Competition and Post-Innovation Strategies:

Imitation, Masking and Licensing

Author: Adnan ARIF
Supervisor: Arghya GHOSH
Student ID: 3329880

School of Economics
Bachelor of Commerce (Business Economics)

November 4, 2013
Acknowledgements

There are many people who I must thank for assisting me with this thesis.

First and foremost, I’d like to like to thank my wonderful supervisor Associate Professor Arghya Ghosh for the time and effort he has invested in this thesis and my learning. Thank you Arghya for your guidance, dedication and above all your unwavering support. I have benefited greatly from your supervision.

Next, I would like to thank the following people for their feedback during and after final presentation: Dr Zhanar Akhmetova, Dr Gabriele Gratton, Dr Hongyi Li, Dr. Carlos Pimienta and Professor Hodaka Morita. I’m also very grateful for feedback from Dr Chris Bidner, Ashley Cheng and Ashna Taneja.

Thank you to the 2013 honours cohort for making this year such a memorable one. It would have been a much more difficult year without such helpful peers.

Thank you to all members of the school football team for their support throughout the year.

Thank you to the donors of the ASB scholarship fund for their generous financial support throughout the year.

Thank you to my family, particularly my mother.

All errors in this thesis are mine.
Originality Statement

I hereby declare that this thesis is my own work and any contributions or materials from other authors used in this thesis have been appropriately acknowledged. This thesis has not been submitted as to any other university or institution as part of the requirement as part of another degree or award.
Abstract

Protection of Intellectual Property Rights (IPR) is rarely perfect. Under imperfect IPR protection, successful innovators engage in costly masking to preserve their advantage while unsuccessful firms engage in costly imitation to curtail their disadvantage. How does an increase in competition, or competitive pressure, affect these post-innovation business strategies? We address this question in a Hotelling, linear city, duopoly model where one firm has a quality advantage, presumably due to prior success in innovation.

We find that tougher competition decreases imitation for an exogenously given masking effort while it increases masking for an exogenously given imitation effort. When both masking and imitation are endogenously determined, we find that tougher competition always decreases imitation. Its effect on masking however is ambiguous on our analysis.

We also consider the possibility of licensing between the two firms and characterize the optimal two-part tariff contract. We find that tougher competition raises the per-unit royalty and reduces the up-front fixed-fee. Extending our model to incorporate costly licensing we find that firms are more willing to bear the cost and engage in licensing when competition is tougher. Licensing improves average quality in the market, reduces transportation cost both of which improve consumer surplus and welfare. However, we find that price is always higher with licensing, and in fact so much so that despite the increase in quality and decrease in transportation costs, overall consumer surplus declines (due to increased price).
Contents

Acknowledgements........................................................................................................................................ ii
Originality Statement.................................................................................................................................. iii
Abstract ...................................................................................................................................................... iv
1 Introduction & Literature Review .......................................................................................................... 1
  1.1 Introduction ........................................................................................................................................ 1
  1.2 Literature .......................................................................................................................................... 6
2 The Model & Analysis .............................................................................................................................. 12
  2.1 Setup ............................................................................................................................................... 12
  2.2 Analysis .......................................................................................................................................... 15
  2.3 Discussion ...................................................................................................................................... 26
3 Licensing: A Contracting Solution .......................................................................................................... 29
  3.1 Setup ............................................................................................................................................... 29
  3.2 Analysis .......................................................................................................................................... 30
  3.3 Licensing Cost ................................................................................................................................. 34
  3.4 Welfare Comparison ......................................................................................................................... 35
4 Conclusion ............................................................................................................................................. 37
Appendix .................................................................................................................................................... 39
Bibliography ............................................................................................................................................... 47
1 Introduction & Literature Review

1.1 Introduction

“...By the word competition is meant the struggle of two or more individuals who aspire to the same advantage, and vie with each other to obtain it; the end to be attained is different, and in many respects, the means of attaining it are different also.” John Lalor (1899)

Firms invest in reducing costs, improving quality or both. Successful investments give firms an advantage in competition with rivals. However, when IPR protection is imperfect, successful innovations are prone to imitation. To protect its advantage from imitators, successful innovators often engage in “masking” (Taylor, 1993).

Investments in imitation and masking are important post-innovation strategies. Consider for example the case of YKK, currently the largest zipper manufacturer in the world and devotes significant R&D expenditure (YKK Profile and History, 2013). Clothing manufacturers value their zippers so highly that YKK has an advantage in the product market. The company engages in masking of its production process and in-turn the knowledge that facilitates its advantage. Instead of sub-contracting work, it manufactures everything including the construction equipment itself. YKK smelts its own brass, spins its own thread and even makes its own cardboard boxes for shipping (Los Angeles Times, 05/10/1998). YKK is renowned for its significant masking effort in the zipper manufacturing industry.

YKK is certainly not alone when it comes to a high masking effort in an industry of tough competition. Corporations in the IT industries routinely use programming traps, copy-protect schemes and code encryptions to mask their innovation process (Taylor, 1993, p. 626). This
includes Apple Inc.’s digital rights management (DRM) technology, ‘Fairplay’. The DRM technology encrypts its software with authorisation keys, disabling rival companies from imitation. The objective of Apple Inc. is identical to YKK: to deter the imitators by masking the knowledge that facilitates its advantage.

The other side of the story is imitation; a strategy widely used by non-innovators or unsuccessful innovators to improve their competitiveness. In the 1990’s the Asian financial crisis threatened the survival of car manufacturer Hyundai. As a survival strategy, it actively pursued a strategy of imitation (alongside collaboration with Mitsubishi Motors) to further develop small cars for the global market (Mei, 2003). This strategy was largely responsible for Hyundai’s survival and current position as a quality leader in car manufacturing (Kim 1997, p. 127).

Hyundai’s example is in fact not unique. Imitation is widely regarded as one of the most important channels of technology transfer in both domestic and international trade context. General examples of imitation include reverse engineering and program decoding. Although, it may be interpreted as any mechanism used to mimic a rival’s product features. We focus on imitation that is ‘non-deceptive’ (see Grossman and Shapiro, 1988) such that consumers are fully aware of whether a product is an imitation.

Implicit in our attempt to understand these phenomena is an imperfect degree of IPR protection. Under perfect IPR protection, by definition, imitation is futile. No firm finds it worthwhile to engage in imitation and therefore masking is also deemed unnecessary by innovating firms. However, perfect IPR protection is rarely observed. One reason is that monitoring and enforcement of IPR protection is costly. Another is that, even if it were costless, perfect IPR protection is not socially optimal (just as an infinite patent length is not socially optimal). Throughout the thesis we treat the level of IPR protection as imperfect and exogenously given.
With imperfect IPR protection in the background we consider incentives for imitation and masking. In particular, we examine the relationship between competition and these post-innovation business strategies. As we discuss later in Section 1.2, the relationship between competition and innovation has been studied extensively. However, little is known about the relationship between competition and these rent-seeking activities (i.e., imitation and masking). Examining this relationship, we not only establish a connection between competition and a class of commercial rent-seeking activities, but also take a step towards a more complete understanding of the interconnection between competition, IPR protection and innovation.

We illustrate our findings in a Hotelling linear city model. We depart from the standard symmetric Hotelling duopoly by assuming that one of the firms, say firm A, has a higher quality product, presumably due to prior success in innovation---a stage not modelled in this thesis. The rival firm, say Firm B, engages in costly imitation to reduce the quality gap while firm A invests in costly masking to maintain its quality advantage. Masking, imitation and the degree of imperfection in IPR protection jointly determine the effective quality advantage. Following investments in imitation and masking, firms compete in prices. Each consumer makes a purchasing decision based on quality, price and transport cost. Following the standard practice in the industrial organisation literature we interpret a consumer’s per-unit transport cost, $t$, as a measure for competition, or competitive pressure. In particular, the lower is $t$, the tougher is competition.

How does an increase in competition affect firms’ investments in imitation and masking? For a moment, assume that masking is exogenously given. As competition becomes tougher, firm B’s quality disadvantage plays a more prominent role in a consumer’s purchasing decision. Everything else equal, the market share of firm B---the laggard firm---decreases which in turn reduces firm B’s incentive to invest in imitation. Using similar logic about market shares we also show why firm A’s investment in masking might be higher. When both are endogenously
determined, investment in imitation declines directly due to the market share effect mentioned above and also indirectly due to a rise in masking by firm A. The effect of tougher competition on masking however is ambiguous. While tougher competition directly increases masking investment, the fact that firm B’s imitation investment declines implies that firm A can reduce its masking effort. These two conflicting effects are at the heart of the ambiguous relationship between competition and masking.

In addition to the effect of competition, we also looked at the effect of exogenous changes in IPR protection and initial quality gap on masking and imitation incentives. We find that a weakening of IPR protection raises both imitation and masking incentives. The same is also true for a rise in the initial quality gap.

However it is the effect of competition on imitation and masking that remains our primary focus throughout. Under imperfect protection of IPR, understanding the effect of competition on innovation remains incomplete unless we also learn about the effect of competition on post-innovation, rent-seeking strategies. While it would have been ideal to incorporate innovation, as well as imitation and masking in a single model, here we must be content in confining our focus to the post-innovation, rent seeking strategies with a hope to complement this with existing works on competition and innovation in the future.

Firms do not necessarily have to engage in imitation and masking. The knowledge that facilitates a quality advantage in the product market could be reduced or even eliminated via licensing. In Section 3, we assume that the quality gap is eliminated with a two part licensing contract where imitation and masking are exogenously given. We find that as competition becomes tougher, the fixed-fee decreases and the per-unit royalty increases.

Allowing for licensing costs, we find that these costs are more likely to be borne when competition is tougher. In other words, licensing is more likely to occur as competition
toughens. In our model, licensing (and in particular royalties) effectively allows firms to collude and charge higher price. Tougher competition implies that the gap between, on the one hand, collusive profits with licensing, and, on the other hand, competitive profits without licensing, widens. This in turn leads to a greater range of parameter values for costs for which licensing is more profitable.

As the per-unit royalty acts as a collusive instrument to charge higher prices, consumers are worse off under licensing. The loss in consumer surplus from the higher price outweighs the increase in consumer surplus from increased average quality and reduced transportation costs (as more consumers buy from their nearest firms as quality gap between the two firms go down)

The rest of the thesis is organised as follows. Section 1.2 reviews the existing literature on innovation, imitation, masking, and competition. Section 2 develops a two-stage Hotelling duopoly model where firms first invest in masking and imitation and subsequently compete in prices. First we attempt to understand the effect of competition on imitation and masking strategies. In addition we also explore the effect of a change in the degree of IPR protection and the initial quality advantage on such strategies. Section 3 extends the simple model to allow for a licensing. We derive the optimal two-part tariff and examine how the optimal contract varies with competition. In addition we discuss the effect of competition on the likelihood of licensing taking place. Section 4 concludes the thesis with a discussion of possible limitations and possible extensions of the thesis.
1.2 Literature

While the thesis primarily focuses on the relationship between competition and post-innovation strategies (masking, imitation, licensing), these strategies are operational only if (a) there are successful innovations and (b) protection of IPR is imperfect. Accordingly, first we discuss the relationship between competition and innovation, then we introduce the rationale for IPR protection. Finally we look at the literature on masking, imitation and piracy which has developed in the recent years.

The relationship between innovation and competition was first discussed by Schumpeter (1939) and then more formally analysed by Arrow (1962). Both agreed that some form of protection or monopoly post-innovation were required for incentives to innovate:

“any information obtained ... should, from a welfare point of view, be available free of charge...., but of course this provides no incentive for investment in research. (Arrow, 1962, pp. 616-617)”.

However Schumpeter and Arrow differed in their opinion on effectiveness of ex-ante competition in inducing innovation. While Schumpeter argued that a monopolist has more incentives to innovate, Arrow’s view was that a firm in a competitive industry has greater incentives. The essence of Arrow’s argument was that a monopolist’s fall back profit is positive while that of the competitors is zero --- thus the competitor values the innovation more.

Kamien & Schwartz (1982) were the first to quantitatively examine whether R&D activity depends positively or negatively on competition or market structure. They found no conclusive evidence. They note that a difficulty with empirical investigation of the relationship is that market structure and R&D expenditure are both endogenously determined. Similar ambiguity is noted in the theoretical study by Dasgupta and Stiglitz (1980).
More sophisticated, game theoretic models exploring the relationship between competition and innovation have been explored only recently (Raith, 2003; Vives 2008). Both Raith and Vives note that several measures have been used in the literature to serve as a proxy for competition including: number of firms, product differentiation, market size and costs of entry. Which measure is used does matter for understanding the relationship between competition and innovation. Vives (2004) finds that an increase in competition measured as an increase in the number of firms typically reduces incentives for R&D while when viewed as a decrease in product differentiation, an increase in competition increases the incentives for R&D.

We abstract away from market structure, or the number of firms, as a measure of competition by assuming a duopoly structure throughout the thesis. Instead, our focus is on product differentiation to examine the effect of competition on incentives for imitation and masking.

Mookherjee and Ray (1991) show that an increase in product market competition can stimulate R&D expenditure. Their intuition is that innovation incentives are higher when it provides a way to escape from close competition. This result is confirmed by empirical results by Nickell (1996) and Blundell, Griffith & Van Reenen (1993) which show a positive correlation between product market competition and productivity growth. Aghion, Bloom, Blundell, Griffith & Howitt (2000) find that the effect of product market competition on growth is usually monotonically positive, although sometimes it is inverse U-shaped. Ghosh, Kato & Morita (2011) make a distinction between discrete innovation and continuous improvement. They find that an increase in product market competition may reduce firms’ incentives to conduct continuous improvement. While a significant emphasis of our study is on product market competition, we confine our focus to its effect on the incentives for imitation and masking --- the possibility of which arise only when IPR protection is imperfect.
Early seminal works on IPR focus on patents, in particular the optimal length of patent. See, for example, the papers by Nordhaus (1969) and Tandon (1982). Patent offers monopoly to the innovator. On the one hand, strengthening IPR protection, i.e., a longer patent duration offers monopoly for longer periods of time which in turn provides more incentives to innovate. On the other hand, strengthening IPR protection reduces static welfare as the patent holder charges monopoly price, produces too little and generates deadweight loss. Optimal patent length is one where the marginal benefit from dynamic gains (i.e., higher innovation incentives) is equal to the marginal cost due to static welfare loss.

IPR debate, and patent violations in particular, has been prominent in the debate between the developed countries (i.e., North) and the developing countries (i.e., South). Helpman (1993) uses a general equilibrium framework to find that stronger IPR protection in the South reduces Southern welfare while the impact on Northern welfare is ambiguous. A general equilibrium model captures the static and dynamic welfare effects of IPR protection but it is not well suited for capturing the interactions between firms. Closer to our analysis, are the partial equilibrium frameworks used by Chin & Grossman (1990) and Deardorff (1992). They examine a model whereby Northern firms invest in R&D while the Southern firms invest in imitation. They find that the Southern firms and consumers benefits from weakening IPR protection while the Northern firm prefers full IPR protection. While we ignore R & D in our framework, we enrich our model by considering competition and costly masking and imitation which are not considered in these papers.

The partial equilibrium models of Mansfield, Schwartz & Wagner (1981), Levin (1988) and Taylor (1993) show that internal efforts are required by innovative firms to prevent misappropriation of rents from R&D investments. Taylor (1993) finds that both North and South have much to gain by moving away from a Pareto-inferior position where Northern and Southern resources are employed in masking and imitation. They propose that since the
intermediate level of patent stringency is welfare maximizing, multilateral negotiations concerning intellectual property rights hold promise for a settlement benefitting both North and South.

As in the papers mentioned above, our analysis incorporates the concept of masking and imitation; however our main focus is in understanding the interaction between these activities and competition.

Examining the impact of unauthorised usage on innovation incentives, Novos and Waldman (1984) find that the monopolist’s product quality is lower than socially optimum and conclude that there exists a negative relationship between unauthorised usage and innovation incentives. In a multi-product monopolist framework, Johnson (1985) also shows that the presence of unauthorised copying results in a dynamic under-provision of intellectual property. The dynamic under-provision depends on elasticity of innovation incentives and the value that consumers place on product quality. See also Besen & Kirby (1989) and Klemperer (1990) who report similar findings.

Yoon (2002) finds that welfare optimising IPR protection should be set in such a way such that a monopolist sets a price to deter entry. Profits are lower than unconstrained monopoly profits which reduce the incentives to innovate. However, the reduction in price increases static efficiency. Yoon finds that welfare gains arising from an increase in static efficiency dominates the welfare loss due to decline in innovation incentives. In Bae and Choi (2003), unauthorised users face two types of costs; a degradation cost and a reproduction cost. They find the extent of the trade-off between static and dynamic effects depends crucially on the type of IPR protection imposed.

Liebowitz (1985) shows that copying need not reduce the incentives to innovate. Revenues can be indirectly appropriated by the innovator as a result of imitation. This concept is pursued in
recent qualitative literature through a focus on the network effects of copying. Connor & Rumelt (1991), Takeyama (1994), Shy & Thisse (1999) among others, identify that piracy in software industries often has network effects on product usage. They find that network effects raise consumer valuations and enhance the demand by legitimate users.

Banerjee (2003) examines the impact of the government’s role in imitation prevention given competition between an incumbent monopolist and an entrant (i.e., commercial pirate). He finds that the government’s role is greater when network externalities are present. Lu & Poddar (2012) consider an original producer that makes a costly investment to deter a commercial pirate in a given regime of IPR protection. They find it is optimal for the original producer to accommodate the commercial pirate when IPR protection is weak and deter when IPR protection is strong. They also find that the most profitable way for an imitator to survive in the market is to produce a product of moderate quality.

A key difference with much of the work on commercial piracy described above is that we consider competition between two established firms rather than competition between an incumbent and an entrant. Furthermore, most papers on copying focus solely on vertical dimension: pirate produces a lower quality product than the incumbent. We introduce differentiation in both dimensions --- horizontal and vertical. Finally, a key difference is in the question. Unlike most papers which are concerned about welfare effects of IPR protection and piracy, we are concerned with a positive question: how does competition affect imitation and masking?

We conclude the thesis with licensing where firms’ ability to imitate and masking are treated as exogenous. Much of the discussion in the licensing literature focuses on the optimal payment mechanism. In the context of homogenous products and linear demand, Kamien and Tauman (1986) show that an external patentee prefers fee to royalty. Wang (1998) has shown that if the
patentee is an insider (i.e., also a competitor in the same industry) then royalty is more profitable licensing mechanism. Faulli-Oller & Sandonis (2002) analyses optimal two part tariff contract in a differentiated duopoly framework. They find that unless the extent of product differentiation is too little or too large optimal contract will involve royalty as well as fixed fee. In our Hotelling framework with differentiated products we also find that a two-part contract is optimal.

We differ in our emphasis on the role of competition. As competition increases the fixed fee component of the payment decreases while the royalty rate increases. The increase in royalty rate leads to higher price. In fact the price rise can be so much that the consumers can be worse off with licensing. Allowing for costly licensing we find that competition makes licensing more likely. Thus, our finding lends support to the casual observation that competition makes collaboration more likely.


2 The Model & Analysis

2.1 Setup

Assume a unit mass of consumers are uniformly distributed on the interval \([0,1]\). There are two firms, \(A\) and \(B\), competing for consumers. Firm \(A\) is located at \(x_A = 0\), and firm \(B\) is located at \(x_B = 1\) (see Figure 1 below).

![Figure 1: Hotelling Line](image)

Each consumer buys at most one unit from either firm \(A\) or \(B\). The indirect utility of any consumer \(y \in [0,1]\) from purchasing one unit of product \(i\) is given by:

\[
U_i(y) = V_i - p_i - t|x_i - y|; \quad i \in \{A, B\}
\]

where \(V_i, p_i\) and \(t|x_i - y|\) respectively denote the gross valuation of product \(i\), price of product \(i\) and transport cost of consumer \(y\) if she buys from firm \(i\). Consumer \(y\) buys from firm \(i\) if

\[
U_i(y) \geq \max\{U_j(y), 0\}; \quad i, j \in \{A, B\} \quad i \neq j.
\]

The transport cost, or disutility, incurred by consumers from buying product \(i\), has two components; the parameter \(t\) and the distance \(|x_i - y|\). We treat \(t\) as a parameter capturing the degree of competition. An increase in \(t\) raises the per-unit transport cost for consumers and softens competition between the two firms. Thus, \(t\) is inversely related to the degree of competition. As discussed in Section 1.2, the degree of competition represents the competitive pressure of the product market rather than the number of firms. The distance \(|x_i - y|\) captures the difference between the location of firm \(i\) and consumer location \(y\).
A firm’s market power is derived from both horizontal and vertical differentiation. As the locations and hence the distance between the two firms are fixed, horizontal differentiation is captured solely by the competition parameter $t$. The higher is $t$, the greater is the degree of horizontal differentiation. Without loss of generality assume $V_A > V_B$, i.e., firm $A$ has a better quality product than firm $B$. The extent of vertical differentiation is captured by the initial quality gap $\Delta \equiv V_A - V_B$.

Firm $B$ exerts effort $z_B$ to imitate and curtail the initial quality gap. Firm $A$ exerts effort $z_A$ to deter imitation and preserve the initial quality gap. As firms engage in imitation and masking, effective quality of product $A$, is unaffected by imitation and masking. Hence, $\overline{V}_A = V_A$. The effective quality of product $B$ is:

$$\overline{V}_B = V_B + \theta \Delta z_B (1 - z_A),$$

where $z_A$ and $z_B$ are as explained above and $\theta$ captures the degree of IPR protection. If $\theta = 0$, IPR protection is perfect and $\overline{V}_B = V_B$. The extent of vertical differentiation is unaffected by imitation and masking. If $\theta > 0$, IPR protection is imperfect and $\overline{V}_B > V_B$. As $\theta$ increases and IPR protection weakens, *Ceteris Paribus*, the extent of vertical differentiation is reduced as the effective quality of firm $B$ is higher. The same is true for an increase in firm $B$’s imitation effort $z_B$, while the opposite is true for an increase in firm $A$’s masking effort $z_A$ and a rise in the initial quality gap. The effective quality gap can be expressed as:

$$\tilde{\Delta} \equiv \overline{V}_A - \overline{V}_B$$

$$= V_A - V_B - \theta \Delta z_B (1 - z_A)$$

$$= \Delta (1 - \theta z_B (1 - z_A))$$

Lemma 1 records some basic features of $\tilde{\Delta}$ for future reference:
Lemma 1

a) The effective quality gap narrows as
   i) The degree of IPR protection weakens;
   ii) Imitation effort increases;

b) The effective quality gap widens as
   i) The initial quality gap rises;
   ii) Masking effort increases.

We assume both firms incur zero production costs. However, firms incur costs for imitation and masking efforts. The cost of masking to firm \( A \) is given by \( C_A(z_A) = \frac{y_A z_A^2}{2} \). The cost of imitation to firm \( B \) is given by \( C_B(z_B) = \frac{y_B z_B^2}{2} \). The cost parameters \( y_A \) and \( y_B \) determine the marginal cost of imitation and masking. In particular, a higher \( y_i \) implies a steeper marginal cost of investment. Note that the marginal cost of the first unit of imitation and masking is zero. This implies both imitation and masking always occur in equilibrium under imperfect IPR protection.

We consider the following two stage game, denoting \( z_A \) and \( z_B \) as masking and imitation effort:

Stage 1: Masking and Imitation

Given \( \theta, \Delta, t \) and \( y_i \), each firm \( i \) exerts effort \( z_i \) to maximise profit, taking rival firm’s effort \( z_j \) as given; where \( i, j \in \{A, B\}, i \neq j \).

Stage 2: Bertrand Competition

Given \( \theta, \Delta, t, z_i, \) and \( z_j \), each firm \( i \) chooses price \( p_i \) to maximise profit, taking rival firm’s price \( p_j \) as given; where \( i, j \in \{A, B\}, i \neq j \).
2.2 Analysis

Starting in Stage 2, we find equilibrium prices $p_i^*$ and profits $\pi_i^*$ from Bertrand competition.

Proceeding iteratively to Stage 1, we find the optimal choice of $z_i$ for a given $z_j; i, j = \{A, B\}, i \neq j$. We then analyse the unique subgame perfect equilibrium and present comparative statics. Prior to our analysis we make one simplifying assumption on the parameter values $\Delta, t, V_A$ and $V_B$.

Assumption 1:

$$\Delta < 3t. \quad (2.2)$$

Assumption 1 ensures Stage 2 equilibrium prices are positive in all sub games. We also assume $V_A$ and $V_B$ are large enough to ensure and that firms compete over all consumers and in equilibrium, all consumers buy at least one unit of the product.

2.2.1 Bertrand Equilibrium

Consider the Stage 2 game. First, we determine the marginal consumer $\hat{y}$ who is indifferent between buying from firm $A$ and firm $B$. Solving $U_A(\hat{y}) = U_B(\hat{y})$ gives:

$$\hat{y} = \frac{1}{2} + \frac{\hat{A} - (p_A - p_B)}{2t}.$$ 

All consumers $y \in [0, \hat{y}]$ buy product $A$ and all consumers $y \in [\hat{y}, 1]$ buy product $B$. Given the total market size is one and consumers are uniformly distributed, the respective demand functions faced by firms $A$ and $B$ are:

$$Q_A(p_A, p_B) = \hat{y} = \frac{1}{2} + \frac{\hat{A} - (p_A - p_B)}{2t}, \quad Q_B(p_A, p_B) = 1 - \hat{y} = \frac{1}{2} - \frac{\hat{A} - (p_A - p_B)}{2t}. \quad (2.3)$$
Using the demand functions from (2.3) we write the stage 2 profits of firms $A$ and $B$ as:

$$
\pi_i(p_A, p_B) = p_i \left( \frac{1}{2} + \frac{\tilde{\Delta} - (p_i - p_j)}{2t} \right); \quad i, j = \{A, B\}, i \neq j.
$$

(2.4)

As firms engage in Bertrand competition, firm $i$ chooses $p_i$ to maximise its profit function, given by (2.4). Setting $\frac{\partial \pi_i}{\partial p_i} = 0$, solving for $p_A$ and $p_B$, and then expanding $\tilde{\Delta}$ using expression (2.1), we get the optimal prices:

$$
p_A^* = t + \frac{\tilde{\Delta}}{3} = t + \frac{\Delta(1 - \theta z_B(1 - z_A))}{3},
$$

(2.5)

$$
p_B^* = t - \frac{\tilde{\Delta}}{3} = t - \frac{\Delta(1 - \theta z_B(1 - z_A))}{3}.
$$

(2.6)

Observe (2.5) and (2.6). As product $A$ is of better quality than product $B$, firm $A$ charges a higher price than firm $B$. Substituting equilibrium prices from (2.5) and (2.6) in the demand functions from (2.3) and simplifying, gives the equilibrium quantities $Q_i^*$ and profits $\pi_i^*$.

$$
Q_A^* = \left( \frac{1}{2} + \frac{\Delta(1 - \theta z_B(1 - z_A))}{6t} \right), \quad Q_B^* = \left( \frac{1}{2} - \frac{\Delta(1 - \theta z_B(1 - z_A))}{6t} \right),
$$

(2.7)

$$
\pi_A^* = 2t \left( \frac{1}{2} + \frac{\Delta(1 - \theta z_B(1 - z_A))}{6t} \right)^2, \quad \pi_B^* = 2t \left( \frac{1}{2} - \frac{\Delta(1 - \theta z_B(1 - z_A))}{6t} \right)^2.
$$

(2.8)

Despite a higher price, (2.7) shows firm $A$ also sells to more consumers than firm $B$. The effective quality gap $\tilde{\Delta}$ is of greater value to consumers than the difference in prices, $\left( \frac{2\Delta}{3} \right)$. As a result of a higher price and greater quantity, (2.8) shows firm $A$’s profit to be larger than firm $B$’s profit. Firm $A$’s ability to charge higher prices whilst commanding a greater quantity results from the extent of vertical differentiation. A widening or narrowing of the effective
quality gap determines the extent of vertical differentiation and in-turn firm A’s market power.

Lemma 2 records comparative static results for the Stage 2 Bertrand equilibrium outcome:

**Lemma 2**

Given firm locations (i.e., \( x_A = 0 \) and \( x_B = 1 \)),

a) \( p_A^*, Q_A^* \) and \( \pi_A^* \) are decreasing in \( \theta \) and increasing in \( \Delta \);

b) \( p_B^*, Q_B^* \) and \( \pi_B^* \) are increasing in \( \theta \) and decreasing in \( \Delta \);

c) i) \( p_A^* \) and \( p_B^* \) are increasing in \( t \);

ii) \( Q_A^* \) is decreasing in \( t \) and \( Q_B^* \) is increasing in \( t \);

iii) \( \pi_A^* \) and \( \pi_B^* \) are increasing in \( t \).

**Proof**: See Appendix.

Consider first the effect of IPR protection the equilibrium outcome. From Lemma 1, we recall that a weakening of IPR protection (i.e., an increase in \( \theta \)) narrows the effective quality gap. The consequent rise in product B’s effective quality \( \bar{V}_B \) reduces the extent of vertical differentiation. Thus, firm A’s price and market share both decline while firm B’s price and quantity both rise. A fall in the initial quality gap \( \Delta \) works exactly the same way as a weakening of IPR protection.

An increase in \( t \) softens competition between firms. This has two effects. Firstly, weaker competition (i.e., greater product differentiation) enables both firms to raise their prices. Secondly, firm A’s market power is diminished. As products become more differentiated, product quality becomes less important as a source of differentiation. Thus, firm A’s market share decreases while firm B’s market share increases.
The effect of softening competition on firm B’s profit is positive as both its price and quantity increase. The effect on firm A’s profit however is unclear as its price increases and quantity decreases. We find that the positive effect from a higher price dominates the negative effect from a lower quantity. Consequently, softer competition raises firm A’s profit as well as firm B’s profit.

### 2.2.2 Imitation Strategy

Now we consider the choice of imitation $z_B$ for an exogenously given masking effort $z_A$.

Taking $z_A, \theta, \Delta, t$ and $\gamma_B$ as given, firm B chooses $z_B$ to maximise

$$\Pi_B = \pi_B^* - \frac{\gamma_B z_B^2}{2}.$$  

The marginal benefit from imitation, denoted by $MB_{z_B}$, is:

$$\frac{\partial \pi_B^*}{\partial z_B} = \left(\frac{1}{2} - \frac{\Delta(1 - \theta z_B(1 - z_A))}{6t}\right) \left(\frac{2\theta \Delta(1 - z_A)}{3}\right) = MB_{z_B}, \quad (2.9)$$

while the marginal cost of imitation, denoted $MC_{z_B}$, is:

$$\frac{\partial}{\partial Z_B} \left(\frac{\gamma_B z_B^2}{2}\right) = \gamma_B z_B = MC_{z_B}. \quad (2.10)$$

Equating the marginal benefit $MB_{z_B}$ with the marginal cost $MC_{z_B}$ from (2.9) and (2.10) gives the optimal imitation $z_B^*$, for a given masking effort $z_A$:

$$z_B^* = \frac{(\theta \Delta)(3t - \Delta)(1 - z_A)}{9t \gamma_B - (\theta \Delta(1 - z_A))^2}. \quad (2.11)$$

The following Proposition follows from analysis of (2.11):
Proposition 1

For a given masking effort $z_A$, firm $B$'s optimal imitation effort $z_B^*$

a) increases as

i) IPR protection weakens ($\theta$ increases);

ii) The initial quality gap rises ($\Delta$ increases);

iii) Firm $A$'s masking effort declines ($z_A$ decreases);

b) decreases as

i) Competition becomes tougher ($t$ decreases).

Proof: See Appendix.

Before explaining the intuition, we use Figure 2 (see below) to illustrate how the marginal benefit and marginal cost of imitation are affected by IPR protection. The marginal benefit and marginal cost curves are labelled $mB_{z_B}$ and $mC_{z_B}$ respectively. A weakening of IPR protection raises the marginal benefit of imitation for a given masking effort (see appendix). Consequently, as shown in Figure 2, the marginal benefit curve shifts upwards from $mB_{z_B}$ to $mB'_{z_B}$. The marginal cost of imitation is independent of IPR protection. Ceteris paribus, a shift in the marginal benefit curve increases the optimal imitation effort from $z_B^*$ to $z_B^{*'}$ when masking is exogenously given. The same is true for a rise in the initial quality gap and a decrease in firm $A$’s masking effort. The opposite is true for tougher competition.
From Lemma 1, we know that a weakening of IPR protection narrows the effective quality gap. A reduction in vertical differentiation diminishes firm A’s market power. Therefore, firm A’s price and quantity decline while firm B’s price and quantity rise. An increase in firm B’s market share raises its incentive to engage in imitation. All else equal, weaker IPR protection increases the optimal imitation effort $z^*_B$ for a given masking effort $z_A$. A rise in the initial quality gap and a decrease in firm A’s masking effort work similarly to increase $z^*_B$ for a given $z_A$.

Now consider the effect of competition. As competition becomes tougher both products are less horizontally differentiated. As a result, vertical differentiation is more important as a source of differentiation for consumers. Since firm B has a lower quality product than firm A, the demand for product B declines. A decrease in firm B’s market share reduces its incentive to engage in imitation. Thus, we find that else equal, tougher competition decreases the optimal imitation effort for a given masking effort.
2.2.3 Masking Strategy

We now consider firm A’s choice of masking $z_A$ for exogenously given imitation $z_B$. Taking $z_B$, $\theta$, $\Delta$, $t$ and $\gamma_A$ as given, firm A chooses $z_A$ to maximise:

$$\Pi_A \equiv \pi_A^* - \frac{\gamma_A z_A^2}{2}.$$  

The marginal benefit of masking, denoted by $MB_{z_A}$, is:

$$\frac{\partial \pi_A^*}{\partial z_A} = \frac{1}{2} + \frac{\Delta(1 - \theta z_B(1 - z_A))}{6t} \left( \frac{2\theta \Delta z_B}{3} \right) \equiv MB_{z_A}. \quad (2.12)$$

while the marginal cost of masking, denoted by $MC_{z_A}$, is:

$$\frac{\partial}{\partial z_A} \left( \frac{\gamma_A z_A^2}{2} \right) = \gamma_A z_A \equiv MC_{z_A}. \quad (2.13)$$

Equating the marginal benefit, $MB_{z_A}$, with the marginal cost, $MC_{z_A}$ from (2.12) and (2.13) gives the optimal masking $z_A^*$ for a given imitation effort $z_B$:

$$z_A^* = \frac{(3t + \Delta - \theta \Delta z_B)(\theta \Delta z_B)}{9t \gamma_A - (\theta \Delta z_B)^2}. \quad (2.14)$$

The following Proposition follows from analysis of (2.14):

**Proposition 2**

*For a given imitation effort $z_A$ firm A’s optimal masking effort $z_A^*$ increases as*

a) *IPR protection weakens ( $\theta$ increases);*

b) *The initial quality gap rises ( $\Delta$ increases);*

c) *Competition becomes tougher ( $t$ decreases);*

d) *Firm B’s imitation effort increases ( $z_B$ increases).*
**Proof**: See Appendix.

We use Figure 3 (see below) to illustrate how the marginal benefit and marginal cost of masking are affected by IPR protection. The marginal benefit and marginal cost curves are labelled $mB_{zA}$ and $mC_{zA}$ respectively. A weakening of IPR protection raises the marginal benefit of masking for a given imitation effort (see appendix). Consequently, as depicted in Figure 3, the marginal benefit curve shifts upwards from $mB_{zA}$ to $mB'_{zA}$. The marginal cost curve $mC'_{zA}$ is independent of this. *Ceteris paribus*, a shift in the marginal benefit curve increases the optimal masking effort from $z_A^*$ to $z_A^{*'}$, for an exogenously given imitation effort. The same is true for a rise in the initial quality gap, tougher competition and a decrease in firm $B$’s imitation effort.

![Figure 3: Marginal benefit and marginal cost of masking.](image)

The total level of imitation prevention is comprised of the public and private sector’s roles. Weakening of IPR protection magnifies the private sector’s role in preserving the effective quality gap. Therefore, a greater effect of masking raises their incentive for masking. All else equal, weakening of IPR protection increases the optimal masking effort for a given imitation effort.
Recall that as competition becomes tougher, vertical differentiation is more important as a source of differentiation for consumers. Since firm $A$ has a higher quality product than firm $B$, the demand for product $A$ increases. An increase in firm $A$’s market share raises their incentive for masking. All else equal, tougher competition increases the optimal masking effort for a given imitation effort.

### 2.2.4 Subgame Perfect Nash Equilibrium

We now analyse the unique SPNE using optimal strategies derived in Sections 2.2.2 and 2.2.3. Figure 4 plots the masking reaction function (curve) by $A$ and the imitation reaction function (curve) by $B$. The equilibrium, denoted $E^*$, is given by the intersection of $A$ and $B$. The equilibrium masking and imitation effort are denoted $\tilde{z}_A$ and $\tilde{z}_B$ respectively.

![Figure 4: Reaction Functions and SPNE](image-url)
The following proposition follows from analysing the SPNE of the overall game.

**Proposition 3**

*The equilibrium masking effort* $\tilde{z}_A$:

a) Increases as

i) IPR protection weakens ($\theta$ increases);

ii) The initial quality gap rises ($\Delta$ increases);

b) is ambiguously affected by tougher competition ($t$ decreases).

*The equilibrium imitation effort* $\tilde{z}_B$:

a) is ambiguously affected as IPR protection weakens ($\theta$ increases);

b) is ambiguously affected as the initial quality gap rises ($\Delta$ increases);

c) Decreases as

i) Competition becomes tougher ($t$ decreases).

**Proof**: See Appendix.

Figure 5 (see next page) illustrates the effect of weakening IPR protection on masking and imitation. As IPR protection weakens, both masking and imitation curves shift to the right from $AA'$ to $AA''$ and $B'B'$ to $B''B''$, respectively. Consequently, the equilibrium moves to the right from $E^*$ to $E''$ and masking conclusively increases from $\tilde{z}_A$ to $\tilde{z}_A'$.

The effect on imitation is ambiguous depending on the relative shift in curves. If the shift in the masking curve is greater than the shift in the imitation curve from, imitation increases from $\tilde{z}_B$ to $\tilde{z}_B'$ (as in Figure 5). If the same shift in the imitation curve is smaller than the shift in the
masking curve, imitation decreases from $\bar{z}_B$ to $\bar{z}_B'$. The exact same explanation of Figure 5 is true for a rise in the initial quality gap.

Figure 5: The effect of weakening IPR protection

Figure 6 (see next page) illustrates the effect of tougher competition on masking and imitation. As competition becomes tougher, the masking curve shifts to the right from $AA'$ to $A'A''$ while the imitation curve shifts to the left from $B'B'$ to $B''B''$. Consequently, the equilibrium moves down from $E^*$ to $E^{*'}$ and imitation conclusively decreases from $\bar{z}_B$ to $\bar{z}_B'$.

The effect on masking is ambiguous depending on the relative shift in curves. If the shift in the masking curve is greater than the shift in the imitation curve, masking increases from $\bar{z}_A$ to $\bar{z}_A'$. If the shift in the masking curve is smaller than the shift in the imitation curve, masking decreases from $\bar{z}_A$ to $\bar{z}_A'$ (as in Figure 6).
2.3 Discussion

There are many confounding factors such as endogenously determined strategies which add ambiguity to our primary focus; understanding the effect of competition on imitation and masking incentives. However, the pure effects of competition, determined by Propositions’ 1 and 2, are still noticeable within industries in which competition has a crucial role to play.

Competition in our framework is tougher as product differentiation declines. Recall the examples of the zipper and car manufacturing industries respectively. Competition in the zipper manufacturing industry is relatively tough as there are only a handful of features to differentiate (i.e., colour, fabric, durability). In contrast, competition in the car manufacturing industry is relatively weak as there are countless features that can be differentiated.

Figure 6: The effect tougher competition
Proposition 1 reveals the intuition behind Hyundai’s significant imitation strategy. In contrast to an industry of tough competition, when competition is weak product quality becomes less important as a source of differentiation for consumers. Since Hyundai in the 1990’s was renowned for its quality disadvantage, its market share was low relative to its competitors. As a result, Hyundai’s imitation strategy is significant in the car manufacturing industry.

Proposition 2 reveals the intuition behind YKK’s significant masking strategy. In an industry of tough competition, product quality becomes more important as a source differentiation for consumers. Since YKK is renowned for its relatively high product quality, its market share is high relative to its competitors. As a result, YKK’s masking strategy is significant in the zipper manufacturing industry.

Remark

While tougher competition unambiguously reduces imitation, the effect on masking is ambiguous as explained in Section 2.2.4. This prevents us from considering a full-blown analysis of welfare effects. However, a few observations for consumers can be made by assuming an exogenously given masking effort.

Figure 7 (see next page) divides the unit interval into three sets of consumers. Let the initial value of the competition parameter be $t = t_o$. As competition becomes tougher, the new lower value for the competition parameter becomes $t = t_N$. The marginal consumers with $t = t_o$ and $t = t_N$ are denoted $\hat{y}_o$ and $\hat{y}_N$ respectively.

- The set $\alpha$ consists of all consumers $y \in [0, \hat{y}_o]$ who buy from firm $A$ both when $t = t_o$ and $t = t_N$.
- The set $\beta$ consists of all consumers $y \in [\hat{y}_N, 1]$ who buy from firm $B$ both when $t = t_o$ and $t = t_N$.  

27
The set \( y \) consists of all consumers \( y \in [\hat{y}_o, \hat{y}_N] \) who buy from firm \( B \) when \( t = t_o \) and from firm \( A \) when \( t = t_N \).

The following points extend the observations made above:

1. Recall from Proposition 1 that imitation decreases as competition becomes tougher (i.e., \( t \) decreases from \( t_o \) to \( t_N \)). A reduction in imitation results in a decrease in the effective quality of product \( B, \overline{V}_B \). Consequently, consumers in set \( \beta \) are made worse off as they now buy a lower quality product. While consumers in sets \( \alpha \) and \( \gamma \) are unaffected by a decrease in \( \overline{V}_B \) as both sets of consumers purchase product \( A \).

2. A decrease in \( \overline{V}_B \) implies that the effective quality gap \( \tilde{\Delta} \) widens. Thus, consumers in the set \( \gamma \) are willing to travel further than their closest firm, firm \( B \), to purchase a higher quality product from firm \( A \). This has an increasing effect on the aggregate transport cost. However, the total effect of tougher competition is ambiguous as it also reduces the transport costs for all consumers on the interval (i.e., sets \( \alpha, \beta \) and \( \gamma \)).

3. Another effect of a widening \( \tilde{\Delta} \) is that firm \( A \)'s price increases while firm \( B \)'s price decreases (see Lemma 2). Consumers in sets \( \alpha \) and \( \gamma \) are worse off from higher prices while consumers in set \( \beta \) are better off from lower prices.
3 Licensing: A Contracting Solution

3.1 Setup

In the previous section, firms non-cooperatively engaged in imitation and masking. We now consider the possibility of a contracting solution with imitation and masking in the background. Suppose firm \( A \) can license its product features to firm \( B \). For simplicity, assume that licensing eliminates the quality gap. Thus, \( \Delta = 0 \).

Firm \( A \) sets a two-part tariff for the license. The two-part tariff includes a fixed-fee, denoted \( F \), and a per-unit royalty, denoted \( r \). Licensing only takes place if both firms earn at least as much as the non-licensing case, where imitation and masking are exogenously given. For now, assume that the licensing is costless for both firms. The timing of the game is as follows.

Stage 1: Option to License

Firm \( A \) sets a two part tariff \((r, F)\) to maximise its product market profit plus licensing revenues.

Stage 2: Bertrand Competition

Firm \( i \) chooses price \( p_i \) to maximise product market profit taking rival firm’s price \( p_j \) as given; \( i, j \in \{A, B\}, i \neq j \).

Prior to our analysis we make a simplifying assumption on the parameter values of \( V_A \) and \( t \).

Assumption 2:

\[
V_A > \frac{5t}{2} \tag{3.1}
\]

Assumption 2 ensures that (i) all consumers buy and (ii) both firms sell a strictly positive amount in the equilibrium of the licensing sub-game. We also carry over our earlier assumptions from Section 2, namely, Assumption 1.
3.2 Analysis

3.2.1 Bertrand Equilibrium

If licensing occurs the quality gap is eliminated. The demand functions faced by both firms are similar to the demand functions from Section 2, given by (2.3), except now $\Delta = 0$:

$$Q_A(p_A, p_B) = \frac{1}{2} + \frac{p_A - p_B}{2t}, \quad Q_B(p_A, p_B) = \frac{1}{2} - \frac{p_B - p_A}{2t}. \quad (3.2)$$

Using (3.2), we can write the Stage 2 profit functions as:

$$\pi_A(p_A, p_B) = p_A \left( \frac{1}{2} + \frac{p_B - p_A}{2t} \right) + r \left( \frac{1}{2} + \frac{p_A - p_B}{2t} \right) + F, \quad (3.3)$$

$$\pi_B(p_A, p_B) = (p_B - r) \left( \frac{1}{2} + \frac{p_A - p_B}{2t} \right) - F. \quad (3.4)$$

Solving for equilibrium prices under licensing, denoted $p^L_\ast$, we get:

$$p^L_\ast(r) = p^L_\ast(r) = t + r. \quad (3.5)$$

Note that the equilibrium price (3.5) is the same for both firms. The per-unit royalty acts as a collusive device for firms to maintain high prices particularly as competition becomes tougher.

Comparing prices to Section 2, firm $B$’s price under licensing is always greater than its price under quality asymmetry. This is true for two reasons. First, firm $B$’s product quality is now higher for which consumers are willing to pay more. Second, firm $B$ is able to pass on the entire increase in unit cost from its per-unit royalty payment through a higher price. Substituting the equilibrium price (3.5) into the demand and profit functions above gives the equilibrium quantities $Q^L_\ast$ and profits $\pi^L_\ast$ with a two-part licensing contract.
\[
Q^L_A(r) = Q^L_A(r) = \frac{1}{2},
\]
\[
\pi^L_A(r) = \frac{t}{2} + r + F, \quad \pi^L_B(r) = \frac{t}{2} - F.
\]

Observe (3.6). The market is divided equally as prices and product qualities are the same. Note that firm B’s profit (3.7) is independent of the per-unit royalty rate. The increase in cost from the per-unit royalty is offset by an increase in its price of exactly the same amount.

3.2.2 Licensing

Now consider Stage 1. Firm B, the licensee, will accept any licensing contract as long as its product market profit with licensing (3.7) is at least as much as its product market profit without licensing from (2.8):

\[
\frac{t}{2} - F \geq 2t \left( \frac{1}{2} - \frac{\tilde{A}}{6t} \right)^2.
\]

Firm A, the licensor, will similarly be willing to set any licensing contract if its product market profit with licensing (3.7) is at least as much as its product market profit without licensing (2.8):

\[
\frac{t}{2} + r + F \geq 2t \left( \frac{1}{2} + \frac{\tilde{A}}{6t} \right)^2.
\]

Assume firm A sets a take-it or leave-it offer for the licensing contract. The offer is such that firm B is indifferent between licensing and not licensing. Firm A sets the fixed-fee to extract firm B’s entire surplus from licensing. Setting firm B’s participation constraint (3.9) to bind with equality gives Lemma 3.
Lemma 3

The optimal fixed-fee $F^*$ is:

$$F^* = \frac{\bar{\Delta}(6t - \bar{\Delta})}{18t}$$

Firm $A$ chooses the per-unit royalty rate $r$ to maximise its product market profit plus licensing revenue:

$$\pi_A^L = \frac{t}{2} + r + F^*$$

Recall that simply setting the fixed-fee at $F^*$ ensures firm $B$’s participation. The fixed-fee decreases as firm $B$’s profit declines. It is worth noting that firm $B$’s participation in the licensing contract is independent of the per-unit royalty. Firm $A$ can increase the per-unit royalty to the point when then the marginal consumer with licensing (i.e., $\hat{y}^L = \frac{1}{2}$) is indifferent between buying and not buying.\(^1\) Thus, $r$ must satisfy:

$$V_A - t - r - \frac{t}{2} = 0.$$  \hfill (3.11)

Re-arranging (3.11) for $r$ and applying Assumption 2, we arrive at Lemma 4:

Lemma 4

The optimal per-unit royalty, $r^*$, is:

$$r^* = V_A - \frac{3t}{2}.$$  

Combining Lemma 3 and Lemma 4 gives Proposition 4.

\(^1\) Firm $A$ can charge a higher per-unit royalty rate than $r^*$ such that the marginal consumer $\hat{y}^L$ does not buy and firms charge a monopoly price to a smaller set of consumers. Assumption 2 ensures that this is a less profitable strategy than choosing a royalty rate that ensures all consumers are covered.
Proposition 4

a) The optimal two part tariff contract \((r, F)\) involves a per-unit royalty \(r^*\) and a fixed-fee \(F^*\):

\[ r^* = V_A - \frac{3t}{2}, \quad F^* = \frac{\bar{\Delta}(6t - \bar{\Delta})}{18t}. \]

b) As competition becomes tougher, the fixed fee decreases and the per-unit royalty increases.

Substituting \(r^*\) and \(F^*\) from Lemma 3 and Lemma 4 into the equilibrium outcome above, given by (3.5), (3.6) & (3.7), we get:

\[ p^*_A = p^*_B = V_A - \frac{t}{2}, \quad (3.12) \]

\[ Q^*_A = Q^*_B = \frac{1}{2}, \quad (3.13) \]

\[ \pi^*_A = V_A - t - \frac{\bar{\Delta}(6t - \bar{\Delta})}{18t}, \quad \pi^*_B = \frac{t}{2} - \frac{\bar{\Delta}(6t - \bar{\Delta})}{18t}. \quad (3.14) \]

Observe from (3.12) that tougher competition results in a higher equilibrium price. Firm \(A\)'s profit increases as a result of the higher price while firm \(B\)'s profit in fact decreases. Recall that firm \(B\)'s higher price is offset by its royalty payment. This implies that its net price \((i.e., p^*_B - r = t)\) declines as competition becomes tougher. The surplus that firm \(A\) can extract from firm \(B\) through a fixed-fee decreases. The basis for this outcome is the fact that the per-unit royalty acts as a collusive instrument.
3.3 Licensing Cost

So far we have assumed that licensing is a costless process. In reality, licensing like all other forms of contracting is usually costly. Let $L$ denote the cost associated with licensing. The joint profit of firms with licensing is given by:

$$\pi_A^* + \pi_B^* = V_A - \frac{t}{2}. \quad (3.15)$$

Recall that tougher competition increases firm $A$’s profit with licensing but reduces firm $B$’s profit with licensing. However, it’s clear from (3.15) that joint profit with licensing increases with tougher competition. As the per-unit cost of transport for consumers decreases, firms use the royalty as a collusive device to extract more through higher prices.

The joint profit without licensing is:

$$\pi_A^* + \pi_B^* = 2t \left( \frac{1}{2} + \frac{\bar{\Delta}}{6t} \right)^2 + 2t \left( \frac{1}{2} - \frac{\bar{\Delta}}{6t} \right)^2. \quad (3.16)$$

Recall from Lemma 2 that tougher competition reduces both firms’ profits without licensing. Therefore, the joint profit decreases as competition becomes tougher.

A licensing agreement will only take place if the joint profit under licensing including the cost, is at least as much as the joint profit without licensing:

$$\pi_A^{l*} + \pi_B^{l*} - L \geq \pi_A^* + \pi_B^*. \quad (3.17)$$

Re-arranging the condition given by (3.17) for $L$ gives the threshold cost of licensing, denoted $\hat{L}$, for which licensing occurs:

$$L \leq (\pi_A^{l*} + \pi_B^{l*}) - (\pi_A^* + \pi_B^*) \equiv \hat{L} \quad (3.18)$$

As mentioned above, tougher competition implies that the joint profit with licensing increases and without licensing decreases. Thus, $\hat{L}$ (the difference between the joint profits) increases as competition becomes tougher.
Proposition 5

As competition becomes tougher, licensing becomes more likely. More precisely, \( \hat{L} \) increases as \( t \) decreases.

3.4 Welfare Comparison

A full comparison of social welfare with and without licensing is not possible as imitation, masking and the initial quality gap are all exogenous. However, a few welfare observations of licensing compared to without licensing are worth noting.

Figure 8 divides the unit interval into three sets of consumers. Let \( l = 1 \) when licensing occurs and \( l = 0 \) when licensing does not incur. The marginal consumers with and without licensing is denoted \( \hat{y}^L \) and \( \hat{y} \) respectively.

- The set \( \alpha \) consists of all consumers \( y \in [0, \hat{y}^L] \) who buy from firm \( A \) both when \( l = 1 \) and \( l = 0 \).
- The set \( \beta \) consists of all consumers \( y \in [\hat{y}, 1] \) who buy from firm \( B \) both when \( l = 1 \) and \( l = 0 \).
- The set \( \gamma \) consists of all consumers \( y \in [\hat{y}^L, \hat{y}] \) who buy from firm \( B \) when \( l = 1 \) and from firm \( A \) when \( l = 0 \).

\[
\hat{y}^L = \frac{1}{2} \quad \hat{y}
\]

Figure 8: Welfare comparison with licensing and without licensing.
The following points extend the observations made above:

1. As both firms sell a high quality product, licensing eliminates the quality gap and raises the average product quality. Consumers in set $\beta$ are a better off as they buy a higher quality product compared to the case without licensing. Consumers in sets $\alpha$ and $\gamma$ are unaffected as they buy a high quality product both with and without licensing.

2. As product quality and prices of both firms are the same under licensing, all consumers purchase from their closest firm. Recall that in the absence of licensing, consumers in the set $\gamma$ incur additional transport costs from travelling to firm $A$. Therefore, under licensing, the transport costs for consumers in set $\gamma$ are reduced as they no longer travel to firm $A$. However, transport costs of consumers in sets $\alpha$ and $\beta$ remain unaffected by licensing.

3. Recall that the per-unit royalty is used as a collusive device by firms to charge higher prices. All consumers on the interval are worse off from a higher price compared to without licensing.

**Lemma 5**

*Under licensing, consumers in sets $\alpha$ and $\gamma$ are worse off while consumers in set $\beta$ are only worse off if product B's quality is sufficiently high.*

**Proof:** See Appendix.

The benefit to consumers from higher quality products and lower transport costs is offset by a loss from higher prices. However, it is worth noting that the loss to consumers from higher prices is simply a net transfer to producers. Therefore, even though consumers are worse off, licensing can be socially desirable.
4 Conclusion

Imitation and masking are important post-innovation strategies employed by commercial firms. While there is an extensive literature on competition in relation to innovation, limited attention has been given to competition and these post-innovation, rent seeking strategies. Our study fills this important gap in the literature by analysing the effect of product market competition on imitation and masking.

We have considered a linear Hotelling duopoly model using the per-unit transport cost as a measure for competition. We primarily examined the effect of competition on imitation and masking. Our main finding is that tougher competition reduces the incentive for imitation and raises the incentive for masking. We also find that a weakening of IPR protection and a rising initial quality gap both raise the incentive for imitation and masking respectively.

We extend our model to determine the effect of competition on licensing. The analysis assumes that both firms are capable of post-innovation rent seeking strategies (imitation and masking) and that licensing eliminates the entire initial quality gap. We find that tougher competition raises the fixed-fee and reduces the per-unit royalty. When licensing is costly, firms are more willing to bear this cost and ensure licensing takes place when competition is tougher.

There are two main limitations to our analysis which reveal scope for potential extensions;

1. Our analysis has focused on the effect of competition on the post-innovation incentives for imitation and masking. However, we have been silent on the effect of competition on innovation incentives. A fuller model would capture this effect through an endogenously determined innovation. A relatively simple way to do apply this extension is to impose an
additional stage to the game. In Stage 0, firm $A$ makes an investment $\frac{k \Delta^2}{2}$ in the size of its initial quality gap $\Delta$ and then stage 1 and stage 2 remains as in the main text. We conjecture that if imitation goes down with an increase in competition (as it does in our framework), the positive relationship between competition and innovation will be strengthened. More importantly, this suggests that competition can play a supplementary role to IPR policy.

2. Our analysis implicitly assumes that both firms are domestic. However, much of the debate regarding post-innovation strategies and competition actually occurs in the international arena. We could extend our analysis by assuming firm $A$ is a foreign firm which is required to pay a tariff $s$ per-unit of output. Although firm $A$ has a competitive advantage in terms of the initial quality gap, it suffers from a cost disadvantage from the tariff payment $s$. We conjecture that trade liberalisation might increase or decrease imitation depending on what happens to the total market share (i.e., domestic plus foreign) of firm $A$.

The study of innovation incentives and trade liberalisation in the context of imitation, masking and welfare are particularly important areas of research. We plan to take these up in future.
Appendix

Proof of Proposition 1
Taking the total derivative of $z_B^*$ with respect to exogenously given parameters

$\theta, \Delta, t, z_A$, and applying Assumption 1 we get:

$$\frac{dz_B^*}{d\theta} = \frac{9t\gamma_B - (\theta \Delta(1 - z_A))^2 + 2(\theta \Delta(1 - z_A))^2 \Delta(3t - \Delta)(1 - z_A)}{(9t\gamma_B - (\theta \Delta(1 - z_A))^2)^2} > 0,$$

$$\frac{dz_B^*}{d\Delta} = \frac{(3t - 2\Delta)(9t\gamma_B - (\theta \Delta(1 - z_A))^2) + 2(3t - \Delta)(\theta \Delta(1 - z_A))^2 \theta(1 - z_A)}{(9t\gamma_B - (\theta \Delta(1 - z_A))^2)^2} > 0,$$

$$\frac{dz_B^*}{dt} = \frac{3\theta \Delta(1 - z_A)(3\gamma_B \Delta - (\theta \Delta(1 - z_A))^2)}{(9t\gamma_B - (\theta \Delta(1 - z_A))^2)^2} > 0,$$

$$\frac{dz_B^*}{dz_A} = -\left(\frac{3t\gamma_B - (\theta \Delta(1 - z_A))^2}{(9t\gamma_B - (\theta \Delta(1 - z_A))^2)^2}\right) < 0.$$

QED

Explanation of Figure 2
Taking the partial derivatives of firm B’s marginal benefit from imitation with respect to $\theta, \Delta, t$ and $z_A$ we get:

$$\frac{\partial MB_{z_B}}{\partial \theta} = \left(\frac{2\Delta(1 - z_A)}{3}\right) \left(\frac{1}{2} - \frac{\Delta(1 - 2\theta z_B(1 - z_A))}{6t}\right) > 0,$$

$$\frac{\partial MB_{z_B}}{\partial \Delta} = \frac{2\theta(1 - z_A)}{3} \left(\frac{1}{2} - \frac{\Delta(1 - \theta z_B(1 - z_A))}{3t}\right) > 0,$$
\[
\frac{\partial MB_{z_B}}{\partial t} = \left( \frac{\Delta (1 - \theta z_B (1 - z_A))}{6t^2} \right) \left( \frac{2\theta \Delta (1 - z_A)}{3} \right) > 0,
\]
\[
\frac{\partial MB_{z_B}}{\partial z_A} = - \left( \frac{2\theta \Delta}{3} \left( \frac{1}{2} - \Delta \left( \frac{1 - 2\theta z_B (1 - z_A)}{6t} \right) \right) \right) < 0.
\]

Since the marginal cost is independent of these parameters. Equating marginal benefit and marginal cost of imitation gives Proposition 1.

**Proof of Proposition 2**

Taking the total derivative of \( z_B^* \) with respect to exogenously given parameters \( \theta, \Delta, t, z_B \) and applying Assumption 1 we get:

\[
\frac{dz_A^*}{d\theta} = \frac{(9t \gamma_A - (\theta \Delta z_B)^2)(3t + \Delta - 2\theta \Delta z_B) + 2(\theta \Delta z_B)^2(3t + \Delta (1 - \theta z_B))}{(9t \gamma_A - (\theta \Delta z_B)^2)^2} > 0,
\]
\[
\frac{dz_A^*}{d\Delta} = \frac{\theta z_B [(9t \gamma_A - (\theta \Delta z_B)^2)(2\Delta (1 - \theta z_B) + 3t) + 2(\theta \Delta z_B)^2(3t + \Delta (1 - \theta z_B))]}{(9t \gamma_A - (\theta \Delta z_B)^2)^2} > 0,
\]
\[
\frac{dz_A^*}{dt} = - \left( \frac{(3\theta \Delta z_B)(3\gamma_A(\Delta - \theta \Delta z_B) + (\theta \Delta z_B)^2)}{9t \gamma_A - (\theta \Delta z_B)^2} \right) < 0,
\]
\[
\frac{dz_A^*}{dz_B} = \frac{\theta \Delta [(3t + \Delta - 2\theta \Delta z_B)(9t \gamma_A - (\theta \Delta z_B)^2) + 2(\theta \Delta z_B)^2(3t + \Delta - \theta \Delta z_B)]}{(9t \gamma_B - (\theta \Delta z_B)^2)^2} > 0.
\]

**Explanation of Figure 3**

Taking the partial derivatives of firm A’s marginal benefit from masking with respect to \( \theta, \Delta, t \) and \( z_B \) we get:

\[
\frac{\partial MB_{z_A}}{\partial \theta} = \frac{2\Delta z_B}{3} \left( \frac{1}{2} + \Delta \left( \frac{1 - 2\theta \Delta z_B (1 - z_A)}{6t} \right) \right) > 0,
\]
\[
\frac{\partial MB_{z_A}}{\partial \Delta} = \frac{2\theta z_B}{3} \left( \frac{1}{2} + \Delta \left( \frac{1 - \theta z_B (1 - z_A)}{3t} \right) \right) > 0,
\]
\[
\frac{\partial MB_{z_A}}{\partial t} = -\left(\frac{2\theta \Delta z_B}{3}\right) \left(\frac{\Delta (1 - \theta z_B (1 - z_A))}{6t^2}\right) < 0,
\]
\[
\frac{\partial MB_{z_A}}{\partial z_B} = \left(\frac{2\theta \Delta}{3}\right) \left(\frac{1}{2} + \frac{\Delta (1 - 2\theta z_B (1 - z_A))}{6t}\right) > 0.
\]
Since the marginal cost is independent of these parameters. Equating marginal benefit and marginal cost of masking gives Proposition 2.

\[Q.E.D.\]

**Proof of Proposition 3**

Computing the total derivative of imitation with respect to IPR protection gives:

\[
\frac{d\bar{z}_B}{d\theta} = \frac{\partial \bar{z}_B(z_A)}{\partial \theta} + \frac{\partial \bar{z}_B(z_A)}{\partial z_A} \cdot \frac{\partial z_A}{\partial \theta},
\]

\[
\frac{d\bar{z}_B}{d\theta} = \frac{(9t\gamma_B - (\theta \Delta (1 - z_A))^2 + 2(\theta \Delta (1 - z_A))^2) \Delta (3t - \Delta)(1 - z_A)}{(9t\gamma_B - (\theta \Delta (1 - z_A))^2)^2} \left(\frac{3t\gamma_B - (\theta \Delta (1 - z_A))^2}{(9t\gamma_B - (\theta \Delta (1 - z_A))^2)^2}\right) \left(\frac{(\Delta z_B)(9t\gamma_A - (\theta \Delta z_B)^2)(3t + \Delta - 2\theta \Delta z_B) + 2(\theta \Delta z_B)^2(3t + \Delta - \theta \Delta z_B)}{(9t\gamma_A - (\theta \Delta z_B)^2)^2}\right).
\]

There is clearly an ambiguity in the effect of weakening IPR protection on imitation. The direct component of the total derivative is positive while the indirect component is negative. That is, the overall effect of weakening IPR protection depends on the relative sizes of the shifts in Figure 5.

Similarly, computing the following total derivative of masking with respect to IPR protection gives:
In this case there is no ambiguity in the effect of weakening IPR protection on masking. The direct component of the total derivative is positive while the indirect component is also positive. Thus, a weakening of IPR protection conclusively increases masking.

The exact same pattern as above, with regards to an ambiguous and conclusive effect, follows for the remainder of the total derivatives derived.

Computing the total derivative of imitation with respect to competition gives:

$$\frac{d\hat{z}_A}{d\theta} = \frac{\partial z_A^*(z_B)}{\partial \theta} + \frac{\partial z_A^*(z_B)}{\partial z_B} \cdot \frac{\partial z_B^*(z_A)}{\partial \theta},$$

$$\frac{d\hat{z}_A}{d\theta} = \left(\frac{(\Delta z_B)[(9t\gamma_B - (\theta\Delta z_B)^2)(3t + \Delta - 2\theta\Delta z_B) + 2(\theta\Delta z_B)^2(3t + \Delta(1 - \theta z_B))]}{(9t\gamma_A - (\theta\Delta z_B)^2)^2}\right)$$

$$+ \left(\frac{\theta \Delta (3t + \Delta - 2\theta \Delta z_B)(9t\gamma_A - (\theta \Delta z_B)^2) + 2(\theta \Delta z_B)^2(3t + \Delta - \theta \Delta z_B)}{(9t\gamma_A - (\theta \Delta z_B)^2)^2}\right)$$

$$\left(\frac{(9t\gamma_B - (\theta \Delta (1 - z_A))^2 + 2(\theta \Delta (1 - z_A))^2)\Delta (3t - \Delta)(1 - z_A)}{(9t\gamma_B - (\theta \Delta (1 - z_A))^2)^2}\right).$$

In this case there is no ambiguity in the effect of weakening IPR protection on masking.

The direct component of the total derivative is positive while the indirect component is also positive. Thus, a weakening of IPR protection conclusively increases masking.

The exact same pattern as above, with regards to an ambiguous and conclusive effect, follows for the remainder of the total derivatives derived.

Computing the total derivative of imitation with respect to competition gives:

$$\frac{d\hat{z}_B}{dt} = \frac{\partial z_B^*(z_A)}{\partial t} + \frac{\partial z_B^*(z_A)}{\partial z_A} \cdot \frac{\partial z_A^*(z_B)}{\partial t},$$

$$= 3\theta \Delta (1 - z_A) \left(3\gamma_B \Delta - (\theta \Delta (1 - z_A))^2\right)$$

$$\left(9t\gamma_B - (\theta \Delta (1 - z_A))^2\right)^2$$

$$+ \left(\frac{3t\gamma_B - (\theta \Delta (1 - z_A))^2}{(9t\gamma_B - (\theta \Delta (1 - z_A))^2)^2}\right)\left(\frac{(3\theta \Delta z_B)(3\gamma_A (\Delta - \theta \Delta z_B) + (\theta \Delta z_B)^2)}{(9t\gamma_A - (\theta \Delta z_B)^2)^2}\right).$$

Computing the total derivative of masking with respect to competition gives:

$$\frac{d\hat{z}_A}{dt} = \frac{\partial z_A^*(z_B)}{\partial t} + \frac{\partial z_A^*(z_B)}{\partial z_B} \cdot \frac{\partial z_B^*(z_A)}{\partial t},$$

$$= -\left(\frac{(3\theta \Delta z_B)(3\gamma_A (\Delta - \theta \Delta z_B) + (\theta \Delta z_B)^2)}{(9t\gamma_A - (\theta \Delta z_B)^2)^2}\right).$$
\[
\begin{aligned}
&+ \left( \theta \Delta (3t + \Delta - 2 \theta \Delta z_B) (9ty_A - (\theta \Delta z_B)^2) + 2(\theta \Delta z_B)^2 (3t + \Delta - \theta \Delta z_B) \right) \\
&\quad \left( \frac{3 \theta \Delta (1 - z_A) (3y_B \Delta - (\theta \Delta (1 - z_A))^2)}{(9ty_B - (\theta \Delta (1 - z_A))^2)^2} \right).
\end{aligned}
\]

Computing the total derivative of imitation with respect to the initial quality gap gives:

\[
\frac{d \bar{z}_B}{d \Delta} = \frac{\partial z_B^*(z_A)}{\partial \Delta} + \frac{\partial z_B^*(z_A)}{\partial z_A} \cdot \frac{\partial z_A^*(z_B)}{\partial \Delta},
\]

\[
= \left( \frac{\theta (1 - z_A) \left( (3t - 2\Delta) \left( 9ty_B - (\theta \Delta (1 - z_A))^2 \right) + 2(3t - \Delta) (\theta \Delta (1 - z_A))^2 \right)}{(9ty_B - (\theta \Delta (1 - z_A))^2)^2} \right) \\
- \left( \frac{3 \theta y_B - (\theta \Delta (1 - z_A))^2}{(9ty_B - (\theta \Delta (1 - z_A))^2)^2} \right) \\
\left( \frac{\theta z_B \left( 9ty_A - (\theta \Delta z_B)^2 (2\Delta (1 - \theta z_B) + 3t) + 2(\theta \Delta z_B)^2 (3t + \Delta (1 - \theta z_B)) \right)}{(9ty_A - (\theta \Delta z_B)^2)^2} \right).
\]

Computing the total derivative of masking with respect to the initial quality gap gives:

\[
\frac{d \bar{z}_A}{d \Delta} = \frac{\partial z_A^*(z_B)}{\partial \Delta} + \frac{\partial z_A^*(z_B)}{\partial z_B} \cdot \frac{\partial z_B^*(z_A)}{\partial \Delta},
\]

\[
= \left( \frac{(3t - 2\Delta) \left( 9ty_B - (\theta \Delta (1 - z_A))^2 \right) + 2(3t - \Delta) (\theta \Delta (1 - z_A))^2 \theta (1 - z_A)}{(9ty_B - (\theta \Delta (1 - z_A))^2)^2} \right) \\
+ \left( \frac{\theta \Delta (3t + \Delta - 2 \theta \Delta z_B) (9ty_A - (\theta \Delta z_B)^2) + 2(\theta \Delta z_B)^2 (3t + \Delta - \theta \Delta z_B)}{(9ty_B - (\theta \Delta z_B)^2)^2} \right) \\
\left( \frac{\theta (1 - z_A) \left( 3t - 2\Delta \left( 9ty_B - (\theta \Delta (1 - z_A))^2 \right) + 2(3t - \Delta) (\theta \Delta (1 - z_A))^2 \right)}{(9ty_B - (\theta \Delta (1 - z_A))^2)^2} \right).
\]
Proof that \((r^*, F^*)\) satisfies condition (3.9)

The optimal two-part contract must satisfy firm \(A\)'s participation constraint:

\[
\frac{t}{2} + r^* + F^* > 2t \left( \frac{1}{2} + \frac{\bar{A}}{6t} \right)^2,
\]  
(A.1)

Re-arranging (A.1) for \(r^*\) and substituting \(F^*\) gives:

\[
\iff V_A - \frac{3t}{2} > \frac{\bar{A}^2}{9t}
\]  
(A.2)

\[
\iff V_A > \frac{5t}{2}
\]  
(A.3)

Therefore, by Assumption 2 (A.3), the condition given by (A.2) holds which implies (A.1) is satisfied.

Lemma 5

Consumers in set \(\alpha\) are strictly worse off under licensing if:

\[
V_A - p_{A}^{l,*} - ty < V_A - p_{A}^{*} - ty
\]  
(A.6)

Substituting the equilibrium prices from Sections 2 and 3 (i.e., (2.5) and (3.6)) into (A.6) gives the following condition:

\[
\iff \frac{t}{2} - ty < V_A - t - \frac{\bar{A}}{3} - ty
\]  
(A.7)

\[
\iff V_A > \frac{3t}{2} + \frac{\bar{A}}{3}
\]  
(A.8)

\[
\iff V_A > \frac{5t}{2}
\]  
(A.9)
By Assumption 2(A.9), the condition given by (A.7) holds which ultimately implies (A.6) is satisfied. Therefore, consumers in set $\alpha$ are strictly worse off under licensing.

Consumers in set $\gamma$ are strictly worse off under licensing if:

$$V_A - p_B^* - t(1 - y) < V_A - p_B^* - ty$$  \hspace{1cm} (A.10)

Substituting the equilibrium prices from Sections 2 and 3 (i.e., (2.6) and (3.6)) gives the following condition:

$$\Leftrightarrow V_A - \left( V_A - \frac{t}{2} \right) - t(1 - y) < V_A - t + \frac{\tilde{\Delta}}{3} - ty$$  \hspace{1cm} (A.11)

$$\Leftrightarrow V_A > \frac{t}{2} + \frac{\tilde{\Delta}}{3} + 2ty$$  \hspace{1cm} (A.12)

$$\Leftrightarrow V_A > \frac{5t}{2}$$  \hspace{1cm} (A.13)

By Assumption 2 (A.13), the condition given by (A.11) holds which ultimately implies (A.10) is satisfied. Therefore, consumers in set $\gamma$ are strictly worse off under licensing.

Consumers in set $\beta$ are strictly worse off under licensing if:

$$V_A - p_B^{L^*} - t(1 - y) < V_B - p_B^* - t(1 - y)$$  \hspace{1cm} (A.9)

Substituting the equilibrium prices from Section's 2 and 3 (i.e., (2.6) and (3.6)) gives the following condition:

$$V_A - \left( V_A - \frac{t}{2} \right) - t(1 - y) < V_B - \left( t - \frac{\tilde{\Delta}}{3} \right) - t(1 - y)$$  \hspace{1cm} (A.10)

Re-arranging (A.10)

$$V_B > \frac{t}{2}$$  \hspace{1cm} (A.11)
Therefore, consumers in set $\beta$ are strictly worse off under licensing only if the condition given by (A.11) holds.
Bibliography


