). Thus, in this model, from the incumbent perspective, making a genuine acquisition is always more profitable than making a killer acquisition for all the potential new entrant product innovation degrees and all the product differentiation degrees.

This result is conditioned by the following assumptions stated throughout this study: i) in both genuine and killer acquisitions, the incumbent faces the exact acquisition cost; ii) there is a perfect technology knowledge transfer, and, thus, the implementation costs associated with the innovative product reproduction are not taken into account. These costs arise mainly from the tacit knowledge owned by the innovator concerning the product innovation know-how.

Although the calculations and the results have been reached considering a perfect technology knowledge transfer, which results in the exact acquisition cost faced by the incumbent in both acquisitions, it is important to bear in mind that $\pi_I^{GA^*}$ is even lower than the result obtained. Moreover, the discussion of the results will be done based on the following assumption: the costs associated with the incorporation of the innovative product by the incumbent are sufficiently high to allow a killer acquisition to be more profitable than a genuine acquisition in the interval $\left(1 < \frac{a_S}{a_I} < 1.1\right) \wedge (0.828 < \gamma < 1)$, Figure 3.

As a result, within the model proposed along with its assumptions, where the startup's product innovation degree $\left(\frac{a_S}{a_I}\right)$ belong to $[1;\ 2]$, condition (10), the incumbent does never face the decision of choosing between making a genuine acquisition and a killer acquisition.

5. Social welfare analysis

To study from which incumbent's acquisition decision social welfare would benefit the most, it was used the following maximum utility function (23) suggested by Singh and Vives (1984), which follows the same index as Equation (1):

$$U(q_i, q_j) = a_k q_i + a_k q_j - \frac{1}{2}\left[(q_i)^2 + 2\gamma q_i q_j + (q_j)^2\right] \quad (23)$$

To obtain results, the same methodology as the previous section concerning the incumbent optimal solution was used. This is to say, it was calculated the difference between the maximum utility in each incumbent's acquisition decision. It is important to note that the maximum utility analysis was made not counting with the acquisition costs.

It was founded then that to make a killer acquisition is always the most harmful decision for social welfare, as expected since besides of the competition suppression caused by the acquisition, the consumers keep benefiting from a lower product quality compared to the innovative product. When it comes to a genuine acquisition and a duopoly market, Figure 5 emerges from where it can be observed that a genuine acquisition is more attractive for social welfare since under these conditions, consumers benefit from a higher product quality. Also, the acquiring firm would benefit from a higher profit, since the higher is the product quality, the higher is the demand and hence the higher is the firm's profit.

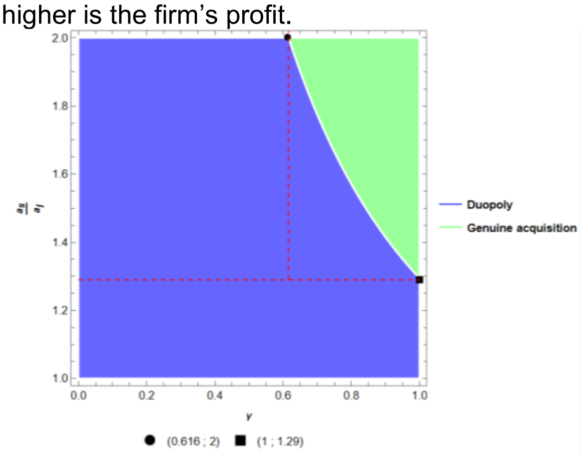

Figure 5. Social welfare: Genuine acquisition vs Duopoly

6. Results discussion and limitations

After maximising each firm's profit in equilibrium, some results can be highlighted.

Firstly, within the context where the startup and the incumbent compete in a duopoly market (*R&D, NA*), it is obtained that the startup can maximise its profit if it spends a high financial resources level to invest in R&D. A high investment in R&D results in a greater innovative product quality which becomes crucial when both firms compete with homogeneous products. The product differentiation degree assumes high values and the competition intensity with high substitutable products. As shown in Figure 1, the startup profit increases for high values of γ when it develops an innovative product with an impact more significant than 25% on its desirable demand compared to the existing technology. This phenomenon is counter-nature since competition erodes profits. This is to say, firm profit decrease with the increase in competitive intensity

By analogy, from the incumbent point of view, it is not so attractive to merge with the potential new entrant or to make a killer acquisition when the startup introduces a new product to the market with such a high product quality impact. For instance, the startup benefits from higher private returns when $\frac{a_S}{a_I} > 1.25$, it becomes more valuable and, therefore, more costly to acquire from the acquiring firm perspective. High investment in R&D from the startup can translate into a high acquisition cost from the incumbent perspective, which does not foster any acquisition.

When the innovative product shows a quality whose impact on the existing firm demand is at a maximum of 14%, the incumbent can benefit from higher profits when it merges with the potential new entrant (Figure 2). The acquisition cost is not prohibitive in that event because the startup profit is not sufficiently high. Thus, the existing firm can appropriate the rents arising from the production and commercialisation of the innovative product.

Once the incumbent decision in the acquisition stage mainly relies on the acquisition cost associated with the innovative product developed by the startup, these results are reflected in the incumbent's acquisition decision, summarised in Figure 6.

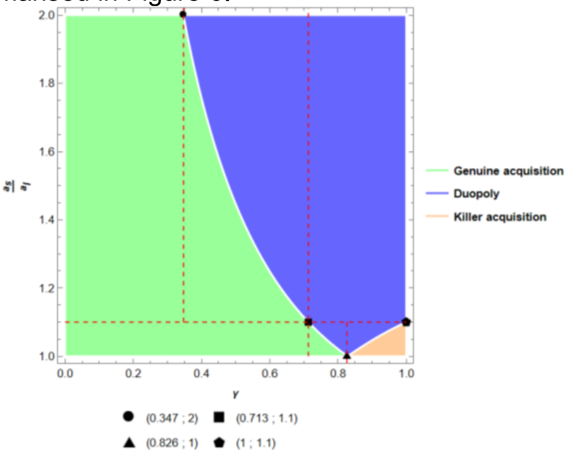

Figure 6. Incumbent optimal solutions

Within the scenario where the startup's product innovation is at a maximum of 10%, it is concluded that merging with the startup seems to be the more attractive alternative to the incumbent. For instance, a genuine acquisition is always the more attractive solution to the incumbent if the startup's output level impacts the incumbent demand by less than 71.3% within a market with low competition intensity and low product homogeneity.

A killer acquisition is more attractive in a competitive market with homogeneous products (high values of γ), in other words, when the startup's output level related to the innovative product has a high impact on the incumbent demand. When the startup's output level weighs more than 82.6% on the incumbent demand, the optimal solution relies on competing in a duopoly with the potential new entrant and making a killer acquisition to preempt future competition, thus shelving its new acquisition. The decision between these alternatives is based on the acquisition cost/financial reward required by the startup.

Acquisitions are more likely to occur within this context since the financial reward required by the startup is not prohibitive. As the startup invests less in R&D in the first stage, the innovative product developed does not show significant enhancements, and the impact on profit is not so high. The main finding of this study is that killer acquisitions may occur when two manufacturing firms compete with similar quality products in a market with high competition intensity reflected on homogeneous products. However, a killer acquisition is the more harmful incumbent's decision to social welfare and its customers. Besides the suppression of competition caused by the acquisition, the customers do not benefit from a greater product quality as they would if a merger took place. Agency Authorities should then intervene in acquisitions associated with lower transaction costs.

It is important to recall that these results only stand for the assumption that the incumbent does not face any costs related to the reproduction of the innovative product. As a result, transaction costs when the incumbent decides to make a genuine acquisition are considered sufficiently high to allow the possibility of a killer acquisition occurring.

Regarding the scenario where the startup's product innovation degree is at a minimum of 10%, it is observed that if the startup's output level affects less than 34.7% of the incumbent demand (for low levels of competition intensity), it is more profitable to incorporate the new product in its operations. On the other hand, for a high product homogeneity and, as a result, for a higher competition intensity, it is more attractive to the incumbent to keep operating with its product and compete with the new entrant. For greater clarity, if the startup's output level has a higher impact than 71.3% on the incumbent demand, within the context where the startup spends more financial resources in R&D, the acquisition cost is a difficult barrier to overcome.

Bearing in mind the results on firms' profit responses to the main variables, whilst in the former interval of product differentiation degree $\left(1 < \frac{a_S}{a_I} < 1.1\right)$, the incumbent can afford the financial reward required by the startup; in the latter $\left(1.1 < \frac{a_S}{a_I} < 2\right)$, as the innovator spends more resources to invest in R&D and to come up with greater product quality, the financial reward is higher. Additionally, as can be observed in Figure 1, startup benefits from an increase in profits when $\frac{a_S}{a_I} > 1.25$ and for high values of product differentiation degree, and thus it requires a high financial return. For these reasons, a high acquisition cost becomes a difficult barrier to overcome when: i) the startup develops a new product whose quality is at least 10% when compared to the existing one; ii) and for high values of γ since the incumbent bargaining power decreases and the startup demands a high financial return in exchange for its innovative product.

Thereby, when it comes to the scenario where the startup heavily invests in R&D and thus develops a new product whose quality surpasses the threshold of 10%, it is concluded that making a killer acquisition is never profitable to the incumbent. Besides the incumbent market share losses related to the entry of a new competitor with a greater quality product, the startup requires a higher financial reward when negotiating the patent commercialisation.

To study the impact of the incumbent's acquisition decision on social welfare, a new graphic emerges from combining Figure 5 and Figure 6. Figure 7 shows the conflict of interests' zones between social welfare and incumbent's profit.

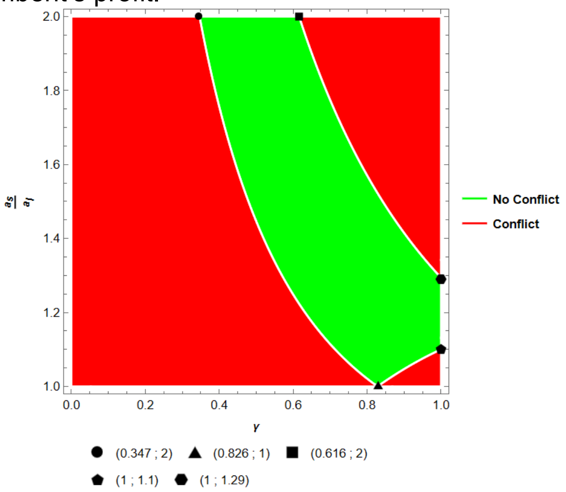

Figure 7. Incumbent and Social welfare: Conflict vs No conflict zones

There are three zones where there is conflict of interests: i) When the incumbent optimal solution is to make a genuine or a killer acquisition, a duopoly market would be more attractive for social welfare. Therefore, acquisitions that occur under those conditions are described as being anti-competitive; ii) When a genuine acquisition is the best option for social welfare, a duopoly market is the best option for the incumbent, since under those conditions the startup requires a high financial reward and then it is very costly to acquire it.The region where there is no conflict of interests is when a duopoly market is the best solution for both social welfare and incumbent.

7. Conclusion

Within the context of killer acquisitions that seek to prevent future competition by "killing" the innovative product entry in the market, this paper proposed a theoretical model which aims to study the startup's product innovation degree $\left(\frac{a_S}{a_I}\right)$ and the competition intensity (γ) on the incumbent acquisition decision (to merge, make a killer acquisition, or do nothing).

This model consists of a three-stage game played by two firms: an incumbent and a potential entrant described as a startup. The startup plays the first stage, in which it decides to invest in R&D or do nothing. In the latter, it is considered that the startup does not invest in R&D if it does not own the required financial resources. An innovative product arises in case of successful investment in R&D, and the startup files a patent application in the country's Patent Office to protect its IP. The game ends if the startup fails to invest in R&D. In the second stage, the incumbent must choose between merging with the startup, making a killer acquisition, and allowing the startup to enter the market. Both firms engage in Cournot competition in the last stage and after the startup entry.

After profit maximisation and solving the game backwards until the second stage, interesting findings were reached. Firstly, within the context where both firms compete in a duopoly market, it is observed that the innovator firm may increase its profit with the competition intensity if its product is sufficiently innovative compared with the incumbent's when competition is already high. It is then in the interval $\left(1.25 < \frac{a_S}{a_I} < 2\right) \wedge (0.536 < \gamma < 1)$ where the incumbent suffers from market share losses to the startup.

The result mentioned above affects the incumbent optimal decision in the second stage. When the startup's product innovation degree is at least 10%, it becomes very costly to make a killer acquisition from the acquiring firm perspective. Besides the startup requiring a high financial return due to the increase in its profit, which is translated to a high acquisition cost, the acquiring firm does not benefit from enough financial gains related to the new product. On the other hand, if the startup's product innovation degree is at a maximum of 10% and the innovative product has an impact higher than 82.6% on the incumbent demand, the interval $\left(1 < \frac{a_S}{a_I} < 1.1\right) \wedge (0.828 < \gamma < 1)$, to make a killer acquisition is an optimal solution when the competition intensity is high. The more intense the competition is, the lower the financial reward required by the startup when negotiating its product innovation. Hence, the lower the acquisition cost is from the incumbent perspective.

As mentioned in the section dedicated to approaching the results and their limitations, this previous result only stands for transaction costs being sufficiently high to allow killer acquisitions to be more profitable, at least in the interval mentioned. These transaction costs are associated with the acquisition and incorporation of the innovative product in the incumbent's operations. Otherwise, if the incumbent faces the same transaction costs in genuine and killer acquisitions, merging would always be more profitable for the existing firm. A killer acquisition would never occur within the theoretical model proposed.

Finally, concerning the merging decision, the incumbent may increase its profit if the startup's product innovation degree is at a maximum of 14%. For a high competition intensity (high values of γ which correspond to homogeneous products), the incumbent obtains a competitive advantage, and thus, it may benefit from higher private returns. This competitive advantage emerges from decreased equilibrium prices charged to downstream customers due to increased competitive intensity. For this reason, the startup requires a lower financial reward, which the incumbent can afford. After a merger, the incumbent financial return when operating with the innovative product surpasses the acquisition cost.

Regarding social welfare analysis, meeting the qualitative analysis provided by Fumagalli et al. (2022), the maximum utility is reached in a duopoly market along with the consumer surplus. The opposite occurs when the incumbent decides to make a killer acquisition, where besides the competition suppression, and thus there is no decrease in equilibrium price, the consumers do not benefit from greater product quality.

The results obtained and discussed throughout this study meet some empirical findings within the context of both genuine and killer acquisitions: i) Fumagalli et al. (2022) suggest that Authority Agencies should supervise the acquisitions based on the acquisition cost value and not only on the harm caused by the acquisition to social and consumers' welfare. The results given by the model proposed also suggest that the acquisition cost faced by the incumbent is a difficult barrier to overcome if the startup's product innovation degree is at least 10%; ii) At the beginning of 2022, Adobe's willingness to keep its market share was so high that the acquisition price when acquiring direct competitor Figma, is estimated to be around fifty times the annual acquired firm profit, translated into 20000 million dollars (Magalhães, 2022). Although this is a merger, since Adobe incorporates Figma's features and ideas, this leads to an adjustment in the acquisition value threshold. As observed in Figure 3, a killer acquisition only occurs when the startup requires a low financial reward, in other words, when the startup does not invest high financial resources to develop product innovation and hence, its product innovation degree is low; iii) According to Cunningham et al. (2021), between 5.3% and 7.4% of the acquisitions within the pharmaceutical industry are described as killer acquisitions. It demonstrates that they are unlikely to occur. Once more, making a killer acquisition is only an optimal solution for the incumbent in the following interval: $\left(1 < \frac{a_S}{a_I} < 1.1\right) \wedge (0.828 < \gamma < 1)$.

As future work, the author of this dissertation suggests focusing on transaction costs, namely those associated with the implementation costs associated with the innovative product after the incumbent has decided to make a genuine acquisition. The purpose would be to obtain results with greater certainty. Also, to be more realistic, to consider an initial users base locked to the incumbent would be interesting to. For instance, to create a new variable k and then to study within a three dimensions analysis. Regarding the acquisition stage, it is suggested to consider the hypothesis in which the acquiring firm operates with both product qualities, thus making a genuine acquisition and also keeping its operations with the existing product quality. Additionally, based on a dynamic model, it would be interesting to study the scenario where the startup decides to develop a process innovation in latter stages of competition to distance itself from the incumbent in the technological field. In that event, the startup would keep the cost-reduction innovation secret.

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