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

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Declaração

Declaro que o presente documento é um trabalho original da minha autoria e que cumpre todos os requisitos do Código de Conduta e Boas Práticas da Universidade de Lisboa.

Declaration

I declare that this document is an original work of my own authorship and that it fulfils all the requirements of the Code of Conduct and Good Practices of the Universidade de Lisboa.

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Resumo

Para estudar o impacto do grau de inovação de produto de uma start-up e da intensidade da concorrência na decisão de aquisição da startup por parte de uma empresa instalada no mercado, propõe-se um jogo de três estádios jogado por duas empresas: uma empresa monopolista já estabelecida no mercado e um potencial concorrente descrito como startup. O primeiro estádio é jogado pela startup, decidindo esta entre investir em investigação e desenvolvimento do produto e não fazer nada. Um produto inovador surge em caso de sucesso no primeiro estádio e, consequentemente, a empresa inovadora apresenta um pedido de patente no Instituto de Patentes do país para proteger a sua propriedade intelectual. No segundo estádio, a empresa já estabelecida no mercado deve escolher entre conluiar-se com o potencial novo concorrente, fazer uma aquisição “matadora” ou, por fim, permitir que a startup entre no mercado e haja concorrência. Ambas as empresas concorrem em quantidades no último estádio do jogo após a entrada da startup. Conclui-se que as aquisições “matadoras” só ocorrem se a startup desenvolver um grau de qualidade de produto até 10% dentro de elevados graus de concorrência. A autoridade reguladora deve então supervisionar as aquisições não só com base nos danos esperados sobre o bem-estar dos consumidores, mas também nas aquisições a preços baixos. Estes resultados apenas se mantêm para custos de transação elevados, nomeadamente custos associados à implementação do novo produto após a ocorrência de conluio. Por esta razão, sugere-se estudar o impacto desses custos na decisão da empresa instalada.

Palavras-chave: inovação do produto, intensidade da concorrência, aquisição genuína e matadora

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

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List of Acronyms

EPO	European Patent Office
FOC	First-Order-Condition
IP	Intellectual Property
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
USPTO	United States Patent and Trademark Office

1. Introduction

Joseph Schumpeter, an Austrian economist and politician scientist of the first half of the 20th century, stated two definitions of invention and innovation from very early. The former relates to creating something new, and the latter relates to the invention being novel enough to change the firm's production function. From his perspective, innovation is the relevant term since "as long as they are not carried into practice, inventions are economically irrelevant" (p. 88) (Schumpeter, 1934, as cited in Croitoru, 2012).

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.

To prevent an invention from being imitated or used by other firms, it is essential to understand what is Intellectual Property (IP) deeply. According to the World Intellectual Property Organization (WIPO) website[1], the concept of Intellectual Property [2] "refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names, and images used in commerce". Therefore, an innovator may adopt a protection mechanism to protect its IP.

Within the manufacturer market, an empirical survey administered to 1478 research and development (R&D) labs in the U.S. manufacturing sector in 1994 states that firms adopt patents as a protection mechanism (Cohen et al., 2000).

However, the protection mechanism adopted depends on the technological innovation developed. Hall et al. (2014) summarise the main findings from theoretical and empirical surveys (e.g., Levin et al. 1987; Cohen et al. 2000) related to deciding which innovative manufacturing firms should adopt protection mechanisms. It is observed that manufacturing firms are more likely to rely on patents when they develop product innovation. On the other hand, they are more prone to keep their inventions secret when it comes to process innovation [3].

Figure 1 (Reproduced from Sherry and Teece, 2004) shows the stages of a patent's life cycle. After being challenged by competitors or in courts to prove its novelty, the most difficult stage when applying for a patent, the invention becomes innovative and changes the innovator's operations. An invention

[1] WIPO's website: https://www.wipo.int/about-ip/en/

[2] The word "property" is commonly understood as a tangible concept. However, all the inventions are valuable, and thus they are considered similar to other types of property, which can be bought, traded, transferred, or licenced (Poticha and Duncan, 2019).

[3] Moreover, the surveys studied in Hall et al. (2014) find that firms are more prone to protect their product innovations by applying for a patent, since they prefer to reveal information about the invention when it is related with the product and to keep secret when it is associated with the process. Moreover, product innovations usually meet the novelty requirement for patenting and they are on average more valuable, which dominates the costs associated with their application.

becomes an innovation when it achieves its maximum value. The patent reaches the minimum value when it expires after 20 years of activity.

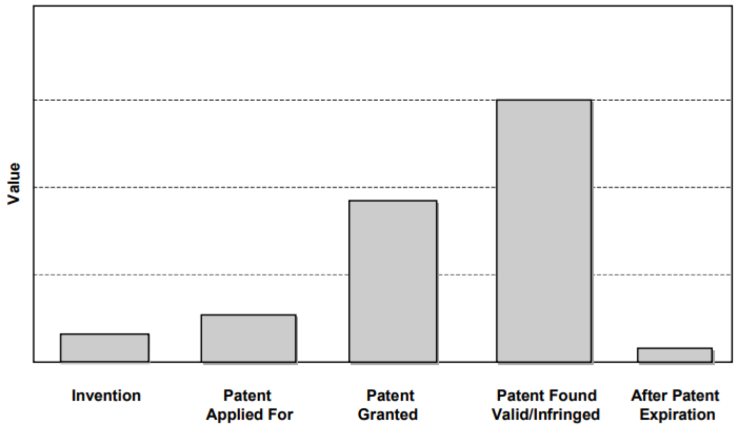

Figure 1. Value and stages of patent life reproduced from Sherry and Teece (2004)

After a patent has been validated, the innovator can appropriate most of the total rents arising from its commercialisation. When entering a market, startups often opt for selling the patent rights to the existing firm as a next strategy to obtain financial returns (Gans and Stern, 2000; Fumagalli, 2022). However, startup acquisitions may negatively affect not only the incentives to innovate but also the consumers' welfare due to competition suppression.

Literature concerning acquisitions involving patents suggests that they mainly occur in digital markets and pharmaceutical industries. Two types of acquisitions are highlighted: mergers or genuine acquisitions, in which the product or service keeps operating within the market; killer acquisitions, which describe the events where the acquiring firms seek to preempt future competition and keep their market share with their technology. In the latter, the acquisition is kept secret and does not reach the market.

Between 2010 and 2020, the five most dominant firms within the digital market (Google, Apple, Facebook, Amazon and Microsoft) acquired more than 400 firms. Some of these mergers are easily observed: i) Even before 2010, Google acquired Youtube in 2006; ii) Facebook acquired Instagram in 2012 and Whatsapp in 2014; iii) Microsoft acquired GitHub in 2018. 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).

Recently, in a competition talk provided by the Portuguese Competition Authority, Fumagalli (2022) suggested that Authority Agencies should introduce notification thresholds based on the acquisition value and not only on the market share owned by the acquiring firm. Remembering the Adobe and Figma acquisition, the acquisition price value should have a lower threshold since too many anti-competitive mergers are authorised.

As cited in Affeldt and Kesler (2021), the Authority Agencies in Germany have already had permission to intervene in abusive acquisitions since 2021. This intervention occurs based on the startup acquisition price.

Nowadays, innovation is considered a key driver of economic growth. Startup acquisitions by large incumbents are anti-competitive and negatively affect innovative incentives. According to Fons-Rosen et al. (2021), prohibiting startup acquisitions would increase economic growth by 0.03% per year.

The main objective of this dissertation is then to theoretically study the impact of a startup's product innovation degree and competition intensity on the incumbent's acquisition decision.

A three-stage game is played by an incumbent and a potential entrant described as a startup. The startup plays first, either investing in R&D or doing nothing. 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. After the patent has been approved, the product innovation achieves its maximum value (Figure 1), 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 decide between merging with the startup, making a killer acquisition, or allowing the startup to enter the market. In the last stage of the game, and after the startup entry occurs, both firms engage in Cournot competition.

This dissertation is structured as follows: Literature Review on the subjects approached within the proposed model in section 2; Model setup and description in section 3; Equilibrium profits and response to the main variables in section 4; Incumbent optimal acquisition solutions in section 5; Social welfare and consumer surplus analysis in section 6; Aggregate results and their limitations in section 7; Conclusions and future work in section 8.

2. Literature Review

This literature review seeks to summarise essential findings from the innovation games collection concerning the crucial aspects approached in the current dissertation. The section is divided into four subsections.

The first subsection presents which technological innovation is more attractive to a startup when penetrating a new market, followed by the second subsection, which reflects some findings on what fosters this type of innovation, namely competition and mergers that can be divided into horizontal and vertical integrations. The third subsection approaches the protection mechanisms adopted by an innovator, depending on its technological innovation and the life cycle of the protection mechanism in question. Finally, the last subsection relies on anticompetitive acquisitions described in the literature as killer acquisitions.

2.1. Technological innovation

Technological innovation is understood to be a product or process improvement which results in new technological features. This innovation category [4] is divided into product and process innovation. Each one is defined as:

1) Production innovation "is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics." (OECD, 2005, p.48);
2) Process innovation "is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software." (OECD, 2005, p.49).

In other words, product innovation is described as a mechanism to improve product quality and thus reduce product substitutability by differentiating it, whilst process innovation intends to reduce the production cost per unit to achieve more efficient processes. The latter is widely described in the literature as cost-reducing innovation.

According to Abernathy and Utterback (1975), which mainly covers industries where consumer preferences are homogeneous, firms tend to invest firstly in product innovation and then process innovation. They consider that product innovation is crucial for a firm entering a new market to fulfil the maximum demand possible and increase its profit since products must effectively match consumers' requirements. Klepper et al. (1996) confirm these findings since firms start acquiring new customers by

[4] The other category consists of the Non-technological innovations. According to OECD (2005), this category is divided into other two types of innovation: i) Organisational innovation defined as "the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations." (p. 51); ii) Marketing innovation defined as "the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing." (p. 49).

differentiating their products when entering the product market. On the other hand, cost-reducing investment is more attractive for firms in the later stages of the competition when they already own a significant market power (Cohen and Klepper, 1996). In that case, firms aspire to match their demand and maximise profits at the lowest possible marginal cost seeking to distance themselves from their competitors technologically.

A firm stops chasing product innovation and starts to pursue process innovation when the product market becomes more homogeneous. Hence, it cannot increase its desirable demand anymore, so the ride of product innovation decreases after achieving its maximum. The firm decides to reduce its operations' marginal cost by optimising its processes to increase profit. Reproduced from Teece (1986), Figure 2 shows the two phases mentioned before. The author describes the former stage as *preparadigmatic design phase* - “There is no single generally accepted conceptual treatment of the phenomenon in the field of study” (Teece, 1986, p.4) - and the latter as *paradigmatic design phase* - “It begins when a body of theory appears to have passed the canon of scientific acceptability” (Teece, 1986, p. 4).

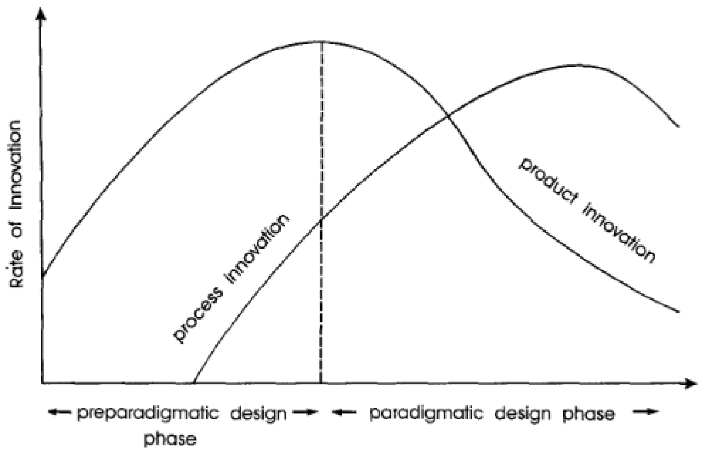

Figure 2. Innovation over the product/industry life cycle reproduced from Teece (1986)

Adner and Levinthal (2001) provide a different perspective from the conventional approach to steering technological innovations. They defend that firms do not necessarily invest firstly in R&D based on two different denominations for a potential new product: *new to the world* and *new to the market*. The first term is adopted when a product is new to the customers, so product innovation is more attractive because of the potential market that can be created or expanded. Alternatively, the second term is adopted when a new technology is introduced in a market where the old one is already known. In this case, the innovation becomes more limited over time. The only purpose of product innovation would be to obtain a larger share of customers, not significantly impacting firms’ profits. Therefore, reducing their production cost per unit would be more profitable, and firms would only proceed to product innovation after achieving process optimisation. In addition, this study meets the findings of Cohen and Klepper (1996), who state that the larger the firm, the more incentives it has to engage in process innovation.

Lambertini and Mantovani (2010) study the adoption of both product and process innovation, or only one of them, over continuous time through a differential duopoly game. A differential game, or a dynamic model, studies variables evolving throughout time according to differential equations. Their study is based on a Cournot and a Bertrand game with two stages each, wherein the two market leaders make their decisions simultaneously and compete in quantities or prices, depending on the type of game played. Beyond that, both firms produce differentiated products. In the first stage, players decide whether to invest in a product or process innovation (or both). In the second stage, they choose the quantity level or the products' price at which they desire to compete. The game can be played in one of four scenarios: 1) firms adopt both mechanisms of investment; 2) firms initially invest in product innovation and then decide whether to invest in both; 3) firms initially invest in process innovation and then decide whether to invest in both; 4) firms do not invest in either type of innovation. This study concludes that product innovation does not necessarily come first and then process innovation, stressing out the findings of Adner and Levinthal (2001). It demonstrates that the incentives for cost-reduction innovation are higher than product differentiation since spillovers resulting from product innovation promote imitation by direct competitors, jeopardising competitive advantage.

2.2. What fosters technological innovation?

2.2.1. Competition

The question of how competition affects the incentive to develop technological innovation emerges from a study conducted by Schumpeter in 1943. According to Schumpeter (1943), large firms play an essential role in concentrated markets in driving innovation since they possess high resources to invest in risky R&D projects and to build expertise to introduce successful new products into the market, replacing outdated ones. The author denominates this phenomenon as *creative destruction*. Therefore, following the author's perspective, innovation is fostered by market power, which also facilitates the absorption of innovation rents in circumstances where it is difficult to protect against potential innovations.

In contrast to Schumpeter's perspective, Arrow (1962) defends that markets with high competition and a large number of *neck-and-neck* firms (firms at the same technological level) are more prone to acquire a head start and escape competitive pressure through product innovation. The author describes this competitive escape as the *competition escape effect*. His study reveals that a firm has fewer incentives to innovate in monopolistic markets than in markets with perfect competition. Therefore, introducing new products in the market decreases the existing firm's profits. Concerning information and knowledge disclosure, the author states that both are easy to "steal" since inventors must share expertise with potential customers, who consequentially imitate the knowledge at little or no expense. As a result, inventors have difficulty obtaining returns from their innovations.

Regarding technological innovation, Aghion et al. (2005) combined the perspectives of Schumpeter and Arrow about the relationship between innovation and the intensity of competition, concluding that this relationship follows an inverted u-shape. Arrow's perspective dominates for low levels of competition since firms with the same technology level decide to innovate to distance themselves – *competition escape effect*, to maximise their profits. Once a firm can establish a significant competition distance and maximise its profit, the market becomes a monopoly. Then, the market leader does not have more incentives to innovate since its private return a future innovation, prevailing the Schumpeter perspective for higher levels of competition. Therefore, the incentives to engage in technological innovation are maximised for an intermediate degree of competition, where the sector in which firms are inserted is balanced.

Furthermore, Tang (2006) empirically studies the relationship between technological innovations and competition in the manufacturing sector, using sample data from the Statistics Canada 1999 Survey of Innovation. This study considers four types of competition: i) Easy substitution of products; ii) Constant arrival of competing products; iii) Quick obsolescence of products; iv) Rapid change of production technologies. The first three are primarily associated with product innovation, whereas the latter is connected with process innovation. The constant entry of new competitors with novel products and the quick obsolescence of products fosters product innovation, as new technology erodes profits from the existing firms. On the other hand, this quick obsolescence does not encourage firms to engage in process innovation since firms will benefit less from outdated technology. When it comes to the competition concerning the easy substitution of products, firms do not have incentives to develop product innovation since the expected profits would become uncertain. Finally, rapid change in production technologies is positively connected with process innovation because firms aim to be more efficient than their competitors, thus producing more and better at a lower marginal cost. His study meets then Aghion's (2005) perspective. It confirms that for low levels of competition, firms tend to engage in product innovation to gain a competitive advantage. For higher levels of competition, large firms with significant market power are more likely to engage in process innovation. Furthermore, it finds that rents resulting from process innovation are likely to be embodied in product innovation, thus proving that these two types of technological innovation are bundled.

As cited in Singh and Vives (1984), competition can be divided into two types: i) Cournot competition, where the strategic variable is the quantities set by firms (Cournot, 1838); ii) Bertrand competition, in which firms compete in price (Bertrand, 1883).

Singh and Vives (1984) suggest a duopoly model with product differentiation in a two-stage game. In the first stage, firms decide the strategic variables (to compete in quantities or prices), followed by the market competition stage. Concerning Cournot competition, they find that competing in quantities when products are substitutes is a dominant strategy because it softens competition and the price in equilibrium stills high. A high price charged to downstream customers increases the dominant firm's profit. On the other hand, when firms' products are complementary, firms can increase profits and customer surplus by setting different prices. These authors also stress the duality between substitutes and complementary products in Cournot and Bertrand competition, respectively. Although this research considers that a single product describes firms' output, it stills inspiring a rich ongoing literature.

The relationship between competition and innovation not only depends on whether firms are competing in quantity (Cournot) or price (Bertrand) but also on the type of technological innovation (product or process innovation). To understand how each type of competition affects the incentives to develop a technological innovation, Vives (2008) studies these relationships based on four key drivers: i) market size; ii) degree of product substitutability, iii) entry costs; iv) technological opportunity. Considering a free entry market, an increase in the number of consumers (market size) results in increased incentives to invest towards both product and process innovation, whereby the impact on product introduction is more likely due to a direct effect on a firm profit. The more the desirable demand is, the higher the private returns of a firm. These findings are consistent across both forms of competition. In addition, a free entry market may decrease the number of firms since the more firms invest in R&D to achieve process innovation, the less room is left for the new firms to enter. It becomes more costly to enter a new market when there is high progress in process innovation. Also, an increase in product substitutability degree positively impacts a firm's output level and cost-reduction investment. A more homogeneous product market leads to a more competitive market. Thus, there is less room for new product introduction (fewer incentives to develop product innovation). However, if the number of consumers expands with the increase in competition intensity, the benefits from the resulting increase in output level and cost-reduction investment would surpass a possible increase in the entry of new firms.

Regarding a restricted entry market, the author considers that an increase in the number of firms results in decreased incentives in investing in process innovation whilst increasing product substitutability degree has the opposite effect towards process innovation. On the other hand, in a more competitive market (high product substitutability), firms tend to increase their output level and escape competition by investing in more efficient processes, thus resulting in a lower marginal cost.

2.2.2. Horizontal integration

Mergers are still considered an important strategy concerning firms' growth (Sherer, 2006), and the primary purpose is to increase market share and profits by reducing operations costs and improving product quality.

Mergers may be classified as horizontal or vertical. The first term refers to the acquisition of a firm that operates on the same level of the supply chain, whilst the latter refers to the acquisition of a firm that operates upstream or downstream. This subsection presents a literature review related to horizontal integration, followed by a subsection which approaches the effects of vertical integration on the incentives to innovate.

Concerning product innovation, Federico (2018) studies the overall effects that a horizontal merger may have on a firm's intention to introduce a new product based on its market power. The author considers an oligopoly and presents a two-stage Bertrand game. In the first stage, firms simultaneously decide the level of R&D investment. In the second stage, firms independently set their products' prices according to the respective quality to maximise profits. The author considers that horizontal mergers affect innovation through *price coordination* and *innovation externality*. *Price coordination* leads to the suppression of price competition in the product market. With the decrease in competition, the merging firms increase their market power and hence the incentives to develop product innovation due to the Schumpeterian effect. Bearing that in mind, if, on the one hand, this channel has a positive effect on innovation, on the other hand, it harms the consumers' welfare because the more monopolistic the product market is, the less the consumers benefit from it. *Innovation externality* is related to the negative impact that innovation by one of the merging firms has on its merging partner's profits. The authors conclude that horizontal merging harms innovation. The negative effect caused by the innovation externality has a more substantial impact than the positive effect derived from the suppression of price competition.

Based on Federico's study, Gilbert (2019) studies the impact of mergers on the probability of discovering innovations accounting for the existence of information spillovers. Being the R&D projects independent and equally likely to succeed, firms can choose as many R&D projects as they want at a constant incremental cost of acquisition, and there are no profits at risk. Profits at risk are the profits lost by one merging firm due to the other merging firm's innovation. By not considering them, the mergers provide the same incentives for R&D investment as an industry with an N – 1 symmetric firm. The model consists of a two-stage Bertrand game played between N symmetric firms in two periods. In the first stage, they choose the investment in R&D simultaneously, and in the second stage, they compete in price, which is set according to their product's quality. The author concludes that mergers can foster innovation and increase consumer surplus if technological information spillovers benefit imitators or enable further innovations since the more competitive the market is, the more firms desire to outperform their competitors. The more the consumers benefit from it due to the price competition. This conclusion is similar to Arrow's perspective for *neck-and-neck* industries, where the competition escape effect is observed. Considering profits at risk, mergers reduce the incentives to develop product innovation, which meets the *innovation externality* described by Federico et al. (2018). However, if the Bertrand game is played over many periods, it is expected that a firm may reduce its investments in R&D after becoming a market leader with technological superiority (Vickers, 1986). In this case, the consumers' welfare decreases due to the decrease in price competition.

Contrary to Federico (2018) and most authors who also discuss this topic, Motta and Tarantino (2017) study the impact of horizontal mergers on investments but do not address product innovation. They model a one-stage Bertrand game played simultaneously by more than two firms. The players compete in price and sell one differentiated product each. The model is based on a cost-reduction innovation, in other words, a firm invests the least possible to maximise its profits by decreasing the production costs per unit. Therefore, the players decide the price of their products and the cost-reducing investment in just one stage. Even though these authors only study the impact of mergers on investments, similar conclusions are reached compared to Federico (2018): for weak or no efficiency gains, horizontal mergers always negatively impact the investment in innovation and harm consumers' welfare. After a merger, both firms are pressured to increase their prices due to the market power effect. When a merged entity decreases its products' price, the demand of the other merged firm decreases too. Hence, both companies increase their prices and the total demand decreases. In turn, with fewer quantities sold, firms have fewer incentives to invest because the costs become higher than the returns. On the other hand, this study defends that mergers are pro-competitive only if they entail sufficient efficiency benefits to the merging firms.

Besides the firm’s incentives to develop technological innovation, mergers also affect the market's social welfare.

Kao and Menezes (2010) explore the effects of horizontal integration on social welfare, which is the sum of consumer surplus with the producer surplus when firms produce differentiated goods and compete in quantities (Cournot competition) and prices (Bertrand competition). The previous studies consider that firms produce homogeneous goods; therefore, their work extends those analyses by considering differentiated products. It considers two monopolistic firms, each one inserted in different sectors, that horizontally integrate with another firm. Under Cournot competition, the new entity derived from the merger can increase its profit since it can replicate the pre-merger performance and also shut down the production line associated with a higher cost of operation. Despite the consumer surplus loss due to the suppression of competition, the producer surplus increases significantly because of a more significant increase in profits, which enhances social welfare.

Nevertheless, this social welfare improvement is only possible since the cost asymmetry between the merging firms is large enough. When firms are under Bertrand competition, and bearing in mind that price competition is fiercer than quantity competition, the total social welfare decreases after a merger. Besides the decrease in consumer welfare due to the suppression of competition, firms benefit from less private returns due to the lower output level and the lower price charged to their consumers.

Nie (2018) study the willingness of firms to engage in horizontal integration under Cournot and Bertrand competition considering product substitutability. His study presents a two-stage oligopoly game, extending Andree’s (2013) research, which only considers a duopoly. In the first stage, a firm chooses to engage in horizontal integration or not. In the second stage, the multiple market firms compete in quantity or price whether or not horizontal integration has occurred. After the game has been solved backwards, the author demonstrates that Bertrand competition is more severe both before and after the merger when compared to Cournot competition. Therefore, it implies that less competition leads to a stronger firms’ intention to develop horizontal integration since Cournot competition is more beneficial for the producer surplus than when firms compete in prices.

2.2.3. Vertical integration

In supply chains where firms are not vertically integrated, they suffer adverse effects from double marginalisation. For instance, consider a two-tier supply chain composed of a manufacturer and a retailer with market power. Double marginalisation occurs when the manufacturer prices its product above its marginal cost to the retailer to increase its private returns. In turn, the retailer again prices above its marginal cost when selling the product to downstream customers. Therefore, it is assumed in the literature that two vertical monopolies can be twice worse than one vertical integrated monopoly because of this double marginalisation effect.

Bearing that in mind, it is important to understand the incentives for firms to integrate vertically. There are three vertical integration strategies: i) forward integration when a firm involves in a downstream vertical integration owning and controlling ahead businesses in the supply chain; ii) backward integration, which holds the same purpose as the previous one, but in this case, the firm involves upstream within the supply chain; iii) no integration at all.

Lin et al. (2014) study which vertical integration strategy should a manufacturing firm choose in a competitive environment. The study is based on a three-stage game played by two supply chains under Bertrand competition. Each supply chain comprises an upstream supplier who can control the raw material quality and provide it to a downstream manufacturer who then produces the final product and sells it to its retailer. Finally, the latter sells the final product to the final customer. This model considers two periods; each period has different customers, with a decrease in demand in the second period. The game starts with each manufacturer choosing between one of the three following vertical integration strategies: i) forward integration, where the manufacturer sets the retail price itself by selling the product through its company stores; ii) backward integration, where the manufacturer expands its operations toward the source of raw materials and gaining then more control over the quality level; 3) no integration at all, where the manufacturer only controls the price charged to the retailer. The authors follow the perspective commonly present in the literature, which states that quality decisions are made before setting the product prices; in other words, upstream firms move first than downstream firms. Hence, in the second stage, suppliers or backward integrated manufacturers determine the quality level of the raw materials and then set the price to their downstream customers. Their study adds value to the existing literature because it considers forward and backward integration in three-tier supply chains, whilst prior studies only consider forward integration in two-tier supply chains. As a result, they first conclude that not integrating at all can be the equilibrium only if backward integration is not an available strategy. Secondly, they also conclude that a manufacturer chooses forward integration when a product quickly becomes obsolete with a decrease in demand in the second period since controlling the price charged to their consumers is crucial.

On the other hand, backward integration is more attractive to the manufacturer when its profits from an investment in R&D are low because of either the high investment cost or the low customer sensitivity. Regarding competition effects, the more competitive the market is, the more incentives the manufacturers have to integrate backwards, thus obtaining a competitive advantage through quality improvement (*competition escape effect* based on Arrow's perspective). Suppose both manufacturers decide to integrate forward; the price competition at the retail level increases, resulting in a price decrease and hence an increase in the consumers' welfare. The manufacturer charging a higher price to the final consumer suffers losses in the margin since the competitor charging the lowest price retains a more significant share of the demand. Conclusions about the best vertical integration strategy are challenging due to the many adverse effects of competition and operation factors. However, these authors argue that vertical integration results in a higher quality product sold at a lower price because it diminishes the effects of double marginalisation and stimulates investment in quality products.

Regarding the effects of vertical integration on the incentives to innovate, Liu (2016) studies whether to integrate or not when innovation is important vertically. To reach some conclusions, a four-stage game with perfect information is played in two distinct markets: an upstream and a downstream firm. The upstream inputs are homogeneous, and any firm may need to make a risky investment at each level. The game starts with the upstream firms choosing their R&D investments, followed by the decision of the downstream firms concerning the same topic. In the third stage, if the upstream and downstream firms invest successfully, they start bargaining for supply conditions simultaneously and with an equal probability of success. In the fourth stage, the final product market is achieved, and the competition in the downstream market determines the profits of both demands. Both markets have a unit demand; in other words, each customer buys only one unit of each product. The author concludes that vertical integration only benefits upstream and downstream firms when innovation is important at both levels. Otherwise, the firms prefer to stay vertically separated and may decide to appeal for outsourcing for more traditional technologies.

These findings clarify the two pathways in the pharmaceutical industry, where big pharma and biotech firms can choose whether to integrate R&D or engage in outsourcing activities. Billette de Villemeur and Versaevel (2019) confirm that outsourcing is more attractive to big pharma firms since they can transfer the risks arising from investments in the early R&D stages to external firms with the capabilities and the ability to incorporate technological externalities. On the other hand, small biotech firms face costly and risky investments in most of the R&D stages due to the high failure rate in the downstream firms' processes. Knowledge and technology transfer becomes difficult to assimilate when firms are disintegrated. According to Grabowski (2012), merging with or acquiring larger and more experienced firms is the more beneficial strategy because of the economies of scale and scope, and the technology transfer helps improve their processes' efficiency. In addition, most of these mergers and acquisitions stem from existing company alliances.

More recently, Lin (2020) aims to study the effects of a vertical market structure on the incentives of suppliers and their customers to introduce a novel product innovation in the market and what strategies the affected firms would adopt to face the emerging threats. This study considers a two-stage game with three players: one monopolistic supplier and two producers that initially produce differentiated products and buy the required raw material from their upstream supplier. In the first stage, one of the producers decides whether to innovate or not. In the second stage, if the producer successfully innovates, it competes with its upstream and downstream suppliers. Successful innovations are described as introducing products with a quality improvement (product innovation) or equivalent at a lower production cost per unit (process innovation). The game is played under two different market structures: i) Vertical separation, wherein all the three firms are independent and therefore vertically separated; ii) Vertical integration, which considers that the supplier and one of the producers are vertically integrated into a new entity. Given the first scenario and that one of the producers successfully innovates, the industry market structure changes to vertically integrated. Since the producer no longer needs to buy the old raw material from the existing suppliers, it enters backward into the upstream market. When it comes to the second market structure, if the nonintegrated producer innovates, its product outperforms the product produced by the new entity and, therefore, starts a new production line. Hence, the new entity stops its production of raw materials and ends up being a downstream firm, whilst the nonintegrated producer integrates backwards. The main finding of this study is that the incentives of an integrated firm for technological innovation decrease, whilst the nonintegrated downstream competitor firm incentives for this type of innovation increase, seeking to surpass the new product. This finding aligns with Arrow's (1942) perspective on the concept of the *competition escape effect*.

2.3. Intellectual Property

According to WIPO, IP is divided into two categories concerning property rights: i) formal IP, which includes patents, trademarks, designs, and copyright, being the first three subjects of an application for registration, whilst the latter does not need to be registered; ii) informal IP such as trade secrecy, lead time, complexity and first mover advantage. Formal IP encourages firms to innovate, assuring that they will appropriate most of the profits from their successful innovation by excluding rivalry from imitating it for a finite period. This financial benefit handles Arrow's (1962) perspective regarding the problem of appropriability, which is present in the generation of knowledge. Whilst there is innovation disclosure when dealing with formal IP, the invention becomes unobservable or partially observable by third parties with informal IP.

Hall et al. (2014) summarise the main findings from both theoretical and empirical surveys (e.g., Levin et al. 1987; Cohen et al. 2000) related to the decision of what innovative manufacturing firms should adopt protection mechanisms. Based on their study, it is observed that manufacturing firms are more likely to rely on patents when they develop product innovation. On the other hand, they are more prone to keep their inventions secret when it comes to process innovation. Although their study concludes that lead time (an informal appropriation mechanism that refers to the time required to execute an operation process) comes out as the more attractive appropriation mechanism, hereafter, in this literature review, the focus is on patents since this dissertation seeks to study the impact of product innovation. In turn, appropriation is a firm's ability to integrate its technological knowledge and appropriate rents arising from innovation.

2.3.1. Patent

A patent consists of the invention disclosure through a codification of rights to prevent third parties from imitating or using what is covered for a finite period of 20 years. It is the most commonly used appropriation mechanism by scientists for technological innovations (Poticha and Duncan, 2019). A key note to point out is that an invention is only eligible for patenting if it is nonobvious and fulfils the novelty requirement established by the country's Patent Office, taking into account everything that has already been published or commercialised before the date of filing. Otherwise, according to Scotchmer (1996), granting patents for an invention based on existing knowledge with noticeable results may decrease incentives for new inventors. On the other hand, the rate of technological growth may be slowed down. Besides being in charge of ensuring that the invention to be patented is *new to the world*, the corresponding country's Patent Office may also help to promote investment in R&D (Jaffe and Lerner, 2004). To sum up, patent rights must only be granted for *new to the world* technological innovations.

Based on Cohen et al. (2000), an empirical survey administered to 1478 R&D labs in the U.S. manufacturing sector in 1994, the main reasons why firms do or do not patent are set out below.

Bearing in mind the concept of a patent, it is easy to understand that the two main purposes of a patent are: i) to prevent rivalry from imitating the invention; ii) to prevent third parties from commercialising the same invention from inventing around the patent. Kwon (2012), which aims to study the firms' willingness to patent their inventions, describes both reasons as defensive exclusion and offensive exclusion, respectively. The offensive exclusion approach is related to the technological territory claimed and covered by a patent, defined as patent breadth. For instance, if the patent breadth is too narrow, it will not prevent third parties from inventing around the patent and taking advantage of it without violating it. Also, patents may be necessary when commercialising the invention, reinforcing the firms' position in negotiations with potential buyers.

Nonetheless, firms face significant challenges when applying for this type of IP protection. Firstly, firms find it very difficult to prove the novelty of an invention to prevent prior inventions from being patented again. Secondly, the costs associated with the patent application and with its defence when challenged in court sometimes cannot be sustained by startups with an ineffective investment in R&D. Another major problem of this formal IP is the end of the 20-year patent life from which the competitors can quickly imitate and to benefit from the invention, due to the complete information required by the patent application. On the other hand, this knowledge spillover helps a new inventor acknowledge what has been published or sold. Last but not least, the technological territory claimed and covered by a patent is a problem for the inventors, too, since it is easy to invent around a patent with a narrow breadth and to overlap with existing patents.

As mentioned in the introduction of this section, the surveys studied by Hall et al. (2014) find that firms are more prone to protect their product innovations by applying for a patent. They prefer to reveal information about the invention related to the product and keep it secret when it is associated with the process. Moreover, product innovations usually meet the novelty requirement for patenting and are, on average, more valuable, dominating the costs associated with their application.

Nonetheless, the reasons why manufacturing firms decide to patent their product innovations vary depending on the output type. Defensive exclusion is why the manufactured products are distinct and easy to count and face substitutes, which is the case of pharmaceutical industries. When it comes to complex products, such as packages and menus, as with telecommunication industries, firms patent their invention aiming the offensive exclusion and thus forcing the beginning of negotiations between both parties (Cohen et al., 2000). These agreements are one of the paths for inventors to appropriate the profits resulting from a patent application.

2.3.2. Patent validity challenge

After a patent has been successfully granted as the IP protection mechanism, the validity of its technological territory covered and claimed may be directly challenged in the Patent Office or the courts or indirectly challenged by its competitors at a trial for infringement. After being challenged, a patent can either be revoked or the technological territory can be adjusted.

Cyranoski (2004) states that the claimed technological territory of around 80% of all the 6% well successful patent applications in the European Patent Office (EPO) is adjusted after being directly challenged within a period of nine months. Concerning the patents granted by the United States Patent and Trademark Office (USPTO), more than 75% of all the patents directly challenged ended up with their scopes amended.

However, not all patents are directly challenged by the concerned Patent Office because it entails some high costs. Aiming to study how much time and money should be spent by the Patent Office examining a patent, Lemley (2001) confirms the previous statement. According to Schuett (2013), these costs connected with the examination of patent applications are described as patent policy, and it emerges from the combination of the application fee and how rigorous the examination is.

It is intended to reach the same result as the innovation being imitated. Besides that, the patent breadth to be examined depends on the country where it is analysed due to a legal rule defined as the doctrine of equivalents which extends the rights claimed and covered by the patent beyond the literal sense of the competing product or process innovation providing the very same result. For instance, Bond and Zissimos (2017), to study how the national governments can benefit from a standardisation between them concerning what is meant by patent breadth, find that the doctrine of equivalents in the United States of America (U.S.A) considers that an infringement has occurred when the competing product or process innovation performs simultaneously the same function, with the same process. Another example is that whilst Germany applied the same doctrine of equivalents as the U.S.A, Japan and the United Kingdom (UK) decided not to apply any doctrine of equivalents, resulting in a narrower patent breadth in these countries (Ralston, 2007).

Defining a patent breadth becomes a strategic decision since patents are more likely to be challenged by the Patent Office or in courts by claiming the maximum technological territory possible (Yiannaka and Fulton, 2006).

Concerning a drastic product innovation, Yiannaka and Fulton (2006) study the decision on what is the optimal patent breadth when the innovator faces a possible entry of a greater quality product and direct validity challenges. The model is based on a three-stage game wherein a potential new entrant, and an incumbent competes in prices in the last stage. In the first stage, the country’s Patent Office grants a certain patent breadth to the innovator. The second stage consists of the entrant's decision between entering or not the market, taking into account that this new potential competitor can observe the new technology since it is made at the product level and due to the knowledge disclosure by the patent application. If the entry does not occur, the existing firm keeps operating as the sole innovator in the third stage and, thus, benefits from the monopolistic profits. Otherwise, the new competitor may decide on the quality of its product to enter the market and, as a result, if an infringement of the existing patent occurs. If infringement does not occur, the existing innovator and the entrant compete in prices.

On the other hand, if infringement occurs, the validity of the existing patent application is challenged by the Patent Office. At least, whilst entry does not occur if the patent is valid, it does occur, and both firms compete in prices if the existing patent is invalid. After the game has been solved, the authors conclude that the patent breadth that maximises the appropriation of innovation profits depends mainly on the entrant's investment in R&D and the likelihood of the existing patent being directly challenged. The potential entrant firm is only prevented from entering the market if the costs to incur in a trial are significantly high and if the outcome stemmed from the investment in R&D is not very reliable. When entry deterrence is not possible, a patent breadth claiming and covering low technological territory is the most chosen by the existing innovators. This choice leads to low incentives for the entrant to infringe the existing patent and to a more differentiated product market, thus economically benefiting both firms.

Regarding the possibility of drastic process innovation to face a direct validity challenge by non-competitor entities or by new competitors that may enter and infringe the patent, Yiannaka (2009) study the optimal patent breadth that allows the existing firm to maximise its ability to appropriate its innovation financial returns. Also, it studies the entrant's incentives to develop a novel process innovation, thus not infringing the existing technology. It is then based on a four-stage game with perfect information played by an incumbent monopolistic firm and a new potential entrant. The game begins with the existing firm choosing the patent breadth of its process innovation, followed by the possibility of being directly challenged by a third party and thus being revoked or requiring an adjustment in the technological territory covered and claimed. The third stage is played by the entrant and consists of deciding whether to enter. Suppose the entry succeeds in the scenario where the incumbent's patent has been amended or not even challenged. In that case, the new competitor chooses between developing a novel process innovation and infringing the existing firm's patent.

On the other hand, when the patent of the incumbent is revoked, the new entrant enters the market using the existing firm's process technology. This study concludes that the incumbent's patent breadth of its invention is negatively related to the entrant's incentives to develop a non-infringing process innovation. The more the technological territory the existing patent covers, the more the new entrant has to invest in R&D to enter successfully without committing any infringement. Also, to prevent the entry of a new competitor without being directly challenged, the incumbent aims to maximise its profits appropriation by claiming the smaller patent breadth possible.

A further study conducted by Yiannaka and Fulton (2011) concerning the relationship between the ability of an innovator and the decision of its innovation patent breadth concludes that claiming as many as possible patent rights is an optimal strategy under some conditions, such as the inability to prevent the entry of a new competitor and if the entrant considers it optimal not to infringe the existing patent. However, due to the assumption of perfect information, Yiannaka and Fulton (2006) and Yiannaka (2009) state that claiming the maximum patent breadth is never an optimal strategy when the entry of a new competitor occurs since the incumbent may easily detect the infringement.

In line with Yiannaka (2009), a patent with a narrower breadth allows firms providing a new output to enter the market, thus increasing the intensity of competition. On the other hand, Nordhaus (1969), since the very beginning, states that covering a large technological territory leads to a more monopolistic market by excluding new inventors from entering the market. Besides that, they cannot support a lower price, and unlike the existing firm, the investment required to develop a non-infringing innovation becomes costly. This finding meets the conclusions of Yiannaka (2009) and reinforces the results of Judd (1985), who concludes that patent protection relates to product innovation through an inverted-U shape.

2.3.3. Patent commercialisation

A patent or other appropriation mechanism allows the innovator to appropriate rents arising from its IP. According to Poticha and Duncan (2019), there are three main reasons to adopt one. As mentioned above, firms intend to patent their creative ideas to exclude other parties from imitating and using them, defensive exclusion and prevent rivalry from inventing around the technological territory covered, offensive exclusion. Following the defensive exclusion perspective, the patent owner can produce and sell a differentiated product and thus benefit from the invention by excluding the old technology, which meets the *creative destruction* argued in Schumpeter (1943). Regarding the offensive exclusion point of view, the patent holder can provide a licence to others trying to find gaps and invent around the patent. A licence allows third parties to perform the invention patented in exchange for financial returns. Also, a patent is more likely to be sold if the innovation is a tangible asset that can be traded without harming firms' operations and creating competition, which is not the case for process innovation. In addition, cross-licences are very common in the technological world due to the patent overlapping, which is not exact due to the novelty required by this formal IP. Last but not least, a more direct and rapid option to commercialise a patent is selling rights and technology knowledge transfer related to the new technology.

Startups often obtain economic gains when entering markets through these negotiations and resultant agreements with the existing monopolistic firms (Gans and Stern, 2000). This collaborative mindset sharply contrasts with the Schumpeterian perspective, which argues that new entrants may only acquire an advantage over incumbents after overturning their technology.

Seeking to study the relationship between an incumbent monopolist and a startup under an innovation race, Gans and Stern (2000) propose a two-stage, in which the first stage consists of an R&D competition where each player can innovate at any time. If the incumbent innovates first, the entrant firm does not have more incentives to keep its research due to the distance between the respective market powers. Hence, the incumbent keeps its monopoly in the product market, and the game ends. On the other hand, if the entrant innovates first, the game proceeds to a second stage, where both players can cooperate and reach an agreement by licensing the innovation. The incumbent monopolistic then acquire the startup innovation. In this case, the bargaining power depends first on the capability of the entrant to impose competitive costs on the incumbent entering the product market and second on its ability to protect the IP against the incumbent's intention to expropriate the startup's technology.

Additionally, the entrant can choose a more dramatic strategy and immediately compete with the existing firm in the product market. This scenario can also occur if the incumbent keeps its research whilst bargaining is in progress. Regarding the licensed activity, three main aspects are considered: i) if there are gaps in IP rights, the incumbent has strategic incentives to invest in imitative R&D to increase its bargaining power; ii) the maximum price that each player would be willing to pay to acquire the innovation immediately, being the license fee for the entrant and the difference between *pre* and *post*-innovation profits, as known as rents, for the incumbent. Whenever the incumbent's willingness to pay is higher than the entrant's, the first may invest in R&D more intensively; iii) in the second stage of the game, the startup's innovation is considered a strategic substitute for the incumbent R&D when the licensing fee is low. Finally, the authors based their conclusions on two Schumpeterian questions about the relationship between innovation and entry: how both firms differ in their incentives for investment in R&D and what is the impact of technological change on market structure. Bearing in mind the first question, each firm's willingness to pay for successful innovation stems from the contrast between the license fee and the rent earned by the incumbent after innovating. Regarding the second question, in the absence of knowledge spillovers, there are strong incentives for a licensing solution to keep a monopoly since startup innovators cannot significantly increase their profits by competing with existing firms in product markets.

The nature of technology is divided into: i) the technological innovation developed by the innovator; ii) codified knowledge; iii) tacit knowledge, which is connected with the innovation know-how (Teece, 2006). Technology knowledge transfer when commercialising a patent via licencing or outsell rights is not only an important step for the acquiring firm but also very difficult to accomplish. Even though the technology knowledge is successfully transferred, the innovator owns a competitive advantage due to the wisdom and insights acquired through personal experiences denominated as tacit knowledge or innovation know-how. It is, therefore, implicit and is only transferable after it has been codified and explicitly stated, attempting to make the third party fully understand. The tacit knowledge transfer process entails an absorptive investment, which becomes more costly than starting an entrepreneurial business involving startup expenses and profit losses from competing with incumbents.

Based on the model that Gans and Stern (2000) suggest, Spulber (2012) studies the impact of tacit knowledge when choosing between being an innovative entrepreneur and transferring technological knowledge to a third party. The author models a three-stage game with perfect information that presents strategic interactions between an innovator and an existing firm in the market. This study differs from the previous one in the following aspects: i) the inventor's tacit knowledge is considered; ii) only the inventor can invest in R&D, which emphasises the importance of tacit knowledge in this game; iii) the invention only belongs to the inventor, who consequentially owns the right to it. In the first stage, the innovator and the incumbent decide the level of R&D investment and absorptive capacity, in other words, appropriability. In the second stage, the players choose between competing or collaborating through knowledge transfer. In the last stage, the market can follow two paths: if cooperation between both happens, the incumbent firm absorbs the knowledge resulting from the investment done and initiates its production; otherwise, the new firm enters the market and starts competing with the existing firm. This study concludes that tacit knowledge held by the inventor is important because it can give competitive advantages that outperform the ones obtained by the incumbent firms through complementary assets. These competitive advantages arise from the lower price set by the innovative firm due to creative destruction (Schumpeter, 1943). The lower price charged to firms' consumers leads to an increase in sales, and hence profits generated from the own-use inventions increase, overcoming the economic returns of the incumbent. The inventor then becomes an innovative entrepreneur.

2.4. Killer acquisitions

Within patent commercialisation, acquisitions (which can be divided into mergers/genuine and killer acquisitions) are becoming a central concern to the Authorities Agency. Contrary to mergers or genuine acquisitions (as some authors describe them), a killer acquisition consists of keeping the new technology acquired secret to preempt future competition. The acquiring firm maintains then its market share after incurring acquisition costs, which are equal to the expected financial reward required by the innovator to outsell his patent rights. According to the literature, killer acquisitions mainly occur between firms at the same supply chain level, which means these acquisitions are interpreted as horizontal integrations.

To understand a startup's incentives to invest in R&D and hence its willingness to sell the resulting product innovation, Norbäck et al. (2014) model a three-stage game with an entrepreneur and an incumbent. It considers a locked initial user base associated with the existing firm product. In the first stage, the startup invests in R&D towards product innovation, and in the following stage, it decides whether to sell or not its innovative product. If it decides not to sell it, firms engage in Cournot competition and decide its output level. What the incumbent expects with the acquisition is to preempt future competition, and thus it is described as a killer acquisition. Their model stresses that the startup's incentives to innovate increase with its ambition to obtain the highest financial reward possible from selling the innovation to an existing firm.

As mentioned before, innovation is considered a key to economic growth. Since startup acquisitions by large incumbents are anti-competitive and negatively affect the incentives to innovate, Fons-Rosen et al. (2021) present a four-stage model to study the quantitative impact of acquisitions on economic growth. The game is played by a startup and an incumbent under Bertrand competition. In the first stage, the startup invests in R&D and comes up with an innovative project, followed by a negotiation stage. If the incumbent does not acquire the new project, the startup decides to either develop it and enter the market or do nothing. If acquisition occurs, the incumbent decides to implement the new project in its operation or keep it secret. The author concludes that by prohibiting startup acquisitions, economic growth would increase 0.03% per year.

Bryan and Hovenkamp (2020) question if there should be limits on startup acquisitions by dominant firms. They model a two-stage game with two incumbents and a single startup. One of the incumbents is a leader, and the other is the lagger. In the first stage, the startup decides to either provide nonexclusive licensing or sell its innovation. A nonexclusive licensing allows the patent holder to keep benefiting from a private return associated with its innovation. The acquiring firm may license the startup innovation to its competitor in the following stage. Their study concludes that to obtain the higher financial reward possible, the startups invest in R&D to innovate towards the incumbent with more market power since it owns higher resources to sustain a higher acquisition cost. After the killer acquisition has occurred, the acquiring firm starts to benefit from a monopoly profit and then the incentives to purchase future innovations decrease. These authors suggest that the Agency Authorities should apply antitrust policies to mitigate these problems.

Based on the strategic investment intensity in R&D by startups and incumbents, Letina et al. (2021) examine the acquisition and patent commercialisation within two policies: *(A)* enables acquisitions; *(B)* acquisitions are not allowed. A four-stage game is then played by an incumbent and a potential new entrant under these two policies. In the first stage, both firms invest simultaneously in R&D towards product innovation and then engage in an acquisition negotiation. This second stage is not played under policy *(B)*. In the third stage, the patent holder decides whether to commercialise its product innovation and finally, if no acquisition occurs, firms engage in Cournot competition. They conclude that under a non-acquisition policy, the incumbent imitates the new product introduced to the market to avoid significant market share losses. Moreover, acquisitions may only occur when the entrant's innovation is not considered very strong on its own.

Cunningham et al. (2021) theoretically and empirically prove that killer acquisition may only occur to preempt future competition and that the acquiring firms do not expect to appropriate rents with these product acquisitions. The theoretical model is focused on a two-player game with an incumbent and a startup. In the first stage, the incumbent decides between acquiring the potential entrant project, and then the project owner decides whether or not to develop the innovative project. As project, the authors refer to a potential innovative product that has not already been developed. The empirical study is based on pharmaceutical data provided by Pharmaprojects. This dataset keeps all the candidate drugs developed or during the stage of development before entering the US market. The sample includes projects that initiated their activity between 1989 and 2010, emphasising ongoing development projects, totalling 16015 projects introduced by 4637 pharmaceuticals. It concludes that drug projects are unlikely to be developed in monopolistic markets when the startup product innovation project overlaps with the existing firm product. Therefore, the incumbent decides to make a killer acquisition. In the US pharmaceutical market, killer acquisitions represent between 5.3% and 7.4% of the sampled data's total acquisitions.

Besides the pharmaceutical industry, the digital and technological market is another environment where acquisitions are likely to occur. Affeldt and Kesler (2021) empirically analyse the data related to the big tech acquisitions within the Google Play Store. They observe that half of the apps acquired are discontinued. For instance, the app's bugs are not fixed.

Between 2010 and 2020, the five most dominant firms within the digital market, Google, Apple, Facebook, Amazon and Microsoft, acquired more than 400 firms. Since the acquired firms do not shut down their operations, these acquisitions are described as mergers (Affeldt and Kesler, 2021). For instance, some of these mergers are easily observed: i) Google acquired Youtube in 2006; ii) Facebook acquired Instagram in 2012 and Whatsapp in 2014; iii) Microsoft acquired GitHub in 2018.

Even though these mergers negatively impact the incentives to innovate and cause a decrease in consumers' welfare due to the suppression of competition, they do not surpass the turnover threshold. Therefore, the Authority Agencies approve them.

Fumagalli et al. (2020, 2022) study the optimal merger policy from the incumbent's perspective when facing potential competitors, based on a three-stage model played by an incumbent, a startup and an Authority Agency. In the first stage, the startup invests in R&D, seeking an innovative project. The potential new entrant only develops the project if it owns the financial resources required. Otherwise, the project is not developed, and thus the startup never enters the market. In the second stage, if the startup has developed the project, the incumbent decides between acquiring the new product and shelving it (killer acquisition) or doing nothing, resulting in a competitive market since the new product is a substitute.

On the other hand, if the project is not developed, the incumbent decides between acquiring and developing the project or doing nothing. According to the author, the incumbent may prefer to do nothing due to the decrease in profit arising from the investment required to develop the project. In the third stage, the Authority Agency intervenes if the acquisition surpasses a threshold of harm defined by the entity. This is to say that this third party always conditionates the acquisitions. The author concludes that a killer acquisition may have negative and positive impacts. In a competitive environment where the startup can develop its innovative project, a killer acquisition may decrease competition and harm consumers' welfare. If the startup does not successfully develop the product, making a killer acquisition may be beneficial due to the ability to invest in developing the innovative project. Regarding the policy perspective, acquisitions connected with high acquisition costs are more prone to be prohibited. High acquisition costs are equivalent to stating that the startup would benefit from a high profit. Therefore, the competition intensity would increase with its entry into the market. Since the consumers' welfare would increase, the Authority Agencies should intervene to prohibit such acquisitions with a high value. On the other hand, acquisitions that occur when the startup cannot develop the project increase consumers' welfare and therefore are more likely to be approved.

Based on a simplified model provided by Fumagalli et al. (2020), Motta and Peitz (2021) seek to study the impacts of big tech mergers on competition intensity. In line with Fumagalli's studies, they conclude that some mergers are anti-competitive, thus harming consumers' welfare. They suggest the intervention of Antitrust Authorities in digital markets by redefining the threshold acquisition based on the acquisition price since this entity approves some anti-competitive mergers. For instance, some big tech firms acquire new startups that require a low financial return, equivalent to a low acquisition cost.

As cited in Affeldt and Kesler (2021), the Authority Agencies in Germany have already had permission to intervene in abusive acquisitions since 2021. This intervention occurs based on the startup acquisition price.

Table 1 summarises both theoretical and empirical findings concerning genuine and killer acquisitions.

Table 1. Killer Acquisitions

Author(s)	Model	Conclusions
Norback et al. (2014)	Two-player oligopoly with an entrepreneur and an incumbent. In the first stage, the entrepreneur invests in R&D, pursues product innovation and then decides whether to sell the innovation or not to the incumbent. In the third stage, firms compete in quantities.	Killer acquisitions are encouraged over entry under strong network effects; thus, the entrepreneurs' incentives to innovate increase.
Fons-Rosen et al. (2021)	A startup and an incumbent play a four-stage model. The startup discovers an innovative project in the first stage, followed by the negotiations stage. If the incumbent decides not to acquire the new project, the startup can develop the project or do nothing. The incumbent can implement or keep its new acquisition secret if an acquisition occurs. If startup entry occurs, both firms compete in prices.	Prohibiting startup acquisitions would positively affect economic growth by 0.03 percentage points per year.
Bryan and Hovenkamp (2020)	Three-player game with two incumbents (a leader and a lagger) and one startup. Based on a Cournot demand system, in the first stage, the startup faces the decision of providing nonexclusive licensing and selling its innovation. In the second stage, the acquiring incumbent may licence the startup innovation to its competitor.	Startups innovate towards the leading firm in the market since it owns a higher market power. The market becomes a monopoly after the dominant firm acquires the startup innovation. Then, the incentives to acquire future innovations decrease.

Letina et al. (2021)	Two-player product innovation game with an incumbent and an entrant firm played under two policies: *(A)* allows acquisitions; *(B)* does not allow them. In the first stage, both firms simultaneously choose their investment level and then they engage in negotiations. This second stage is not played under policy *(B)*. In the third stage, the patent holder (if any) decides whether to commercialise the innovation and lastly, in the last stage, firms compete à la Cournot.	In case of prohibition to acquire the startup innovation, the incumbent imitates it to prevent future competition. Moreover, acquisitions may only occur in rare cases when the entrant innovation is not considered very strong on its own.
Cunningham et al. (2021)	An empirical study based on pharmaceutical industry data. Two-player game with an incumbent ad an entrepreneur. In the first stage, the incumbent decides whether to acquire the new potential competitor innovation and then, the project owner chooses between developing or not the project. In the third stage, both firms compete in prices with differentiated products	When 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.
Fumagalli et al. (2020, 2022)	A three-stage game played by a startup, an incumbent and an Antitrust Authority. In the first stage, the startup invests in R&D, thus resulting in an innovative project. In the following stage, if the startup successfully develops the project, the incumbent can either acquire the innovative product and shelve it (killer acquisition) or do nothing and compete with the new entrant. Otherwise, if the startup does not have the financial resources to develop the project, the incumbent decides to acquire the project and develop the product or do nothing. In the last stage, the Antitrust Authority conditionates the acquisitions, that only occur if they fulfil the condition imposed by this third entity.	When the startup does not own the required financial resources to develop its innovative project, low price mergers increase consumers' welfare and, thus, are less likely to be prohibited. On the other hand, Authority Agencies are more prone to intervene when the acquisitions entail a high cost.

Motta and Peitz (2021)	A simplified Fumagalli's model mentioned above.	Young startups with potential inventions are viewed as cheap targets by big tech firms. Due to the low acquisition price, big tech anti-competitive mergers are investigated and approved by the Authority Agencies. The Authority Agencies should redefine the threshold acquisition price.

3. Model

This dissertation presents 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. After the patent has been approved, the product innovation achieves its maximum value (Figure 1), 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 dissertation states that a merger will also be described as a genuine acquisition.

Section 3 is divided into two subsections. The initial model setup is presented in the first subsection, followed by the model description in the second subsection, where each stage and subgame are described along with the outcomes combinations.

3.1. Model setup

This theoretical model involves two manufacturing firms: an incumbent (I), which operates as a monopolistic firm, and a startup (S) which possibly comes up with product innovation. Both firms aim to maximise their profits. Henceforth the subscripts I and S refer to the incumbent and the startup, respectively.

In this dissertation, both firms operate under Cournot competition based on the linear demands 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 $i \neq j$:

1) If $i = S$, then $k = i$;
2) If $i = I \wedge \gamma \neq 0$, then $k = i$;
3) If $i = I \wedge \gamma = 0$, then $k = \{S, I\}$.

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

The Cournot competition effect can be easily observed since when the output level of firm j increases, the output level of firm i should decrease not to push price down too much, thus meaning that firms' quantities are strategic substitutes.

Contrary to Singh and Vives (1984), this dissertation considers a symmetric marginal cost $c = 0$, which is a very common assumption within the technological market where several startups emerge. Therefore, the above equation (1) represents each firm's price net marginal cost., which must be strictly positive ($p_k > 0$, for $k = \{S, I\}$).

Based on Adner and Levinthal (2001) and Figure 2 reproduced from Teece (1986), mentioned before in subsection 2.1, it is assumed that the potential new entrant invests in R&D towards product innovation. It states that firms tend to invest firstly in product innovation to achieve the highest market share possible when penetrating a new market with a *new to the world* innovation.

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, and hence the higher will be the firm's profit. 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 $k = \{S, I\}$).

Nonetheless, $\gamma \in [0; 1]$ 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 ($\gamma = 1$).

3.2. Model description

This subsection presents a more detailed description of each game stage composed of the following three stages: 1) Investment stage; 2) Acquisition stage; 3) Market competition stage. Moreover, it states all the assumptions made throughout this dissertation and summarises each player's order of moves and the possible outcomes combinations.

Recalling what is written at the beginning of section 3, this model consists of a three-stage game played under Cournot competition based on the linear demand suggested by Singh and Vives (1984). The game is played by an incumbent and a startup, where the latter intends to develop non-drastic product innovation and enter the market successfully. Once more, Cournot competition means that firms compete in quantities of substitute products, so when the output level of one firm increases, the optimum response of the other's output level is to decrease and vice-versa (quantities are strategic substitutes). Each stage is then described by:

1) **Investment stage:** S decides whether or not to invest in R&D. If S successfully innovates ($R\&D$), it files a patent application in its country's Patent Office to protect the product innovation. After the patent has been granted and approved, S enters the market. Otherwise, it does not enter the market, and it gets zero profit ($NR\&D$). When S files a patent application, it pays a patent fee which is considered a sunk cost since it is unrecoverable. As a result, it is not taken into consideration in future decisions. Also, it is considered an entry cost associated with setting up a new firm. Based on Norback et al. (2014), the entry cost is assumed to be zero when S succeeds in the investment stage and sufficiently high to prevent its entry when failing in this same stage.
2) **Acquisition stage:** After a patent application submitted by the startup has been validated, I negotiates the product innovation acquisition with S. If a killer acquisition (KA) or a genuine acquisition (GA) occurs, S does not enter the market, and I keeps benefiting from monopoly profit. The main difference between these acquisitions is that in the former, the acquiring firm keeps the acquired product secret to preempt future competition; in the latter, the acquiring firm shuts down the production of the existing product with quality a_I and starts producing the innovative one with quality a_S. On the other hand, if none of the acquisitions occurs (NA), S enters the market whose structure changes to a duopoly. If S is acquired, it benefits from a financial reward which is equal to the profit which it would benefit from competing with I under a duopoly market structure (its reservation price). The startup financial reward is equal in both types of acquisitions. Following the same reasoning, this financial reward is also described as the acquisition cost from the incumbent perspective when acquiring the potential new entrant. In this dissertation, it is assumed that when S files a patent, the knowledge transfer rate associated with its acquisition is equal to 100%. I can then appropriate the total rents arising from the innovative product acquired.
3) **Market competition stage:** The game moves to the third stage in case the incumbent decides to do nothing (*NA*) in the acquisition stage. As a result, firms engage in Cournot competition. As S patentees its product innovation, to imitate the new product enhancements introduced to the market is considered an infringement by the courts. Then, the incumbent and the startup produce and commercialise an output with product quality corresponding to a_I and a_S, respectively.

Within this dissertation model, not to patent the product innovation is never an optimal choice for the startup because the innovator would be subject to a possible imitation. Even though the imitator cannot make a perfect imitation of the new product introduced to the market, the startup would suffer profit losses. By imitating the new product, the incumbent could operate with a greater product quality than the existing one. Thus, it would obtain a greater desirable demand. The startup demand would decrease and then benefit from a lower profit compared to the event where it decides to patent its IP. For this reason, in this dissertation, it is assumed that the innovator obligatorily patents its product innovation after successfully investing in R&D (dominant strategy).

Each stage of the game has already been described. Figure 3 shows the corresponding game tree. It allows a better organisation and consequent visualisation of the order in which each firm moves together with the expected outcomes in equilibrium. Since it is a profit-maximising game, the expected results can be translated into each firm's profit.

Hereafter, in this dissertation, 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.

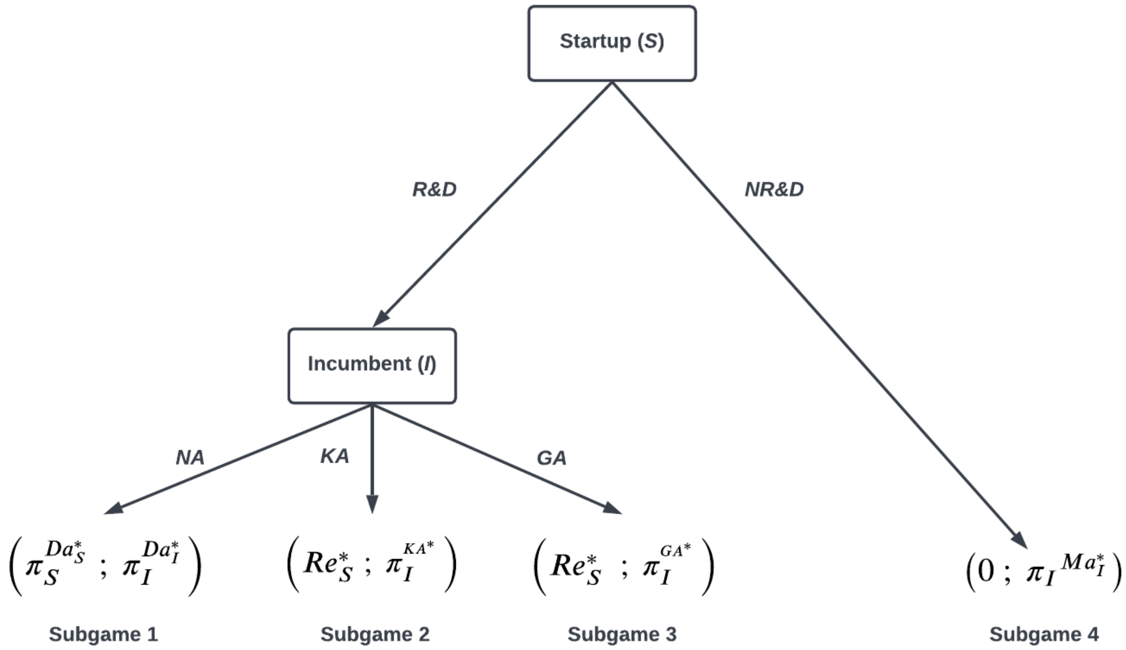

Figure 3. Killer acquisition game - Incumbent vs Startup

As mentioned in the description of the third stage of this game (acquisition stage), even though the startup does not enter the market after negotiating its product innovation with the incumbent, the startup benefits from a minimum financial reward when negotiating its product innovation with the incumbent. This financial reward is equal to the expected profit the startup would benefit from competing with the existing firm with different product qualities in a duopoly (subgame 1).

From Figure 3 and summarising all possible subgames and the respective outcome combinations, this dissertation presents Table 2. The first column shows each subgame, the following column contains each subgame description, and the last column gives the firm's expected profits in equilibrium for each subgame: i) Subgame 1 *(R&D, NA)*; ii) Subgame 2 *(R&D, KA)*; iii) Subgame 3 *(R&D, GA)*; iv) Subgame 4 *(NR&D)*. The last subgame may also be described as subgame 2 if the startup fails in the investment stage (first stage). The author of this dissertation 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.

Table 2. 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 with 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 $\pi_I^{Ma_I}$.	$\left(0 ; \pi_I^{Ma_I*}\right)$

Nevertheless and before proceeding to the following section, it is important to bear in mind some crucial assumptions made within this model:

1) Profits are non-negatives (≥ 0), and monopoly profits are strictly positive (> 0);
2) The fixed cost of filing a patent is considered as being a sunk cost, and thus, it is not taken into account for future decisions;
3) There is an entry cost associated with setting up a new firm, which is assumed to be null when the startup enters the market and sufficiently high when its entry does not occur;
4) 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;
5) The startup protects its IP using a patent because it is a product innovation. In this dissertation, it is assumed that there are no spillovers, and then the innovator can appropriate the total rents arising from its product innovation when competing in a duopoly;
6) Imitation is an infringement since the innovator protected its IP by patenting it. Firms engage then in Cournot competition when the incumbent decides to do nothing in the acquisition stage;
7) If the startup fails to innovate successfully in the first stage or the incumbent acquires it in the second stage, it does not enter the market. In the former case, it gets zero profit; in the latter, it benefits from a financial reward equal to the profit it would benefit from competing in a duopoly market with the incumbent. Moreover, this startup financial reward is considered as the acquisition cost from the acquiring firm perspective;
8) In the second stage, the incumbent only chooses to make a killer or genuine acquisition if and only if its total profit increases, thus implying that to make an acquisition, conditions (2)(3) must be fulfilled:

$$\pi_I^{KA^*} = \pi_I^{Ma_I{}^*} - \pi_S^{Da_S{}^*} > \pi_I^{Da_I{}^*} \tag{2}$$

$$\pi_I^{GA^*} = \pi_I^{Ma_S{}^*} - \pi_S^{Da_S{}^*} > \pi_I^{Da_I{}^*} \tag{3}$$

9) The incumbent can appropriate the total rents stemming from the new product acquired when it decides to merge with the potential new competitor;
10) The startup requires the same financial reward whether the incumbent makes a genuine or a killer acquisition. Also, the incumbent faces an equal acquisition cost (acquisition price plus implementation costs) in both genuine and killer acquisition due to a perfect technology knowledge transfer;
11) As mentioned in the literature review section, competition erodes monopoly profits due to price competition and market share losses. Then, monopoly profit gained by I when producing and commercialising its product is higher than duopoly profit when competing with the startup and keeping operating with its technology ($\pi_I^{Ma_I{}^*} > \pi_I^{Da_I{}^*}$).

Using the 13th version of the mathematical software named "Wolfram Mathematica" allowed to simplify the mathematical expressions and plot the relevant graphs in the following sections. As the aim of this dissertation 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).

4. Profit maximisation and response to main variables

In this section, not only each subgame perfect Nash equilibrium will be calculated, but also each profit in equilibrium depending on the existing product quality (a_I), on the innovative product quality (a_S), and finally, depending on the product differentiation degree (γ) will be studied. Therefore, this section is divided into three subsections that reflect the study concerning each subgame's perfect Nash equilibrium.

In subgame 4, the incumbent does not have to make any acquisition decision because the startup does not even reach the product market due to failing in the investment stage. Since this dissertation aims to study the incumbent optimal solutions in the acquisition stage, subgame 4 will not be studied.

Before proceeding to the following subsections, it is necessary to keep in mind conditions (4)(5)(6) shown below and that have already been mentioned in model setup subsection 3.1:

$$\frac{a_S}{a_I} > 1, a_k > 0 \text{ for } k = I, S \tag{4}$$

$$0 < \gamma < 1 \tag{5}$$

$$q_k > 0 \text{ for } k = I, S \tag{6}$$

Note that condition (4) arises from the fact that the innovative product has a better product quality than the existing one.

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

In the first subgame, S successfully invests in R&D, and it files a patent application, which is granted and approved by the country's Patent Office. In the second stage, I decides to do nothing. Thus, both firms compete in a duopoly market wherein S produces and commercialises its innovative product with product quality a_S and I keeps operating with its product with quality a_I (Table 2).

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 (7)(8):

$$\frac{\partial \pi_S{}^{Da_S}}{\partial q_S} = 0 \Leftrightarrow q_S = \frac{a_S - \gamma q_I}{2} \tag{7}$$

$$\frac{\partial \pi_I{}^{Da_I}}{\partial q_I} = 0 \Leftrightarrow q_I = \frac{a_I - \gamma q_S}{2} \tag{8}$$

Solving the equations system with both reaction functions (7)(8), it is calculated each firm's quantities in equilibrium $q_S{}^* = \frac{2a_S - \gamma a_I}{4-\gamma^2}$; $q_I{}^* = \frac{2a_I - \gamma a_S}{4-\gamma^2} > 0$. 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 (9)(10):

$$\pi_S^{Da_S{}^*} = {p_S}^*{q_S}^* = \frac{(2a_S - \gamma a_I)^2}{(2-\gamma)^2(2+\gamma)^2} \tag{9}$$

$$\pi_I^{Da_I{}^*} = {p_I}^*{q_I}^* = \frac{(2a_I - \gamma a_S)^2}{(2-\gamma)^2(2+\gamma)^2} \tag{10}$$

As mentioned in subsection 3.1 and according to conditions (5)(6), 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 (11) presented below.

$$\gamma < \frac{2a_I}{a_S} \tag{11}$$

There are two scenarios in which condition (11) is fulfilled:

1) **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 (4), results in a new condition (12):

$$1 < \frac{a_S}{a_I} < 2 \tag{12}$$

2) **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 (4) provides a new condition (13):

$$\frac{a_S}{a_I} > 2 \tag{13}$$

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, in this dissertation, 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 (12) is the one which prevails for the remaining subgames perfect Nash equilibrium study.

In the following subsection of this dissertation, it is studied the behaviour of both profits in the equilibrium state $\left(\pi_S^{Da_S{}^*}; \pi_I^{Da_I{}^*}\right)$ with both products' quality (a_S and a_I) and with the product differentiation degree

(γ). As can be observed from equations (9)(10), $\pi_S^{Da_S^*}$ 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.

4.1.1. Perfect Nash equilibrium depending on γ

Since γ affects both profits, it is necessary to derivate both profit equations (9)(10) in order to γ. For instance, if $\frac{\partial \pi_S^{Da_S^*}}{\partial \gamma} > 0$ the startup's profit increases with the product differentiation degree. Otherwise, it decreases with this same variable. The same reasoning is applied to study the incumbent's profit behaviour with γ. Firstly it will be analysed the startup profit, followed by the incumbent's financial gain.

Starting with the startup profits, it is obtained equation (14):

$$\frac{\partial \pi_S^{Da_S^*}}{\partial \gamma} = 2{a_I}^2\left(2\frac{a_S}{a_I} - \gamma\right)\frac{\left(-4 + 4\frac{a_S}{a_I}\gamma - \gamma^2\right)}{(2-\gamma)^3(2+\gamma)^3} \tag{14}$$

Since all the remaining multiplication factors and the denominator are strictly positive according to conditions (5)(12), the signal of $\frac{\partial \pi_S^{Da_S^*}}{\partial \gamma}$, equation (14), only depends on the numerator:

1) 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;
2) Otherwise, it decreases with γ.

It is obtained Figure 4, within conditions (5)(12), where it can be observed that for the following intervals:

1) $\left(1 < \frac{a_S}{a_I} < 1.25\right) \vee \left(\left(1.25 < \frac{a_S}{a_I} < 2\right) \wedge (0 < \gamma < 0.536)\right)$, startup profit decreases with γ;
2) $\left(1.25 < \frac{a_S}{a_I} < 2\right) \wedge (0.536 < \gamma < 1)$, startup increases its profits for high values of product differentiation degree.

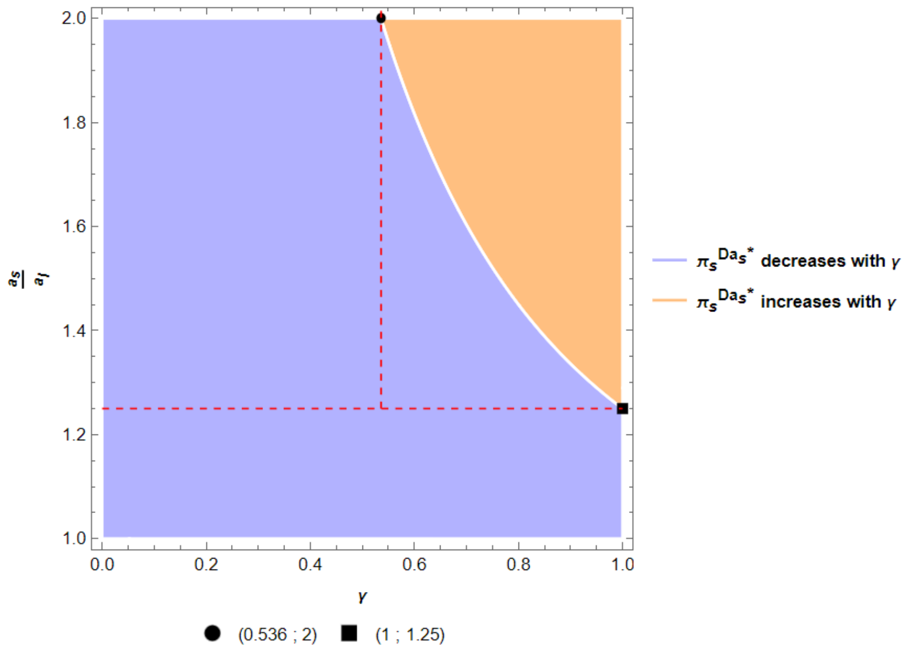

Figure 4. $\pi_S^{Da_S^*}$ behaviour with γ

For high competition intensity (recall that high γ means close to product homogeneity, so fiercer competition) and when S product quality innovation is at least 25% greater than the existing one, the startup has a competitive advantage over the incumbent when for very high values of product differentiation degree. As a result, the incumbent sells fewer quantities of its old product and suffers market share losses due to the Cournot competition effects. On the other hand, within this interval $\pi_S^{Da_S^*}$ continuously decreases with γ for low values of product differentiation.

When it comes to the incumbent's profit, the following equation (15) is obtained:

$$\frac{\partial \pi_I^{Da_I^*}}{\partial \gamma} = 2{a_I}^2\left(2-\gamma\frac{a_S}{a_I}\right)\frac{\left(-4\frac{a_S}{a_I}+4\gamma-\gamma^2\frac{a_S}{a_I}\right)}{(2-\gamma)^3(2+\gamma)^3} \tag{15}$$

Since all the remaining multiplication factors and the denominator are strictly positive according to conditions (5)(12), $\frac{\partial \pi_I^{Da_I^*}}{\partial \gamma}$, equation (15), only depends on the numerator:

1) 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;
2) Otherwise, it decreases with γ.

It can be observed that $\frac{a_S}{a_I}(-4-\gamma^2)+4\gamma$ is always negative within conditions (5)(12). 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).

In conclusion, as expected, the incumbent's profit decreases with the competition intensity. However, the startup's profits may increase with the competition intensity if its product is sufficiently innovative as compared with the incumbent's when competition is already high: it is in these circumstances that it can "steal" more business from the incumbent.

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

In this subgame 2, S successfully invests in R&D, and it files a patent application, which is granted and approved by the country's Patent Office. In the next stage, S is acquired by I at an acquisition cost equal to the financial reward obtained by S. Even though I acquires the innovative product, it decides to keep its new acquisition secret to preempt future competition. Thereby, I keeps benefiting from monopoly profits and S does not enter the market. Although S does not enter the market, it benefits from a financial reward equal to the profit it would obtain in a duopoly with I when producing and commercialising its new innovative product whilst I keeps operating with its existing product (Table 2).

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 (16):

$$\frac{\partial \pi_I{}^{Ma_I}}{\partial q_I} = 0 \Leftrightarrow q_I{}^* = \frac{a_I}{2} \tag{16}$$

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 (17):

$$\pi_I^{Ma_I{}^*} = p_I{}^* q_I{}^* = \left(\frac{a_I}{2}\right)^2 \tag{17}$$

As mentioned in subsection 3.1 and according to condition (6), the output level must be strictly positive, and therefore it depends on the numerator a_I. Once condition (4) is always fulfil, quantities produced by the incumbent are always positive for all values of a_I.

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 (9) and then the total equilibrium incumbent profit after making a killer acquisition is reflected on a new equation profit (18):

$$\pi_I^{KA^*} = (17) - (9) = \left(\frac{a_I}{2}\right)^2 - \frac{(2a_S - \gamma a_I)^2}{(2-\gamma)^2(2+\gamma)^2} \tag{18}$$

Having in mind conditions (5)(12), the incumbent's profit equation in equilibrium (18) will not be deeply studied depending on the three main variables for the following two reasons:

1) As it can be observed, $\pi_I^{KA^*}$ always increases with a_I and decreases with a_S;
2) Since I keeps producing and commercialising its old product in a monopoly, the incumbent monopoly profit equation (17) does not depend on γ. As a result, its profit equation after making a killer acquisition (18) only depends on the acquisition cost. Since the acquisition cost is reflected only on the startup profit equation (9), the results are the opposite to the ones obtained from the analysis of Figure 4. To be more representative, Figure 5 emerges. Since the startup benefits from a higher profit when it develops a new product with significantly greater quality and in the presence of high levels of competition intensity, it will require a high financial reward and then it becomes more costly for the incumbent to acquire it. This way, the acquiring firm sees its profit decreasing after acquiring the innovative product in those conditions.

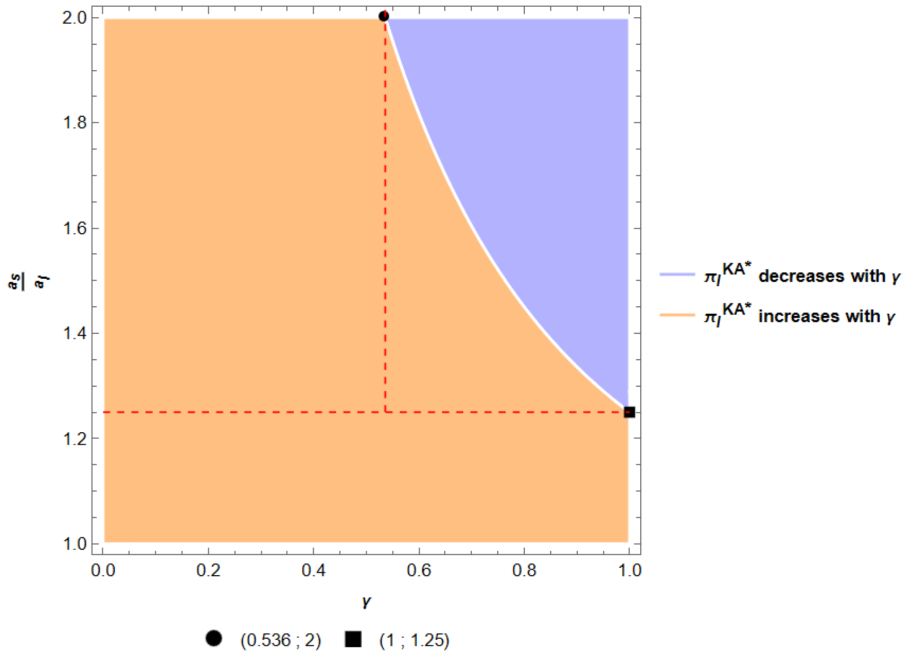

Figure 5. $\pi_I^{KA^*}$ behaviour with γ

4.3. Subgame 3 *(R&D, GA)*

In this subgame 3, S successfully invests in R&D, and it files a patent application, which is granted and approved by the country's Patent Office. In the second stage, S is acquired by I at an acquisition cost equal to the expected financial reward obtained by S. Contrary to subgame 2, I acquires the innovative product and starts producing and commercialising it in the market. In other words, there is a merger between both firms. The technology knowledge transfer rate is 100%, thus meaning that the incumbent can appropriate the total rents arising from this new product. Thereby, I keeps benefiting from monopoly profits and S does not enter the market. Analogously to subgame 1, S benefits from a financial reward which is equal to the profit it would obtain when producing and commercialising its new innovative product whilst I starts to operate in the market the innovative product acquired with product quality a_S.

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 (19):

$$\pi_I^{Ma_S^*} = {p_I}^* {q_I}^* = \left(\frac{a_S}{2}\right)^2 \tag{19}$$

As mentioned before in subsection 3.1 and according to condition (6), the output level must be strictly positive, and then it only depends on the numerator a_S. As stated by condition (4), quantities produced by the incumbent are always positive for all values of a_S.

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 (9) and then the total equilibrium incumbent profit after merging with the startup is reflected on a new equation profit (20):

$$\pi_I^{GA^*} = (19) - (9) = \left(\frac{a_S}{2}\right)^2 - \frac{(2a_S - \gamma a_I)^2}{(2-\gamma)^2(2+\gamma)^2} \tag{20}$$

Bearing in mind conditions (5)(12), 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:

1) As can be 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 (19) does not depend on γ. As a result, its profit equation after making a genuine acquisition (20) only depends on the acquisition cost. Once the acquisition cost is reflected on the startup profit equation (9), the results are the same as the ones obtained from the Figure 5 analysis.

4.3.1. Perfect Nash equilibrium depending on a_S

In this subgame, by derivating the incumbent profit in equilibrium after merging with the startup in order to a_S it is obtained equation (21):

$$\frac{\partial \pi_I^{GA^*}}{\partial a_S} = \gamma a_I \frac{\left(8 - 8\frac{a_S}{a_I}\gamma + \frac{a_S}{a_I}\gamma^2\right)}{2(2-\gamma)^2(2+\gamma)^2} \tag{21}$$

Since all the remaining multiplication factors and the denominator are strictly positive based on conditions (5)(12), the signal of $\frac{\partial \pi_I^{GA^*}}{\partial a_S}$, equation (21), depends on the numerator:

1) 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;
2) Otherwise, it decreases with the innovative product quality.

Within conditions (5)(12), Figure 6 is obtained, where it can be observed that for the following intervals:

1) $\left(1 < \frac{a_S}{a_I} < 1.14\right)$, incumbent profit increases with its own product quality for high values of product differentiation degree;
2) $\left(1.14 < \frac{a_S}{a_I} < 2\right)$, incumbent profit decreases with the new product quality.

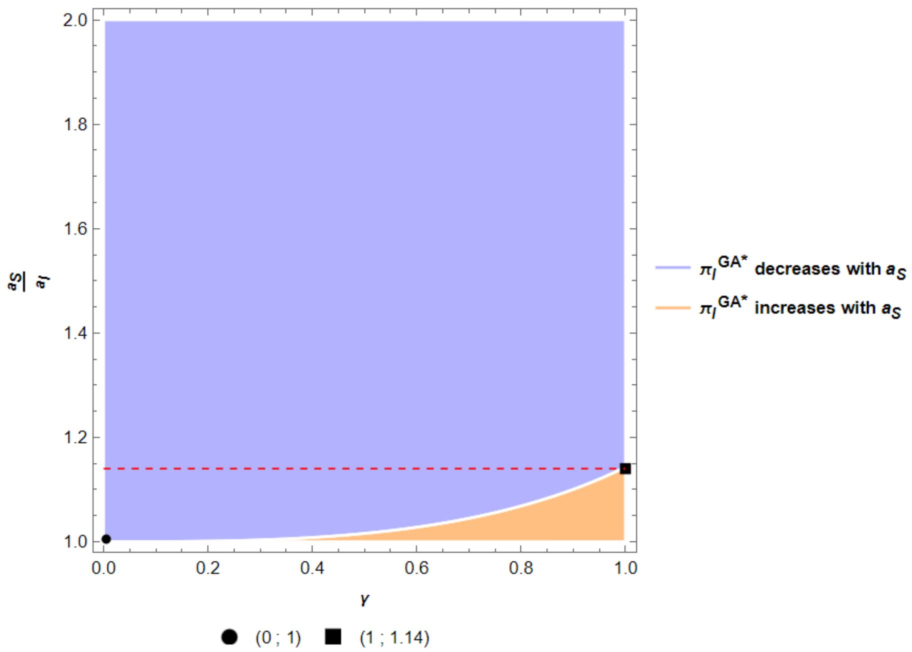

Figure 6. $\pi_I^{GA^*}$behaviour with a_S

When the startup's product innovation degree is at least 14% (considered high), the incumbent profit decreases due to the high acquisition cost associated with the new product purchase. Although the incumbent incorporates the new product in its operations, the rents arising from its commercialisation do not surpass the losses stemming from the genuine acquisition.

Within the context where the startup's product innovation is at a maximum of 14%, the incumbent profit may decrease or increase depending on the competition intensity. 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 downstream customers due to increased competition intensity. For this reason, the startup requires a lower financial reward, which the incumbent can afford.

After a genuine acquisition, the incumbent financial return when operating with the innovative product surpasses the acquisition cost.

5. Incumbent acquisition optimal solutions

Since this dissertation seeks to study how the product innovation degree affects the incumbent's decision to make a killer acquisition, to merge with a potential entrant and do nothing, the game will be solved backwards until the second stage.

After the startup invests successfully in R&D and protects its product innovation in the first stage, the incumbent faces three options: to make a killer acquisition, to merge with the startup and to do nothing, thus competing in a duopoly with the new entrant. This section then consists of comparing which is the optimal solution to the incumbent between those three alternatives.

The duopoly decision reflects the event in which the incumbent decides to do nothing.

5.1. KA vs D

When the incumbent is faced with choosing between making a killer acquisition to preempt future competition and competing in a duopoly with the new entrant, the results are obtained from the difference between the incumbent profit equations (18) and (10). Recalling condition (2), which is the necessary condition for a killer acquisition to occur:

1) 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;
2) Otherwise, $\pi_I^{KA^*} > \pi_I^{Da_I{}^*}$ and the incumbent prefers to make a killer acquisition.

From the difference between (18) and (10), it is obtained a new equation (22):

$$\pi_I^{KA^*} - \pi_I^{Da_I{}^*} = a_I{}^2\left(-2\frac{a_S}{a_I} + \gamma\right)\frac{\left(8\frac{a_S}{a_I} - 12\gamma + \gamma^3 + 2\gamma^2\frac{a_S}{a_I}\right)}{4(2-\gamma)^2(2+\gamma)^2} \tag{22}$$

Within conditions (5)(12), $a_I{}^2\left(-2\frac{a_S}{a_I} + \gamma\right) < 0$ and $4(2-\gamma)^2(2+\gamma)^2 > 0$, thus meaning that the signal of $\pi_I^{KA^*} - \pi_I^{Da_I{}^*}$, equation (22), depends on the numerator:

1) 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;
2) Otherwise, making a killer acquisition is more attractive for the existing firm.

It is then obtained Figure 7, where it can be observed that for the following intervals:

1) $\left(\left(1 < \frac{a_S}{a_I} < 1.1\right) \wedge (0 < \gamma < 0.828)\right) \vee \left(1.1 < \frac{a_S}{a_I} < 2\right)$, it is always more profitable to compete with S;

2) $\left(1 < \frac{a_S}{a_I} < 1.1\right) \wedge (0.828 < \gamma < 1)$, the incumbent prefers to make a killer acquisition when the competition intensity is high and to compete with the startup in a duopoly for low levels of competition.

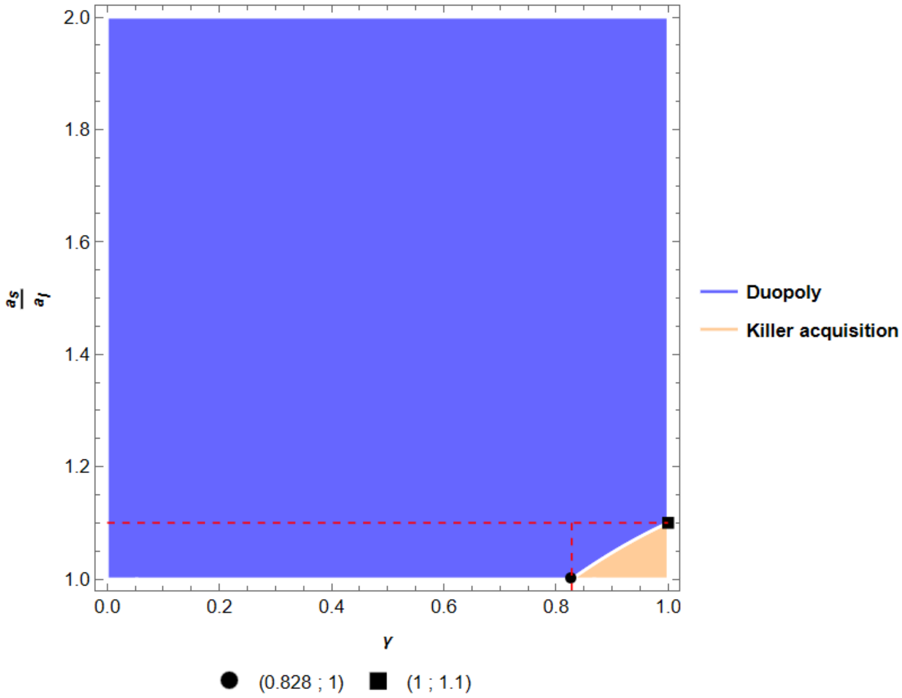

Figure 7. Incumbent's acquisition decision in the 2nd stage: Killer Acquisition vs Duopoly

As shown in the graph above, when the startup's product innovation degree is at least 10%, it is very costly to make a killer acquisition. Besides the startup requiring a high financial return, which translates to a high acquisition cost, the acquiring firm does not benefit from the 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 weighs more than 82.8% on the incumbent demand, making a killer acquisition is more profitable for the incumbent 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. In other words, the lower the acquisition cost is from the incumbent perspective.

5.2. 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 (20) and (10). Recalling condition (3), which is the necessary condition for a genuine acquisition to occur:

1) If $\pi_I^{GA^*} - \pi_I^{Da_I^*} < 0$, to compete with the new entrant is more profitable for the existing firm;
2) Otherwise, $\pi_I^{GA^*} > \pi_I^{Da_I^*}$ and then the incumbent prefers to make a genuine acquisition.

From the difference between (20) and (10), it is obtained the following equation (23):

$$\pi_I^{GA*} - \pi_I^{Da_I*} = a_I^2\left(-2\frac{a_S}{a_I}+\gamma\right)\frac{\left(8-12\frac{a_S}{a_I}\gamma+\frac{a_S}{a_I}\gamma^3+2\gamma^2\right)}{4(2-\gamma)^2(2+\gamma)^2} \tag{23}$$

As stated by conditions (5)(12), $a_I^2\left(-2\frac{a_S}{a_I}+\gamma\right)<0$ and $4(2-\gamma)^2(2+\gamma)^2>0$, and therefore, the signal of $\pi_I^{GA*}-\pi_I^{Da_I*}$, equation (23), depends on the numerator:

1) 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;
2) Otherwise, merging with the potential new entrant is more attractive.

Figure 8 is then obtained, and the following results can be drawn for the following intervals:

1) $\left(\left(1<\frac{a_S}{a_I}<1.1\right)\wedge(0<\gamma<0.713)\right)\vee\left(\left(1.1<\frac{a_S}{a_I}<2\right)\wedge(0<\gamma<0.347)\right)$, it is more attractive to make a genuine acquisition;
2) $\left(\left(1<\frac{a_S}{a_I}<1.1\right)\wedge(0.824<\gamma<1)\right)\vee\left(\left(1.1<\frac{a_S}{a_I}<2\right)\wedge(0.713<\gamma<0.824)\right)$, it is more profitable to compete in a duopoly with S;
3) $\left(\left(1<\frac{a_S}{a_I}<1.1\right)\wedge(0.713<\gamma<0.824)\right)\vee\left(\left(1.1<\frac{a_S}{a_I}<2\right)\wedge(0.347<\gamma<0.713)\right)$, it is more profitable to compete in a duopoly for high values of product differentiation degree; otherwise, it is more attractive to make a killer acquisition.

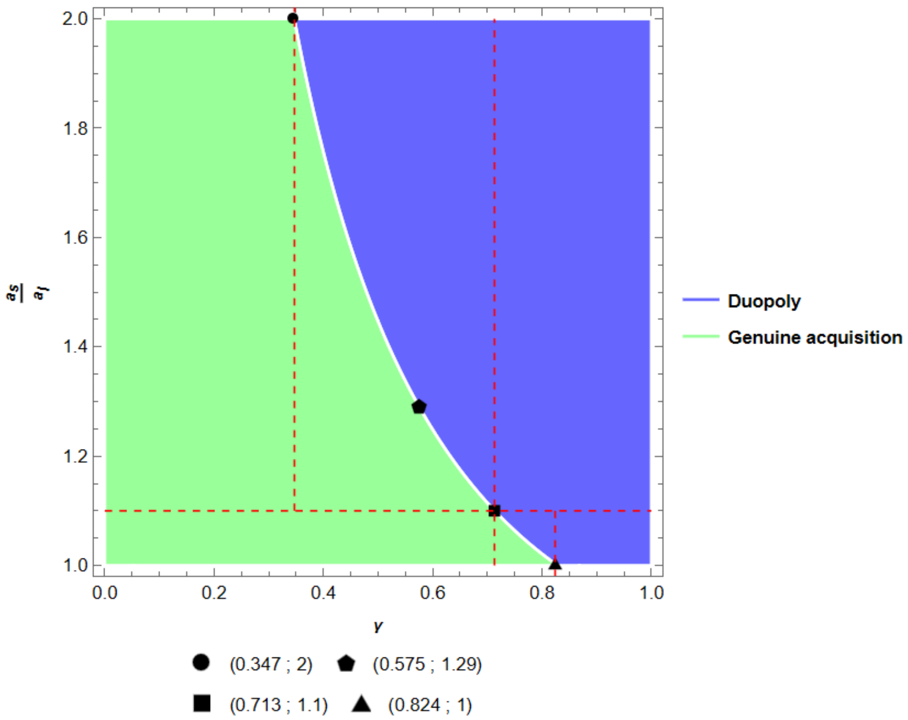

Figure 8. Incumbent's acquisition decision in the 2nd stage: Genuine Acquisition vs Duopoly

From the graph shown above, it can be observed that a merger is more attractive to the incumbent compared to a duopoly market for low levels of competition intensity. For instance, the startup's product differentiation degree is at a maximum of 10%. In that case, merging persists for a larger interval of γ $(0 < \gamma < 0.824)$ since the financial reward requires by the startup is not a prohibitive value. Once the innovative product quality does not significantly differ from the existing one, the private return arising from its production and commercialization is also not so high. The acquisition cost can be afforded from the incumbent perspective.

The greater the startup's product innovation degree, the higher the financial reward required when negotiating the sale of the new product. Therefore, merging becomes less profitable for the acquiring firm.

5.3. KA vs GA

Finally, in order 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, it is calculated the difference between both incumbent profit equations (23) and (18):

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

Since the acquisition cost is the same in both events, it is obtained equation (24):

$$\pi_I^{GA^*} - \pi_I^{KA^*} = \frac{{a_S}^2 - {a_I}^2}{4} \tag{24}$$

$\pi_I^{GA^*} - \pi_I^{KA^*}$ is strictly positive (> 0) since $\frac{a_S}{a_I} > 1$, as stated by condition (4). 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 in section 3.2, which relies on the model description: 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 same 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 7.

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 (12), the incumbent does never face the decision of choosing between making a genuine acquisition and a killer acquisition.

On the one hand, making a killer acquisition may only be more attractive to the incumbent when the startup's product innovation impacts its demand lower than 82.4% (Figure 7). On the other hand, making a genuine acquisition may only be more profitable to the incumbent for a product differentiation degree higher than 82.8% (Figure 8). To facilitate the visualisation of the aggregate results presented in the following section targeted to the results discussion, both genuine acquisition upper bound (82.4%) and killer acquisition lower bound (82.8%) are assumed to be 82.6% (the average value) since the results are not affected by this assumption.

6. Social welfare and consumer surplus analysis

Whilst doing profits maximisation in section 4, the incumbent transaction costs associated with acquiring the innovative product in genuine and killer acquisitions are only considered after the existing firm has decided its output level. For this reason, these costs do not affect the firm's output level, and the social welfare analysis along with the consumer surplus will be studied gross the acquisition costs.

General linear demand equation (1) provided by Singh and Vives (1984) stems from the utility function represented by equation (25), indexed by $i, j, k = \{S, I\}$ for $i \neq j$:

$$U(q_i, q_j) = a_k q_i + a_k q_j - \frac{1}{2}\left[(q_i)^2 + 2\gamma q_i q_j + (q_j)^2\right] \tag{25}$$

The producer surplus is the firms' profit sum, and as a result, the consumer surplus is the social welfare net of the producer surplus.

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

As mentioned in section 4.1, the quantities in equilibrium produced by each firm are obtained by combining equations (7)(8), resulting on $q_S{}^* = \frac{2a_S - \gamma a_I}{4-\gamma^2}$; $q_I{}^* = \frac{2a_I - \gamma a_S}{4-\gamma^2}$. Recalling that in this subgame the startup operates with its innovative product (quality a_S) and the incumbent operates with its old product (quality a_I), based on the utility function (25), the maximum utility is represented by equation (26):

$$U^D = -\frac{(a_I{}^2 + a_S{}^2)(\gamma^2 - 12) - 2\gamma a_I a_S(\gamma^2 - 8)}{2(4-\gamma^2)^2} \tag{26}$$

Combining both firm's profit equations (9)(10), the producer surplus is then obtained and represented by equation (27):

$$PS^D = \pi_S^{Da_S{}^*} + \pi_I^{Da_I{}^*} = \frac{(a_I{}^2 + a_S{}^2)(4+\gamma^2) - 8\gamma a_I a_S}{(4-\gamma^2)^2} \tag{27}$$

Social welfare nets the producer surplus results on the consumer surplus, which is given by equation (28):

$$CS^D = U^D - PS^D = (26) - (27) = \frac{(a_I{}^2 + a_S{}^2)(4-3\gamma^2) + 2\gamma^3 a_I a_S}{2(4-\gamma^2)^2} \tag{28}$$

6.2. Subgame 2 (R&D, KA)

Since the incumbent acquires the potential new entrant in this subgame, the latter does not enter the market. The incumbent keeps operating as a monopolistic firm with its old product with quality a_I, since it decides to shelve its new acquisition. From the FOC represented by equation (16) in section 4.2, the existing firm's output level set accordingly to its desirable demand is given by $q_I{}^* = \frac{a_I}{2}$. Based on the general utility function given by equation (25), the maximum utility is represented by equation (29):

$$U^{KA} = \frac{3{a_I}^2}{8} \tag{29}$$

As the incumbent is the only firm operating in the market, the producer surplus is then equal to the monopolistic firm's profit given by equation (17), $\left(PS^{KA} = \pi_I^{KA^*} = \frac{{a_I}^2}{4}\right)$.

Once more, social welfare nets the producer surplus results on the consumer surplus, which is given by equation (30):

$$CS^{KA} = U^{KA} - PS^{KA} = (29) - (17) = \frac{{a_I}^2}{8} \tag{30}$$

6.3. Subgame 3 *(R&D, GA)*

In the last subgame studied in this dissertation, the incumbent acquires the potential new entrant, and thus, the latter does not enter the market. The incumbent keeps operating then as a monopolistic firm and incorporates its new product acquisition with quality a_S. Analogously to subgame 2, from applying FOC, the existing firm's output level set accordingly to its desirable demand is given by ${q_I}^* = \frac{a_I}{2}$. Recalling again the general utility function given by equation (25), the maximum utility is represented by equation (31):

$$U^{GA} = \frac{3{a_S}^2}{8} \tag{31}$$

As the incumbent is the only firm operating in the market, the producer surplus is then equal to the monopolistic firm's profit given by equation (19), $\left(PS^{GA} = \pi_I^{GA^*} = \frac{{a_S}^2}{4}\right)$.

Finally, social welfare nets the producer surplus results on the consumer surplus, which is given by equation (32):

$$CS^{GA} = U^{GA} - PS^{GA} = (31) - (19) = \frac{{a_S}^2}{8} \tag{32}$$

6.4. Social welfare and consumer surplus inequalities

As a result of conditions (4), (5) and (12), it can be observed that consumers benefit more in a duopoly market. On the other hand, a killer acquisition is more harmful to consumers' welfare. Besides competition suppression caused by the acquisition, the consumers do not start benefiting from greater product quality, as observed when a merger occurs. Therefore, the comparison of consumer surplus equations (28), (30) and (32) leads to the following result: $CS^D > CS^{GA} > CS^{KA}$.

6.4.1. $\boldsymbol{U^{KA}}$ vs $\boldsymbol{U^{GA}}$

To study the impact of both killer and genuine acquisitions on social welfare, it is calculated the difference between the maximum utility function (29) and (31):

1) If $U^{KA} - U^{GA} < 0$, then a merger is more beneficial for social welfare;
2) Otherwise, a killer acquisition is more advantageous in terms of social welfare.

$U^{KA} - U^{GA}$ it is obtained by the following equation (33):

$$U^{KA} - U^{GA} = (29) - (31) = \frac{a_I^2}{8}\left(3 - 3\frac{a_S^2}{a_I^2}\right) \quad (33)$$

Within condition (12), which reflects the lower and upper bound of the startup's product innovation degree, the signal of $U^{KA} - U^{GA}$ depends on the numerator. Since $\frac{a_S}{a_I} > 1$, as stated by condition (12), $\frac{a_I^2}{8} > 0$ and $3 - 3\frac{a_S^2}{a_I^2} < 0$, $U^{KA} - U^{GA}$ is strictly negative. As expected, a merger is more beneficial for social welfare. Although competition is suppressed after a merger, the consumers benefit from a product with greater quality. Moreover, the acquiring firm also benefits from higher profits due to the impact of greater product quality on its desirable demand, which increases profit.

6.4.2. U^{KA} vs U^D

To study the impact of a killer acquisition and a duopoly on social welfare, it is calculated the difference between the maximum utility functions (29) and (26):

1) If $U^{KA} - U^D < 0$, then a duopoly is more beneficial for social welfare;
2) Otherwise, a killer acquisition is more advantageous for social welfare.

From $U^{KA} - U^D$ it is obtained equation (34):

$$U^{KA} - U^D = (29) - (26) = a_I^2 \frac{\left(4\frac{a_S^2}{a_I^2}(\gamma^2 - 12) - 8\gamma\frac{a_S}{a_I}(\gamma^2 - 8) + \gamma^2(3\gamma^2 - 20)\right)}{8(4 - \gamma^2)^2} \quad (34)$$

Within conditions (5)(12), that give the lower and upper bound of $\frac{a_S}{a_I}$ and γ, a_I^2 and the denominator $8(4-\gamma^2)^2$ are strictly positive (> 0) and the numerator is strictly negative. As a result, $U^{KA} - U^D < 0$ and thus, a duopoly is more beneficial for social welfare than when the incumbent decides to make a killer acquisition.

6.4.3. U^{GA} vs U^D

Finally, to study the benefits of doing nothing in the third stage from the incumbent perspective and merging, it is calculated the difference between the maximum utility functions (31) and (26):

3) If $U^{GA} - U^D < 0$, then a duopoly is more beneficial for social welfare;
4) Otherwise, a genuine acquisition is more advantageous for social welfare.

$U^{GA} - U^D$ is given by the following equation (35):

$$U^{GA} - U^D = (31) - (26) = a_I^2 \frac{\left(4(\gamma^2 - 12) - 8\gamma\frac{a_S}{a_I}(\gamma^2 - 8) + \frac{a_S^2}{a_I^2}\gamma^2(3\gamma^2 - 20)\right)}{8(4 - \gamma^2)^2} \quad (35)$$

Once more in line with conditions (5)(12), whilst $a_I{}^2$ and the denominator $8(4-\gamma^2)^2$ are strictly positive (>0), the numerator signal of $U^{GA}-U^D$ depends on the main variables $\frac{a_S}{a_I}$ and γ:

1) If $4(\gamma^2-12)-8\gamma\frac{a_S}{a_I}(\gamma^2-8)+\frac{a_S{}^2}{a_I{}^2}\gamma^2(3\gamma^2-20)>0$, then $U^{GA}-U^D>0$, and hence a merger is more beneficial to social welfare;
2) Otherwise, a duopoly is more advantageous.

It is then obtained Figure 9, where it can be observed that for the following intervals:

1) $\left(1<\frac{a_S}{a}<1.29\right)\vee\left(\left(1.29<\frac{a_S}{a}<2\right)\wedge(0<\gamma<0.616)\right)$, it is always more profitable to be in the presence of a duopoly;
2) $\left(1.29<\frac{a_S}{a}<2\right)\wedge(0.616<\gamma<1)$, it is more advantageous for social welfare to be in the presence of a duopoly for low values of product differentiation degree; on the other hand, it is more advantageous to be in the presence of a merger when there is a higher competition intensity.

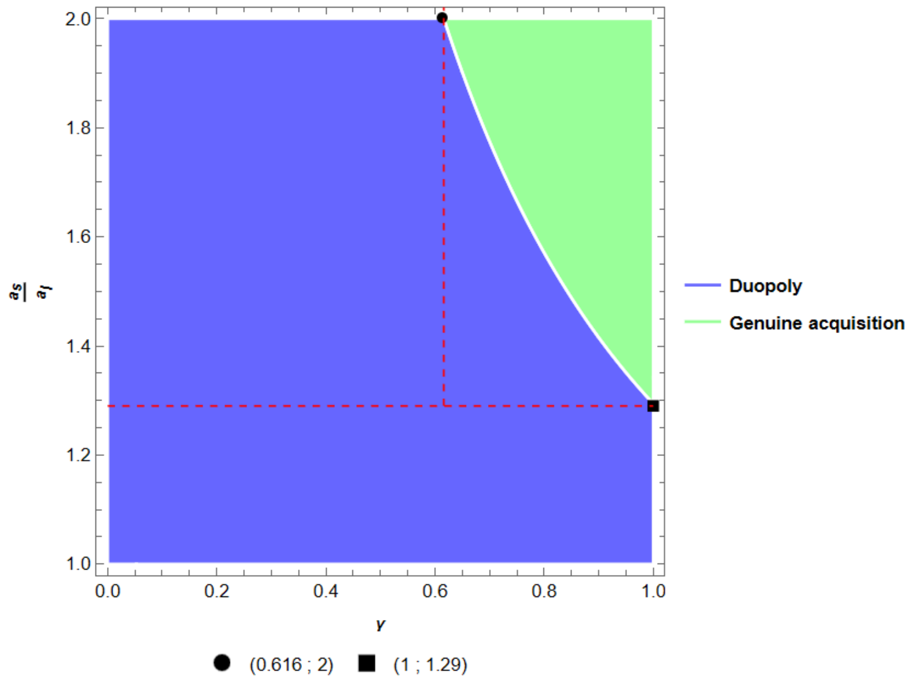

Figure 9. Social welfare: Genuine acquisition vs Duopoly

The results show that a merger is the more beneficial incumbent decision for social welfare for a high competition intensity within the interval $\left(1.29<\frac{a_S}{a}<2\right)\wedge(0.616<\gamma<1)$. As observed in Figure 8, a merger is only an optimal solution for the incumbent for $0<\gamma<0.824$ in a market with low competition intensity. However, for $1.29<\frac{a_S}{a}<2$ the incumbent only faces the decision to choose between doing nothing, and hence competing in a duopoly, and making a genuine acquisition if $0<\gamma<0.575$ (Figure 8).

7. Results Discussion

7.1. Results on the equilibrium profits response to the main variables

After maximising each firm's profit in equilibrium in section 4, some results can be highlighted.

Firstly, within the context where the startup and the incumbent compete in a duopoly market (*R&D, NA*), each one operating with its product, 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 then the competition intensity with high substitutable products). As shown in Figure 4, 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, as 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 6). 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 optimal decision presented and analysed in the following subsection.

7.2. Results on incumbent optimal solutions along with their impact on social welfare

To better understand the results obtained in section 5, Figure 7 and Figure 8 are jointly summarised in one graph plotted in Figure 10.

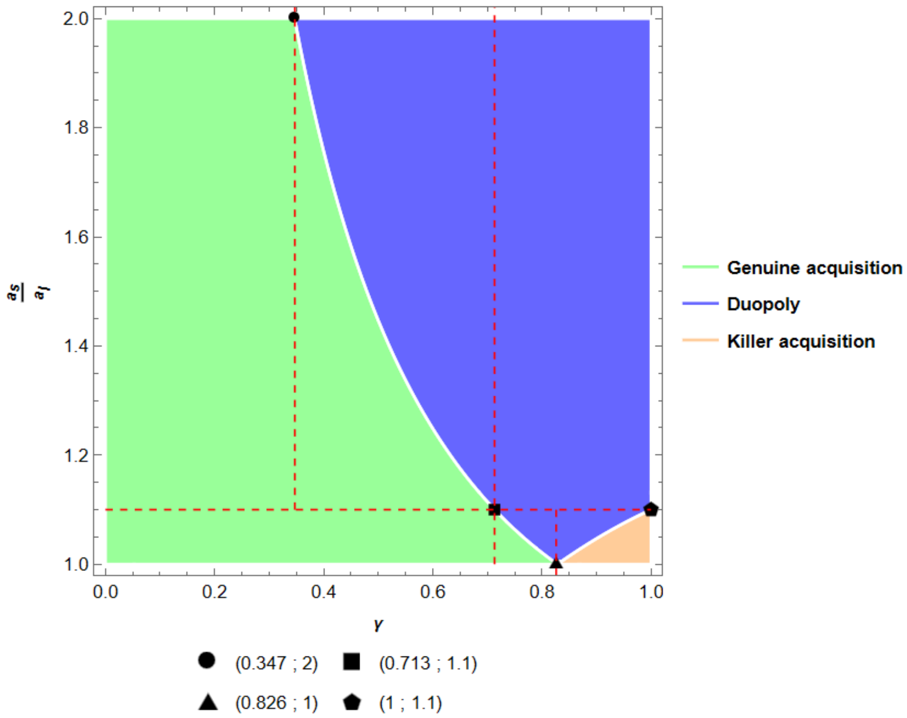

Figure 10. Incumbent optimal solutions

From Figure 10, integrating the respective functions within the considerable intervals of product differentiation degree, the likelihood of each acquisition decision is obtained:

1) GA Area $= 0{,}347 + \int_{0.347}^{0.826} \frac{-8-2\gamma^2}{\gamma^3-12\gamma} d\gamma - (0.826 - 0.347) \cong 0.511 \Longrightarrow \mathbf{51.1}\%$
2) KA Area $= \int_{0.826}^{1} \frac{12\gamma-\gamma^3}{8+2\gamma^3} d\gamma - (0.826 - 0.347) \cong 0.009 \Longrightarrow \mathbf{0.9}\%$
3) D Area $= 1 - 0.511 - 0.009 \cong 0.480 \Longrightarrow \mathbf{48}\%$

For perfect technology knowledge transfer, the incumbent is more likely to make a genuine acquisition around 51.1% of total times. On the other hand, the likelihood of a killer acquisition occurring is around 1%. Such a low figure is consistent withs empirical evidence that also presents low share of killer acquisitions such as the study conducted by Cunningham in 2021 within the pharmaceutical industry, where the author states that between 5.3% and 7.4% of total acquisitions aim to pre-empt future competition.

Also, Table 3 and Table 4 present the incumbent optimal decision in the acquisition stage according to a threshold of 10% associated with the startup's product innovation degree. This threshold equals 10%, whereby the former table reflects a startup product quality degree lower than 10%, and the latter represents a product quality degree greater than 10% compared to the existing one.

Table 3. Incumbent Optimal Solutions for $1 < \frac{a_S}{a_I} < 1.1$

Product Differentiation Degree (γ)	Incumbent Optimal Solutions
$\mathbf{0 < \gamma < 0.713}$	Genuine acquisition
$\mathbf{0.713 < \gamma < 0.826}$	Genuine acquisition: $\frac{a_S}{a_I} < \frac{-8-2\gamma^2}{\gamma^3-12\gamma}$
	Duopoly: $\frac{a_S}{a_I} > \frac{-8-2\gamma^2}{\gamma^3-12\gamma}$
$\mathbf{0.83 < \gamma < 1}$	Duopoly: $\frac{a_S}{a_I} > \frac{12\gamma-\gamma^3}{8+2\gamma^2}$
	Killer acquisition: $\frac{a_S}{a_I} < \frac{12\gamma-\gamma^3}{8+2\gamma^2}$

Table 4. Incumbent Optimal Solutions for $1.1 < \frac{a_S}{a_I} < 2$

Product Differentiation Degree (γ)	Incumbent Optimal Solutions
$\mathbf{0 < \gamma < 0.347}$	Genuine acquisition
$\mathbf{0.347 < \gamma < 0.713}$	Genuine acquisition: $\frac{a_S}{a_I} < \frac{-8-2\gamma^2}{\gamma^3-12\gamma}$
	Duopoly: $\frac{a_S}{a_I} > \frac{-8-2\gamma^2}{\gamma^3-12\gamma}$
$\mathbf{0.713 < \gamma < 1}$	Duopoly

Within the scenario in Table 3, 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, equivalent to depending on the expected startup financial return in a duopoly when competing against the existing product.

Moreover, it can be stated that when the potential new entrant develops an innovative product with a maximum of 10% greater than the existing product, acquisitions are more likely to occur 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 dissertation 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 most harmful incumbent's decision to social welfare and its customers (section 6.4). Besides the suppression of competition caused by the acquisition, the customers do not benefit from a greater product quality as they would if a genuine acquisition had taken place. Agency Authorities should then also intervene in acquisitions associated with lower transaction costs.

It is important to recall that these results only stand for the assumption made in subsection 5.3: the incumbent does not face any costs related to the implementation of the innovative product. As a result, implementation costs when the incumbent decides to make a genuine acquisition are considered sufficiently high to allow the possibility of a killer acquisition occurring. This is to say, killer acquisition may only occur if and only if there is imperfect technology knowledge transfer.

Regarding the scenario presented in Table 4, it is observed that if the startup's output level affects less than 34.7% the incumbent demand, in other words, for low levels of competition intensity, it is more profitable to merge with the potential new entrant and 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 then higher. Additionally, as can be observed in Figure 4, 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 9 and Figure 10. Figure 11 shows the conflict of interests' zones between social welfare and incumbent's profit.

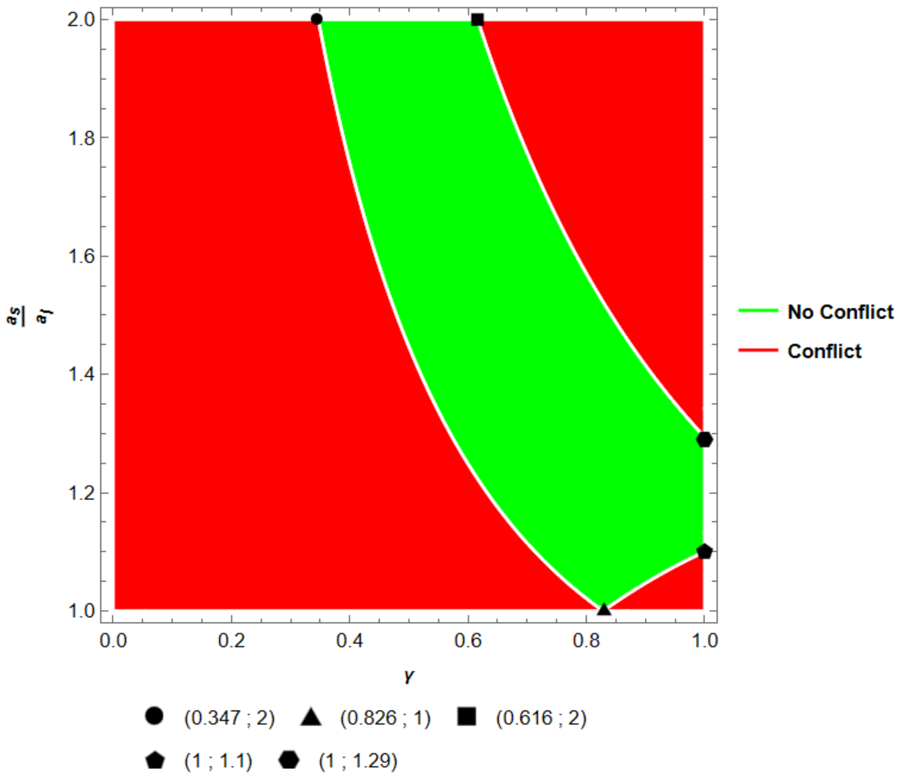

Figure 11. Incumbent and Social Welfare interests: Conflict vs No Conflict zones

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:

1) Conflict Area = GA Area + KA Area $+2(1-0.616)-\int_{0.616}^{1}\frac{2(-12+\gamma^2)}{\gamma(-20+3\gamma^2)}d\gamma = 0.511+0.009+$ $+0.159 \cong 0.679 \Longrightarrow \mathbf{67.9\%}$

The region where there is no conflict of interests is when a duopoly market is the best solution for both social welfare and incumbent:

2) No Conflict Area = D Area $-\left(2(1-0.616)-\int_{0.616}^{1}\frac{2(-12+\gamma^2)}{\gamma(-20+3\gamma^2)}d\gamma\right) = 0.48-0.159 \cong 0.321 \Longrightarrow \Longrightarrow$ $\mathbf{32.1\%}$

In summary, killer acquisitions are unlikely to occur. A killer acquisition is only more attractive to the incumbent when: i) The implementation costs associated with the innovative product after making a genuine acquisition are sufficiently high (imperfect technology knowledge transfer); ii) Both firms' output levels show a high homogeneity; iii) Startup does not heavily invest in R&D, which means that the minimium financial reward required by the innovator is not sufficiently high to prevent the incumbent from making a killer acquisition.

7.3. Limitations

In this dissertation, the results obtained are affected by some assumptions stated before in section 3.2, which presents the theoretical model description. This critical study's limitations are highlighted below:

1) In the first stage of the proposed model, it is not considered a probability of success related to the investment in R&D. Moreover, it is assumed that after the successful development of product innovation, the startup patent application granted by the country's Patent Office is founded valid within a probability of 100%, which in turn is difficult to reach because of the novelty requirement of a patent.
2) The technology knowledge transfer rate is assumed to be 100% in the acquisition stage. It is an ideal and rare scenario to occur since, as mentioned in 2.3.3 within the context of patent commercialisation, the transfer knowledge consists of two components: i) codified knowledge disclosed by the patent, which can be not so easy to understand from the acquiring firm; ii) tacit knowledge related to the know-how of the innovation, which in turn is very difficult to transfer. This assumption leads to a limitation with a significant impact on the results: the incumbent faces the exact transaction costs in both genuine and killer acquisitions, wherefore after a merger, the acquiring firms may also face costs associated with the imperfect technology knowledge transfer;
3) The financial reward required by the startup when it merges with the incumbent is equal to the one required when the existing firm makes a killer acquisition. The financial reward must be higher when the startup merges with the incumbent since, as the literature suggests (subsection 2.3.3), the innovator provides a license to the acquiring firm. As a result, the startup would benefit from a higher financial reward since it would still gain private returns associated with future acquisitions.

8. Conclusions

Between 2010 and 2020, the five most dominant firms within the digital market (Google, Apple, Facebook, Amazon and Microsoft) acquired more than 400 firms. Some of these mergers are easily observed: i) Even before 2010, Google acquired Youtube in 2006; ii) Facebook acquired Instagram in 2012 and Whatsapp in 2014; iii) Microsoft acquired GitHub in 2018. Even though these acquisitions are described as mergers, they lead to a suppression of competition intensity and hence, to a decrease in social welfare, namely connected with the consumer surplus. 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).

Within the context of killer acquisitions that seek to prevent future competition by "killing" the innovative product entry in the market, this dissertation 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. 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.

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 the results analysis and its 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 both genuine and killer acquisitions, merging would always be more profitable for the existing firm, and a killer acquisition would never occur within the theoretical model proposed in this dissertation.

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 the decrease in the equilibrium price charged to downstream customers due to the increase in 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. Also, based on the conflict of interests between the acquiring firm and social welfare, Authorities Agencies should intervene in around two thirds of total cases.

The results obtained and discussed throughout this study meet some empirical findings within the context of both genuine and killer acquisitions:

1) 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%;
2) 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 before, 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;

3) 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 small interval: $\left(1 < \frac{a_S}{a_I} < 1.1\right) \wedge (0.828 < \gamma < 1)$, with a likelihood of occurring around 1% of total cases.

As future work, the author of this dissertation suggests focusing on transaction costs, namely those associated with the implementations 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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