How Does a Brand Become a Status Symbol? A Dynamic Duopoly Game*

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Rogério Mazali[†] Joanna Poyago-Theotoky[‡] José A. Rodrigues-Neto[§]

July 16, 2021

Abstract

This paper analyzes a dynamic duopoly market for indivisible status goods in which two firms enter the market sequentially: the pioneer and the challenger. In each period firms play a quality-then-price game. Consumers will assign high status to the good with higher quality. Which firm occupies the market niche of high status in equilibrium depends on the structure of the quality development costs. If firms have to pay development costs in every period, then the pioneer takes the low quality/low status market niche, while the challenger takes the high status/high quality market niche. When each firm pays its development cost only once, then the pioneer deters the takeover of the high status market niche by its rival. In this case, the pioneer overprovides quality and preempts the challenger's threat. If the pioneer can change its quality between periods and pays the development cost in each period, then it targets the low status niche, while the challenger takes the high status niche.

Key words: deterrence, duopoly, market niche, quality, status goods.

JEL Classification: C72, L11, L13, L15.

*Rogério Mazali would like to thank CNPq and the Research School of Economics at ANU for partial financial support. Part of this research was conducted while this author was affiliated with the Catholic University of Brasilia. All remaining errors are our own responsibility.

†University of Brasilia, Department of Economics - Campus Universitário Darcy Ribeiro, Brasília, DF, CEP 70910-900, Brazil. Phone: +55 (61) 3107-0743. Email: rmazali@tulane.edu.

‡Department of Economics and Finance, La Trobe University, Melbourne, Victoria 3086, Australia and ICRE8, Athens, Greece. E-mail: j.poyago-theotoky@latrobe.edu.au

§Australian National University, College of Business and Economics, Research School of Economics, H.W. Arndt Building 25A, ANU, Canberra ACT - 2601, Australia. Phone: +61 (2) 612-55633. URL: http://rodriguesneto.weebly.com/. E-mail: jarnwi@yahoo.com.

Como uma Marca se Torna um Símbolo de Status? Um Jogo de Duopólio Dinâmico*

Preliminar e incompleto - Por favor não citar sem a autorização dos autores

Rogério Mazali† Joanna Poyago-Theotoky‡ José A. Rodrigues-Neto§

17 de Julho de 2021

Resumo

Este artigo analisa um mercado de duopólio dinâmico para bens de status indivisíveis em que duas firmas entram no mercado sequencialmente: a pioneira e a desafiadora. Em cada período as firmas jogam um jogo qualidade-depois-preço. Consumidores atribuem alto status ao bem de maior qualidade. Qual firma ocupa o nicho de mercado de alto status em equilíbrio depende da estrutura de custos de desenvolvimento de qualidade. Se as firmas tem de pagar custos de desenvolvimento em cada período, então a pioneira toma o nicho de mercado de baixa qualidade/baixo status, enquanto a desafiadora toma o nicho de mercado de alta qualidade/alto status. Quando cada firma paga seu custo de desenvolvimento apenas uma vez, então a pioneira detêm a tomada do nicho de mercado de alto status por sua rival. Nesse caso, a pioneira sobreprovê qualidade e esvazia previamente a ameaça da desafiadora. Se a pioneira puder mudar sua qualidade entre os períodos e paga o custo de desenvolvimento em cada período, então ela mira o nicho de mercado de baixo status, enquanto a desafiadora toma o nicho de mercado de alto status.

Palavras-chave: dissuasão, duopólio, nicho de mercado, qualidade, bens de status.

Classificação JEL: C72, L11, L13, L15.

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*Rogério Mazali agradece ao CNPq e à *Research School of Economics* da ANU pelo suporte financeiro parcial. Parte desta pesquisa foi conduzida enquanto este autor era afiliado à Universidade Católica de Brasília. Todos os erros remanescentes são de nossa exclusiva responsabilidade.

†Universidade de Brasília, Departamento de Economia - Campus Universitário Darcy Ribeiro, Brasília, DF, CEP 70910-900, Brasil. Fone: +55 (61) 3107-0743. Email: rmazali@tulane.edu.

‡Department of Economics and Finance, La Trobe University, Melbourne, Victoria 3086, Austrália e ICRE8, Atenas, Grécia. E-mail: j.poyago-theotoky@latrobe.edu.au

§Australian National University, College of Business and Economics, Research School of Economics, H.W. Arndt Building 25A, ANU, Canberra ACT - 2601, Austrália. Fone: +61 (2) 612-55633. URL: http://rodriguesneto.weebly.com/. E-mail: jarnwi@yahoo.com.

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1 Introduction

Social status is an important feature of many products. From supersports cars to *haute couture* to watchmaking and jewelry, several brands advertise and highlight the extra social status their products provide to consumers. Some status goods have relatively low intrinsic value. The value of these goods lies in the fact that owning them allows the consumers to signal something about themselves to other individuals. Many theoretical studies of the markets for status goods ignore the intrinsic value associated with some of these goods, treating them as *pure* status goods, that is, goods providing no direct utility to their consumers.[1] Assuming that a status good is pure helps researchers understanding particular characteristics of the market for such goods.

Of course, real-world status goods are not pure. Besides status, they also provide direct utility to their consumers. A supersports car can take a consumer from a particular location to another. However, a supersports car is more comfortable, is safer (breaks tend to be more efficient), and can travel faster than regular cars. Supersports cars offer more quality than a regular car. This observation is not exclusive to the automobile industry. Consumers of different products have commonly linked high status to high quality.[2]

Multiple theoretical studies assume that status goods are provided by firms operating in competitive or near-competitive markets (Frank, 1985; Hopkins and Kornienko, 2004, 2009; Bilancini and Boncinelli, 2012, 2013; Mazali and Rodrigues-Neto, 2013), or monopolistic markets (Rayo, 2013; Mazali and Rodrigues-Neto, 2013). These two market structures are opposite extreme cases in the literature: the most and the least competitive ones.

However, most status good markets do not fit in any of these two extreme market structures. Barriers to entry exist in many markets, and the number of firms able to overcome these barriers is limited, but usually greater than one. The resulting market structure is an oligopoly. Firms strategically plan when to enter an oligopolistic market and which niche they will target. Which oligopolistic firm will offer the good of the highest status? Does the pioneer firm prefer its market niche to be of high status? Does a late entrant, a challenger, necessarily capture the high-end status good market niche? Can the pioneer take actions to prevent the challenger from capturing its most preferred market niche?

To answer these questions, the present study develops a dynamic duopoly model of a status good that is not pure.[3] In the model developed in this study, two firms enter the market sequentially, one in each period: the pioneer first, and then, the challenger. Firms know that consumers will assign high status to the good of higher quality, and low status to the good of lower quality. The pioneer selects its quality first, knowing that the challenger will enter the market in the next period. In the second period, the challenger observes the pioneer's quality in both periods before making any decision. Then, the challenger chooses its quality, establishing the relative order of qualities that determines the status of the good sold by each firm. After qualities and status levels in the second period are revealed publicly, heterogeneous consumers form the demand for each good. Then, firms choose prices simultaneously. The pioneer maximizes the sum of profits in the two periods, while the challenger maximizes its profit in the second period only because it does not exist in the first period.

[1] See, for instance, Frank, 1985; Robson, 1992; Hopkins and Kornienko, 2004, 2009; Bilancini and Boncinelli, 2012, 2013; Mazali and Rodrigues-Neto, 2013.

[2] Deloitte's *Global Powers of Luxury* 2017 report lists product quality as the main driver in status goods consumption. See page 7 on Delloite's *Global Powers of Luxury* 2017 report.

[3] Economists often analyze duopolies as the simplest and analytically most tractable form of oligopolistic markets. This occurs because the strategic interactions between the firms that operate in an oligopoly can be quite complex.

The model considers and analyzes three different structures for the cost of quality development. In the first one, firms pay the cost to develop a certain quality in every period, and the pioneer cannot change its quality between the two periods. In the second scenario, firms pay the development cost only once, when the brand is first released, and again, the pioneer is not allowed to change its quality between periods. In the third model, the pioneer can change its quality between the first and second periods, but must pay the development costs in each period according to its chosen quality in that period. The first cost structure portraits the situation faced by many status goods producers that have do develop a new generation of products at every new season, but with little or no technological component, and usually low product development costs. In this category we can put the fashion industry and its related sectors (*haute couture*, shoemaking, leather products, cosmetics, perfumes, etc.). In these industries, a new generation of products has to be developed at every period, but changes in quality are rare. Powerhouses of the fashion industry such as Chanel or Versace seldom lower their standards in quality. The second cost structure better reflects industries in which establishing a reputation for your brand involves repeating the same formula initially developed for your product, such as jewelry, watchmaking, horse breeding, fine wines, cigars and spirits. The third cost structure is realistic in modeling the market for durable, technology-intensive status goods, such as cars, cell phones, television sets, private jets and yachts. For these goods, new technologies play an important role, and producers of such status goods must pay high product development costs frequently, often with a change in product quality.

Because the challenger knows the quality of the pioneer's product when choosing its own product quality, the challenger can choose its quality slightly above the pioneer's and take over the high status market niche. If the pioneer wants to preserve its position as owner of the high status brand, it has to deter the challenger from taking over its market niche. This requires the pioneer to overprovide quality for its good. This overprovision is costly. Hence, the pioneer may not have the incentives to do so.

The analysis of these different cost structures starts with the case in which the development costs must be paid in every period and the pioneer cannot change the quality between periods. In this case, the profit that the pioneer earns by taking the top position in the second period is smaller than the profit it makes by targeting the low status market niche. In equilibrium, the challenger takes the high status/high quality market niche, and the pioneer sells the low quality/status good. The quality of the high status good is strictly larger than that of the low status good, but there is no overprovision of quality.

The analysis turns to the second case, with development costs paid only once, when the brand is first established. Again, the pioneer cannot change the quality between periods. In this case, the pioneer's benefits from deterring the challenger's takeover of the high status market niche outweighs the costs. To accomplish deterrence, the pioneer overprovides quality by picking a quality level above its first-optimal choice. The pioneer chooses a quality sufficiently high; one providing incentives for the challenger to target the low status market niche.

In the third case, the pioneer pays the development cost in every period, but the pioneer can change its quality between the two periods. In the second period, the pioneer chooses its new quality first, while the challenger observes this choice before making its own choice of quality. After both quality levels are publicly known, firms choose their prices simultaneously. The pioneer is a monopolist in the first period, which now does not influence the subgame of the second period. In the second period, the pioneer targets the low status market niche while the challenger captures the high status market. There is no overprovision of quality. This case is relevant in industries where innovation and new technologies are strongly associated to high status.

Out of the three scenarios, only in the second there is overprovision of quality. As the development cost is paid only once, the pioneer can afford to secure the high status market by eliminating the incentives of the challenger to steal it. This strategy has a significant cost because the pioneer is a monopolist in the first period of the game, but is adopting a quality level well above the one a single-period monopolist firm would prefer.

Economists have been studying the economic effects of social status for a long time. Pollak (1967, 1976) and Koopmans (1960), among others, point out the "low cardinal utility" nature of many goods. Frank (1985, 2005) refers to these goods as positional goods. Hopkins and Kornienko (2004, 2009, 2010) and Rege (2008) modeled the status good market as a signaling game in which status goods signal hidden abilities. Mazali and Rodrigues-Neto (2013) showed that the existence of high fixed costs in brand development implies the market equilibrium will be stratified, and full customization is not possible in equilibrium. Rayo (2013) was one of the first to provide a link between status and quality. He provided conditions under which a monopolist facing no fixed costs chooses to offer the same variety of a non-pure status good to a positive measure of consumers. He also shows that overprovision of quality can occur in equilibrium, because of the extra value that status provides to the goods these firms offer.[4] The present study differs from Rayo (2013) in showing that the overprovision of quality usually observed in status goods can occur as a deterrence mechanism, where the pioneer purposely pushes up the quality of its product to discourage competition to occupy that market niche, a mechanism similar to the one described for innovation and R&D investment in Arrow (1972) and Dasgupta and Stiglitz (1980).

Section 2 states the setup of the model. Section 3 computes the demands of consumers for each good in each period. Section 4 computes the equilibria of the prices subgames. Section 5 analyzes the decisions of the challenger. Sections 6, 7 and 8 calculate the value of the pioneer in the three cost strutures and find the subgame perfect equilibrium in each case. Section 9 concludes. The Appendix contains all the proofs.

2 Basic Setup

Two generations of consumers live for one period each, $t = 1$ or $t = 2$. The individuals of each generation belong to two different populations: the Greens, which are uniformly distributed, and indexed by their individual abilities $i \in G = [0, 1]$, and the Reds, uniformly distributed, and indexed by their individual abilities $j \in R = [0, 1]$. Reds' abilities are perfectly observable. The ability of each Green is her private information, but the distribution of Greens' abilities is common knowledge to all players.

There is a consumption good taken as *numéraire*, traded at unit price. In addition, there is a single brand of status good in period $t = 1$, and two different brands of status goods in period $t = 2$. Each status good is indivisible. The status good (and their brands) that each consumer owns is perfectly observable. A social norm dictates that the social status of each consumer is equal to the maximum status level of the brands of status goods that they own. Consequently, each consumer purchases at most only one unit of a single brand of status good. Let $s(i) \in \{\emptyset, L, H\}$ denote the social status of a consumer with ability $i \in [0, 1]$. If consumer with ability i buys no status good, we say that their status level is $s(i) = \emptyset$, or that they buy the status good of brand $n = \emptyset$

[4] Truyts (2010) summarizes theoretical studies on social status. For empirical studies, refer to Heffetz and Frank (2010).

at price $p_0 = 0$. If consumer i buys the status good of low status, their status level is $s(i) = L$. If consumer i buys the status good of high status, their status level is $s(i) = H$.

Every Green consumer is endowed with $y > 0$, assumed to be sufficiently large so that every consumer can afford to buy a unit of the good with status $n = H$, while every Red has an initial endowment of zero. Green consumers are utility maximizers. Greens' utility functions are quasi-linear, given by $U(x, i, s(i)) = x + q(i) + z(i, s(i))$, where x represents the quantity of a regular consumption good, $q(i)$ is the quality of the status good purchased by the consumer of ability i, and $z(i, j)$ represents the amount of consumption good that she takes from the joint production with a Red partner of ability j. Because of the quasi-linearity in Greens' utilities, consumption of status goods is not a function of the initial endowment. Thus, the utilitarian welfare function grows linearly in y.[5] Suppose that $z(i, j)$ has the following Leontief functional form:

$$z(i, j) = 2\min\{i, j\}.$$

The arguments of the function $z(i, j)$ are perfect complements. In order to obtain this utility $z(i, j)$, a Green individual i from generation t must find a match j in the population of Reds. A matching between Greens and Reds is a bijective, measure preserving function $m : G \to R$. A matching is weakly stable if no agent has a profitable deviation, given his/her information. We focus only on stratified equilibria. Mazali and Rodrigues-Neto (2013) show that matchings in stratified equilibria are weakly stable.

There are two firms, A and B. Each firm produces a single brand of status goods. Firm A enters the market at period $t = 1$, producing in periods $t = 1$ and $t = 2$. Firm B enters the market only at period $t = 2$, selling its brand of status good for a single period.

In period $t = 1$, the brand produced by Firm A has high status, H. In period $t = 2$, a social norm dictates how status levels are assigned to the two brands os status goods. The status levels of brands depend on their relative qualities in an ordinal way. Consumers attribute high status, to the product with the higher quality; its brand becomes the high status brand, H. Analogously, consumers attribute low status to the product with the lower quality; its brand becomes the low status brand, L.

Developing quality is costly, and each firm $n \in \{A, B\}$ can develop quality $q_n > 0$ at a cost cq_n^2, where $c > 1$ is a technological cost parameter.[6] We say that Firm n does not operate in the market at time t if it chooses quality $q_n = 0$ and sells it to a market of zero measure, obtaining thus zero profit in that period.

Firm A chooses, at time $t = 1$, the quality of its brand, $q_A > 0$, and the price $p_{A,1} > 0$ for its product at time $t = 1$. Firm A cannot change its quality between periods $t = 1$ and $t = 2$.[7] At period $t = 2$, Firm B enters the market and observes the quality and price chosen by Firm A at $t = 1$. At period $t = 2$, Firm B picks the quality for its product, $q_B > 0$. Then, both firms observe q_A and q_B before choosing their prices. Finally, Firms A and B simultaneously choose prices $p_{A,2}$ and p_B for their products in period $t = 2$.

For simplicity, assume there is no discounting between the two periods. Both firms maximize the present value of their profits. For Firm B, this is simply the profit obtained in period $t = 2$. For Firm A, the present value of its profits is the sum of its profits obtained in both periods.

[5] Hopkins and Kornienko (2004) used a model with general utility functions, where status signals wealth to show that the amount spent on status goods grows more than proportionally with income and that welfare may decrease as the economy grows.

[6] The assumption that $c > 1$ ensures that all optimization problems in the model have interior solutions, with positive qualities and prices, that is, $q_n > 0$ and $p_n > 0$ for all $n \in \{A, B\}$, and with strata limit abilities lying in the relevant intervals, that is, $0 < i_{H,1} < 1$, $0 < i_{H,2} < 1$, and $0 < i_{L,2} < i_{H,2}$.

[7] In Section 8, we relax this assumption and allow the pioneer to change its quality between periods $t = 1$ and $t = 2$.

A strategy for Firm A is a choice of quality $q_A \geq 0$ and a price $p_{A,1} > 0$ at $t = 1$, and a price function $p_{A,2} = p_{A,2}(q_A, q_B)$ that defines, for each pair of qualities q_A and q_B, the price that Firm A charges for one unit of its product at $t = 2$. By definition, the price $p_{A,2}$ does not depend on the first period price $p_{A,1}$.

A strategy for Firm B is composed of a quality function $q_B = q_B(q_A)$ assigning, for each quality choices of Firm A, a quality for its own brand, q_B, and a price function $p_B = p_B(q_A, q_B)$, assigning, for each pair of qualities q_A and q_B, the price that Firm B will charge at $t = 2$.

The study focuses on finding stratified equilibria. As there is only one status good in period $t = 1$, there is only one stratum limit, given by $i_{H,1}$. Consumers with abilities in the interval $[i_{H,1}, 1]$ buy the unique status good brand available at $t = 1$, while those with abilities in the interval $[0, i_{H,1})$ prefer not to buy any status good.

In a stratified equilibrium with two firms, there are at most three strata in the economy, all subintervals of $[0, 1]$. In period $t = 2$, there are two stratum limits, $i_{L,2} < i_{H,2}$. Every consumer with an ability in the interval $[0, i_{L,2})$ buys no status goods. Each consumer with an ability $i \in [i_{L,2}, i_{H,2})$ buys exactly one unit of a status good of brand with status L, and consumers with abilities $i \in [i_{H,2}, 1]$ buy one unit of the status good of the high status (H) brand. The formal definition of Stratified Subgame Equilibrium, adapted from Mazali and Rodrigues-Neto (2013), is given below.

A *Stratified Subgame Perfect Equilibrium* is given by a set of strata limit abilities $\{i_{H,1}, i_{L,2}, i_{H,2}\}$, a strategy $(q_A, p_{A,1}, p_{A,2}(q_A, q_B))$ for Firm A, a strategy $(q_B(q_A), p_{B,2}(q_A, q_B))$ for Firm B, and a social norm ranking the different brands $n \in \{A, B\}$ of status goods available in $t = 2$ according to qualities $q_{A,}$ and q_B, such that:

1. Each firm maximizes the present value of its profits, given the actions of firms that played previously, the strategies of firms, the social norm assigning status value to goods, and the equilibrium consumers' demand;

2. Each consumer is maximizing their expected payoff, given the social norms and the equilibrium values of $p_{A,1}$, $p_{A,2}$, p_B, q_A and q_B;

3. The market for each brand of status good clears for the equilibrium values of strata limit abilities $i_{H,1}, i_{L,2}, i_{H,2}$, prices $p_{A,1}$, $p_{A,2}$, p_B, and qualities q_A and q_B;

4. For each generation $t \in \{1, 2\}$, given the social norm, and the equilibrium values of $p_{A,1}$, $p_{A,2}$, p_B, q_A and q_B, the matching $m : G \to R$ is stable.

3 Consumer Demands

The equilibrium is obtained through backwards induction. We start by evaluating the matching rule and then compute the consumer demands for given prices and qualities picked by the firms. The following proposition states a stratified matching rule that is weakly stable:

Because the status goods Greens possess are observable to Reds, so is their status levels. The following proposition states the stable stratified matching that occurs in equilibrium.

Lemma 1 ***(Stratified Matching)*** *The following stratified matching is weakly stable: at $t = 1$, Green individuals with status levels $s_i = H$ (thus located in interval $[i_{H,1}, 1] \subset G$) randomly match with a Red individual in* *the interval $[i_{H,1}, 1] \subset R$, while Green individuals with status levels $s_i = \emptyset$ (thus located in interval $[0, i_{H,1}) \subset G$) randomly match with a Red individual in the interval $[0, i_{H,1}) \subset R$. At $t = 2$, Green individuals with status levels $s_i = H$ (thus located in interval $[i_{H,2}, 1] \subset G$) randomly match with a Red individual in the interval $[i_{H,2}, 1] \subset R$; Green individuals with status levels $s_i = L$ (thus located in interval $[i_{L,2}, i_{H,2}) \subset G$) randomly match with a Red individual in the interval $[i_{L,2}, i_{H,2}) \subset R$; and Green individuals with status levels $s_i = \emptyset$ (thus located in interval $[0, i_{L,2}) \subset G$) randomly match with a Red individual in the interval $[0, i_{L,2}) \subset R$..*

At the frontier between the market niches, consumers are indifferent between purchasing each of the adjacent brands. This indifference defines the strata limit abilities $i_{H,1}, i_{L,2}, i_{H,2}$, and, consequently, the demand for each product. By stating prices as functions of these strata limit abilities, we obtain the inverse demands. The next result describes the inverse demands.

Lemma 2 ***(Inverse Demands)*** *Fix qualities $q_A, q_B > 0$. Then, the inverse demands for the brands of status goods in the two periods are:*

$$p_{A,1} = i_{H,1} + q_A, \tag{1}$$

$$p_{H,2} = i_{H,2} + \max\{q_A, q_B\}, \tag{2}$$

$$p_{L,2} = i_{L,2} + \min\{q_A, q_B\}. \tag{3}$$

4 Pricing Subgames

4.1 Price in the First Period

The profit of Firm A in period $t = 1$ is $\pi_{A,1} = (1 - i_{H,1})p_{A,1} - cq_A^2$. In period $t = 1$, after quality q_A is fixed, Firm A chooses price $p_{A,1}$ that maximizes its period 1 profit, $\pi_{A,1}$. The following lemma states the solution to this profit maximization problem.

Lemma 3 ***(Equilibrium of the Period 1 Pricing Stage Subgame)*** *Fix quality $q_A > 0$. Then, the price chosen by Firm A in period $t = 1$ is:*

$$p_{A,1} = \frac{1 + q_A}{2}.$$

This price yields the stratum limit ability:

$$i_{H,1} = \frac{1 - q_A}{2}.$$

The quantity of consumers buying the status good in period $t = 1$ is:

$$1 - i_{H,1} = \frac{1 + q_A}{2}.$$

The profit of Firm A in period $t = 1$ is:

$$\pi_{A,1} = \frac{(1 + q_A)^2}{4} - cq_A^2. \tag{4}$$

Given the price choice of Firm A in period $t = 1$, in the absence of a second period, the ideal quantity for Firm A would maximize $\pi_{A,1}$ in equation (4). The ideal quality for Firm A would be:

$$q_A = \frac{1}{4c-1}.$$

The corresponding profit would be:

$$\pi_{A,1} = \frac{c}{4c-1}.$$

However, Firm A understands that the game has a second period, but it cannot change its quality. Firm A chooses its quality to maximize the sum of profits in both periods, taking into account the equilibrium strategy of Firm B.

4.2 Prices in the Second Period

Consider the pricing subgame in period $t = 2$. Suppose that Firm B chooses a quality level $q_B \leq q_A$. In this case, Firm A produces the high status good, and Firm B the low status good in $t = 2$. In this case, the profits at $t = 2$ are:

$$\pi_{A,2} = (1 - i_{H,2})p_{A,2} - cq_A^2, \qquad \pi_{B,2} = (i_{H,2} - i_{L,2})p_{B,2} - cq_B^2.$$

The next result describes the equilibrium of the pricing subgame of period $t = 2$ in the scenario where Firm A has high status.

Lemma 4 ***(Equilibrium of the Period 2 Pricing Subgame when Firm A has high status)*** *Fix qualities $q_A \geq q_B > 0$, so that Firm A is the one with high status. Suppose that qualities satisfy conditions (5) and (6), where:*

$$0 \leq q_{AH} \leq \frac{1+2\sqrt{c}}{4c-1}, \tag{5}$$

$$0 \leq q_{BL} \leq \left(\frac{1-q_{AH}}{2}\right)\left(\frac{1+2\sqrt{c}}{4c-1}\right). \tag{6}$$

Then, the prices chosen by Firm A and Firm B in period $t = 2$ are:

$$p_{AH,2} = \frac{1+q_A}{2}, \tag{7}$$

$$p_{BL,2} = \frac{1-q_A+2q_B}{4}. \tag{8}$$

The strata limit abilities are:

$$i_{H,2} = \frac{1-q_A}{2}, \qquad i_{L,2} = \frac{i_{H,2}-q_B}{2} = \frac{1-q_A-2q_B}{4}.$$

The mass of consumers buying the products made by A and B are:

$$1 - i_{H,2} = \frac{1+q_A}{2},$$

$$i_{H,2} - i_{L,2} = \frac{1-q_A+2q_B}{4}.$$

Profits are:

$$\pi_{AH,2} = \frac{(1+q_A)^2}{4} - cq_A^2, \tag{9}$$

$$\pi_{BL,2} = \frac{(1-q_A+2q_B)^2}{16} - cq_B^2. \tag{10}$$

Offering the high-quality product allows Firm A to charge a higher price, not only because of the higher objective quality of its product, but also because of its status value. This also mean that Firm A's product dominates the market, occupying a larger market share than its rival, as the size of its market niche is strictly larger than $1/2$ for any quality level $q_A > 0$ Firm A chooses. The next result describes the equilibrium of the pricing subgame when Firm A has low status, while Firm B has high status.

Lemma 5 ***(Equilibrium of the Period 2 Pricing Subgame when Firm B has high status)*** *Fix qualities $q_B \geq q_A > 0$, and Firm B is the one with high status. Fix qualities such that:*

$$0 \leq q_{BH} \leq \frac{1+2\sqrt{c}}{4c-1}, \tag{11}$$

$$0 \leq q_{AL} \leq \left(\frac{1-q_{BH}}{2}\right)\left(\frac{1+2\sqrt{c}}{4c-1}\right). \tag{12}$$

Then, the prices chosen by Firm A and Firm B in period $t = 2$ are:

$$p_{AL,2} = \frac{1-q_B+2q_A}{4}, \tag{13}$$

$$p_{BH,2} = \frac{1+q_B}{2}. \tag{14}$$

The strata limit abilities are:

$$i_{H,2} = \frac{1-q_B}{2}, \quad i_{L,2} = \frac{1-q_B-2q_A}{4}.$$

The mass of consumers buying the products made by A and B are:

$$1-i_{H,2} = \frac{1+q_B}{2}, \quad i_{H,2}-i_{L,2} = \frac{1-q_B+2q_A}{4}.$$

Profits are:

$$\pi_{AL,2} = \frac{(1-q_B+2q_A)^2}{16} - cq_A^2, \tag{15}$$

$$\pi_{BH,2} = \frac{(1+q_B)^2}{4} - cq_B^2. \tag{16}$$

Offering the high-quality product now allows Firm B to charge a higher price because of both higher quality and status value of its product. Firm B's product now dominates the market, occupying a larger market share than its rival, as the size of its market niche is strictly larger than $1/2$ for any quality level $q_B > 0$ Firm B chooses.

5 Firm B's Decisions

5.1 Quality of Firm B's Product

Let us proceed with the backwards induction argument and analyze Firm B's quality decisions. Firm B observes Firm A's quality choice, q_A, and anticipates both firms' price policies. Firm B chooses its product's quality, q_B.

Start with the case in which Firm B chooses to produce the low status product. Fix an arbitrary quality q_A for Firm A, with $q_A > 1/(4c-1)$. Firm B chooses q_B in order to maximize $\pi_{BL,2}$ subject to $q_B \leq q_A$. The following result computes Firm B's best reply quality in this case.

Lemma 6 ***(Firm B's optimal quality choice when it has low status)*** *Suppose Firm B's brand has low status and Firm A pays the development cost in both periods. Then, Firm B's best reply to an arbitrary quality q_A chosen by Firm A is:*

$$q_{BL}(q_A) = \min\left\{q_A, \frac{1-q_A}{8c-2}\right\} = \begin{cases} q_A, & \text{if} \quad q_A \leq \dfrac{1}{8c-1} \\ \dfrac{1-q_A}{8c-2}, & \text{if} \quad q_A > \dfrac{1}{8c-1} \end{cases} \tag{17}$$

If $q_A > 1/(8c-1)$, then Firm B obtains profit

$$\pi_{BL,2}(q_A) = \frac{c(1-q_A)^2}{4(4c-1)}. \tag{18}$$

If $q_A \leq 1/(8c-1)$, then Firm B obtains profit

$$\pi_{BL,2}(q_A) = \frac{(1+q_A)^2}{16} - cq_A^2. \tag{19}$$

Remark 1 *The profit of Firm B when its product has low status, $\pi_{BL,2}(q_A)$, is a continuously differentiable function of q_A. It is convex for $q_A \leq 1/(8c-1)$, and concave for $q_A > 1/(8c-1)$. Function $\pi_{BL,2}(q_A)$ has a maximum at $q_A = 1/(16c-1)$. At $q_A = 1/(8c-1)$, the function $\pi_{BL,2}(q_A)$ attains an inflection point. At this point, both its left and right derivatives assume value $-c/(8c-1)$. Figure* 1 *displays the profit of Firm B of high and low status as a function of q_A when $c = 1.25$.*

Consider now the case in which Firm B has high status. Firm B chooses q_{BH} in order to maximize $\pi_{BH,2}$ subject to $q_B \geq q_A$. The following lemma states the quality level Firm B picks in this case.

Lemma 7 ***(Firm B's optimal quality choice when it has high status)*** *Suppose Firm B's brand has high status and Firm A pays the development cost in both periods. Then, Firm B's best reply to an arbitrary quality q_A chosen by Firm A is given by:*

$$q_{BH} = \max\left\{\frac{1}{4c-1}, q_A\right\} = \begin{cases} \dfrac{1}{4c-1}, & \text{if} \quad q_A < \dfrac{1}{4c-1} \\ q_A, & \text{if} \quad q_A \geq \dfrac{1}{4c-1} \end{cases} \tag{20}$$

If $q_A \geq 1/(4c-1)$, then Firm B obtains profit:

$$\pi_{BH,2}(q_A) = \frac{(1+q_A)^2}{4} - cq_A^2, \tag{21}$$

If $q_A < 1/(4c-1)$, then Firm B obtains profit:

$$\pi_{BH,2}(q_A) = \frac{c}{4c-1}. \tag{22}$$

Remark 2 *The profit of Firm B when its product has high status, $\pi_{BH,2}(q_A)$, is a continuously differentiable function of q_A. It is constant when $q_A \leq 1/(4c-1)$, and decreasing and concave when $q_A > 1/(4c-1)$.*

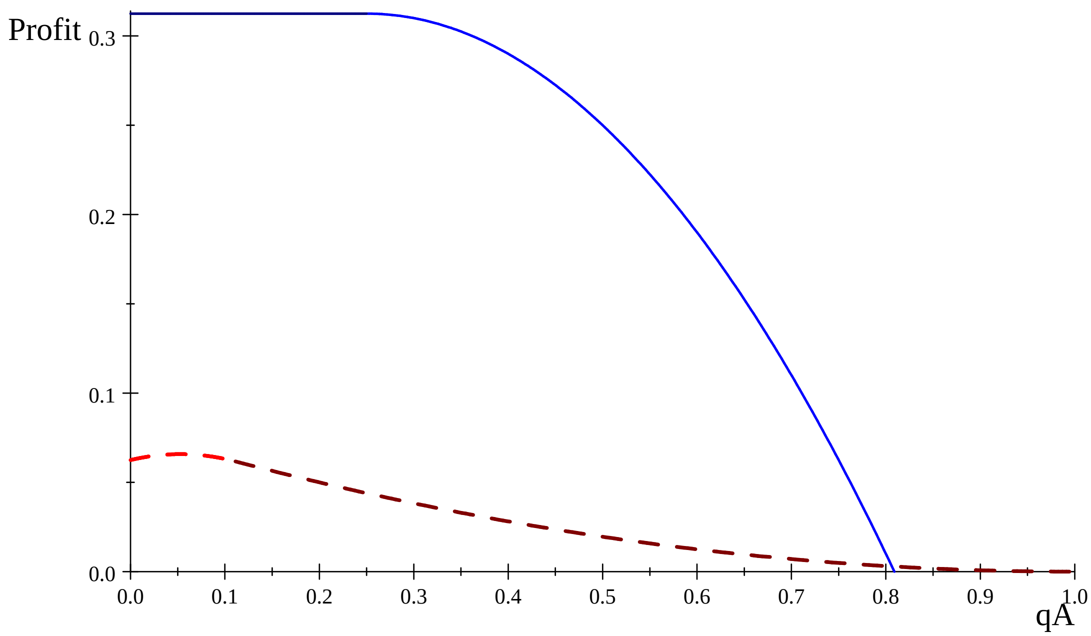

Figure 1. Profit of Firm B as a function of q_A when $c = 1.25$. Blue, solid line represents the case of a high status Firm B. The red, dashed line represents the case of low status Firm B.

Define the constant $\overline{q}$, by:

$$\overline{q} = \frac{1 + 2\sqrt{c}}{4c - 1}.$$

Given that $c > 1$, then, simple algebra reveals that $\overline{q} < 1$. If Firm A chooses a sufficiently high quality q_A, namely $q_A \geq \overline{q}$, then the profit of high status Firm B cannot be positive. That is, $\pi_{BH,2}(\overline{q}) = 0$, and $\pi_{BH,2}(q_A) \leq 0$, for all $q_A \geq \overline{q}$. Indeed:

$$\begin{aligned}
\pi_{BH,2}(\overline{q}) &= \frac{(1+\overline{q})^2}{4} - c\overline{q}^2 \\
&= \frac{1}{4}\left(1 + \frac{1+2\sqrt{c}}{4c-1}\right)^2 - \frac{4c}{4}\left(\frac{1+2\sqrt{c}}{4c-1}\right)^2 \\
&= \frac{(4c+2\sqrt{c})^2 - 4c(1+4\sqrt{c}+4c)}{4(4c-1)^2} = 0.
\end{aligned}$$

The low status Firm B has positive profit if $q_A < 1$. Indeed, $\pi_{BL,2}(1) = 0$, and $\pi_{BL,2}(q_A) > 0$, for all $q_A < 1$.

5.2 Firm B's Market Niche Choice

We have seen how Firm B reacts to every possible quality of Firm A, given the social status value of its product. What type of product Firm B prefers to sell: high status or low status? The following proposition shows that all replies $q_B(q_A)$ that give Firm B's brand low status are strictly dominated by the corresponding strategy giving Firm B's product high status.

Proposition 1 ***(Firm B's preferred market niche)*** *Let $q_A > 0$ be an arbitrary quality chosen by Firm A. Let $\pi_{BL,2}(q_A)$ (respectively, $\pi_{BH,2}(q_A)$) be the profit a low (high) status Firm B when it plays a best response to q_A.*

In this case, firm B has more profit if it has high status, unless q_A is extremely large. Formally, $\pi_{BH,2}(q_A) > \pi_{BL,2}(q_A)$ if and only if $q_A < \widehat{q}_A$, where:

$$\widehat{q}_A = \frac{(4c-1) + c\left(1+\sqrt{12(4c-1)}\right)}{(4c-1)^2 + c}. \tag{23}$$

Proposition 1 states that, whenever Firm A plays $q_A > \widehat{q}_A$, Firm B prefers the low status market niche. When $q_A < \widehat{q}_A$, Firm B prefers the high status market niche. Simple algebra shows that $\widehat{q}_A \leq \overline{q}$.

Firm B's best-reply quality is:

$$q_B(q_A) = \begin{cases} \dfrac{1}{4c-1}, & \text{if} \quad q_A < \dfrac{1}{4c-1} \\ q_A, & \text{if} \quad \dfrac{1}{4c-1} \leq q_A < \widehat{q}_A \\ \dfrac{1-q_A}{8c-2}, & \text{if} \quad q_A \geq \widehat{q}_A \end{cases} \tag{24}$$

6 Firm A's Decisions when it Pays the Development Cost in Both Periods

Completing the backwards induction argument, this section analyzes Firm A's quality decisions. Firm A knows her own quality and anticipates Firm B's quality function, $q_B(q_A)$, and both firms' price policies at $t = 2$. Firm A maximizes its value; that is, the sum of its profits in the two periods, $V_A(q_A) = \pi_{A,1} + \pi_{A,2}$.

6.1 Firm A has Low Status in the Second Period

Suppose that Firm A has low status in period $t = 2$. In this case, the total profit for Firm A is $\pi_{AH,1} + \pi_{AL,2}$. Firm A solves its profit maximization problem:

$$\max_{0 \leq q_A \leq q_B} \left\{ \frac{(1+q_A)^2}{4} - cq_A^2 + \frac{(1-q_B+2q_A)^2}{16} - cq_A^2 \right\}.$$

The following proposition states Firm A's optimal quality choice when it has low status in period $t = 2$.

Lemma 8 ***(Firm A's optimal quality when its product has low status and it pays development costs in both periods)*** *Suppose Firm A pays the development cost in both periods. Suppose that Firm A's product has low status in period t = 2. Then, in equilibrium, the quality of Firm A is:*

$$q_{AL}^{**} = \frac{3c-1}{(4c-1)^2}. \tag{25}$$

Firm A obtains a value of:

$$V_{AL}^{**} = \frac{c(40c^2 - 25c + 4)}{2(4c-1)^3}. \tag{26}$$

6.2 Firm A has High Status in the Second Period

Suppose that Firm A has H status in period $t = 2$. In this case, Firm A's value is $V_A(q_A) = \pi_{AH,1} + \pi_{AH,2}$. Hence:

$$\begin{aligned} q_{AH}^{**} &= \arg\max_{q_A \geq q_B} \left\{ \frac{(1+q_A)^2}{4} - cq_A^2 + \frac{(1+q_A)^2}{4} - cq_A^2 \right\} \\ &= \arg\max_{q_A \geq q_B} \left\{ \frac{(1+q_A)^2}{4} - cq_A^2 \right\}. \end{aligned}$$

Because $c > 1$, then the solution of this maximization problem is:

$$q_{AH}^{**} = \frac{1}{4c-1}. \tag{27}$$

Clearly:

$$q_{AL}^{**} = \frac{3c-1}{4c-1}\frac{1}{4c-1} < \frac{1}{4c-1} = q_{AH}^{**}.$$

However, Firm A cannot keep the high status for its brand by choosing q_{AH}^{**} because Firm B will cut it; that is, play quality q_B slightly above $1/(4c-1)$, pushing brand A to low status. To take the high status market niche, Firm A has to preempt Firm B's threat of takeover of the high status market niche. To preempt Firm B, Firm A needs to play a sufficiently large quality, at least $\widehat{q}_A$. By playing quality $\widehat{q}_A$, Firm A ensures that Firm B does not have incentives to play an even larger quality. How large does $\widehat{q}_A$ need to be to provide the necessary incentives for Firm B to accept being low status? The following proposition states Firm A's choice of $\widehat{q}_A$.

Proposition 2 ***(Firm A's optimal quality when its product has high status and it pays development costs in both periods)*** *Suppose that Firm A's product has high status in period $t = 2$. Then, the quality chosen by Firm A is the quality $\widehat{q}_A$ necessary to deter Firm B from choosing a quality level high enough so its product obtains high status, given by equation (23).*

It is possible to rewrite $\widehat{q}_A$ as a convex combination of $q_{AH}^{**} = 1/(4c-1)$ and $1+\sqrt{12\,(4c-1)}$. Mathematically:

$$\widehat{q}_A = \left[\frac{(4c-1)^2}{(4c-1)^2+c}\right]\frac{1}{4c-1} + \left[\frac{c}{(4c-1)^2+c}\right]\left(1+\sqrt{12\,(4c-1)}\right).$$

Given that $q_{AH}^{**} = 1/(4c-1)$ and $c > 1$, then $q_{AH}^{**} < 1 < 1+\sqrt{12\,(4c-1)}$. As $\widehat{q}_A$ is a weighted average of q_{AH}^{**} and $1+\sqrt{12\,(4c-1)}$, then $q_{AH}^{**} < \widehat{q}_A < 1+\sqrt{12\,(4c-1)}$. Firm A has to overprovide quality to deter Firm B's positioning itself in the high status market niche.

6.3 Firm A's Optimal Decision and Equilibrium

What is the best decision for Firm A in the case it pays the development cost in each period? If Firm A prefers to have low status in period $t = 2$, then its value is V_{AL}^{**} given by equation (26). If, however, Firm A chooses the quality $\widehat{q}_A$ and keeps high status in period $t = 2$, then its value is:

$$V_{AH}(\widehat{q}_A) = 2\widehat{\pi}_{AH}(\widehat{q}_A) = \frac{(1+\widehat{q}_A)^2}{2} - 2c\widehat{q}_A^2. \tag{28}$$

Which choice maximizes the value of Firm A? Occupying the high or the low status market niche? The following proposition shows that Firm A prefers its product to have low status if it pays the development cost in each period.

Proposition 3 ***(Firm A's market niche choice and equilibrium when it pays development costs in both periods)*** *Suppose Firm A pays the development cost in every period $t \in \{1, 2\}$. Then, in equilibrium, Firm A prefers to have low status in period $t = 2$, leaving space for Firm B to produce the high status good in $t = 2$. Firm A's equilibrium quality is q_{AL}^{**} given by equation (25), and its value is V_{AL}^{**} in equation (26). In equilibrium, Firm B produces quality $q_{BH}^{**} = 1/(4c-1)$ and Firm B's profit is $\pi_{BH}^{**} = c/(4c-1)$.*

7 Firm A's Decisions when it Pays the Development Cost Only Once

To analyze the incentives of Firm A when it pays the development cost only once, first we must compute its value if it tries to occupy the low and high status niches in period $t = 2$. If Firm A occupies the high status market niche, then, as before, it has to deter Firm B from entering the market and taking the high status market niche. Because Firm B only operates in one period, its cost structure did not change in comparison to the analysis done in Subsection 6.2.

7.1 Firm A has High Status in the Second Period

If Firm A wants to have high status in period $t = 2$, then it chooses quality $\widehat{q}_A$. In this case, its value is:

$$V_{AH}^* = 2\widehat{\pi}_{AH}(\widehat{q}_A) + c\widehat{q}_A^2 = \frac{(1+\widehat{q}_A)^2}{2} - c\widehat{q}_A^2.$$

Lemma 9 ***(Firm A's Value if it chooses high status)*** *Suppose that Firm A pays the development cost only once and it has high status in period $t = 2$. Then, the value of Firm A is*

$$V_{AH}^* = \frac{c(5c-1)(16c^2-c+1) + 6c^3\sqrt{12(4c-1)}}{(16c^2-7c+1)^2}. \tag{29}$$

7.2 Firm A has Low Status in the Second Period

Suppose that Firm A has low status in period $t = 2$. Let V_{AL}^* denote Firm A's value in this case; that is, the sum of profits along both periods when its brand has low status in period $t = 2$. Firm A's value is $V_{AL}^* = \pi_{AH,1} + \pi_{AL,2}$. Its optimal quality is:

$$q_{AL}^* = \arg\max_{0 \le q_A \le q_B} \left\{ \frac{(1+q_A)^2}{4} - cq_A^2 + \frac{(1-q_B+2q_A)^2}{16} \right\}.$$

The following result calculates the optimal choice of quality by Firm A.

Proposition 4 ***(Firm A's optimal quality when its product has low status and pays development cost once)*** *Suppose that Firm A's product has low status in the second period. Then, its optimal quality choice is:*

$$q_{AL}^* = \frac{5}{16c-5}. \tag{30}$$

Firm A's value is:

$$V_{AL}^* = \frac{5c}{16c-5}. \tag{31}$$

7.3 Firm A's Optimal Decision and Equilibrium

The next proposition shows that Firm A prefers to have high status if it pays the development cost only once.

Proposition 5 ***(Firm A's market niche choice when it pays development costs once)*** *Suppose that Firm A pays the development cost only once. Then, Firm A prefers to have high status in period $t = 2$, leaving space for Firm B to produce the low status brand in $t = 2$. In this case:*

$$V_{AH}^* > V_{AL}^*.$$

Firm A chooses quality $q_A = \widehat{q}_A$, defined by equation (23), and its value is V^*_{AH} defined in equation (29). Firm B's equilibrium quality is:

$$q^*_{BL} = \frac{1-\widehat{q}_A}{8c-2} = \frac{16c^2 - 12c + 2 - c\sqrt{12(4c-1)}}{(8c-2)(16c^2-7c+1)},$$

and its equilibrium profit becomes $\pi^*_{BL} = c(1-\widehat{q}_A)^2/(16c-4)$.

Can Firm A play its global maximum $1/(2c-1)$ and still provide the incentive for Firm B to target the low status market niche? Or must Firm A always overprovide quality to induce Firm B to target the low status niche? The proposition below shows that Firm A must always play a second-best optimal to occupy the high-status market niche.

Proposition 6 ***(Firm A's quality overprovision)*** *Suppose Firm A pays the development cost only once. Then, if Firm A chooses to block Firm B's attempt to take the high status market niche, then Firm A will overprovide quality, that is, choose a quality level greater than its first-optimal choice. Formally:*

$$\widehat{q}_A > \frac{1}{2c-1}.$$

If Firm A does not intentionally drive Firm B to the lower status market niche, it is optimal for Firm B to offer a product of higher quality and take the higher status market niche. Proposition 6 states that Firm A must forcefully drive Firm B to the lower status market niche to take the high status market niche. This is done by producing a product of quality $\widehat{q}_A$, a level of quality that is strictly above the global optimum. This overprovision of quality guarantees high status for Firm A's brand in both periods.

8 Firm A Can Change its Quality Between Periods

Now suppose that Firm A is a monopoly in period $t = 1$, but can freely change its quality in the beginning of period $t = 2$. Let $q_{A,t}$ be the quality of Firm A's good in period $t \in \{1, 2\}$. After Firm A chooses its quality in period $t = 2$, Firm B observes the choice $q_{A,2}$, and then, decides its own quality, $q_B = q_B(q_{A,2})$. Both firms observe the quality choices in period $t = 2$. After qualities become common knowledge, then firms choose prices simultaneously. Firm A pays the development cost in each period: $cq^2_{A,1}$ in period $t = 1$; and $cq^2_{A,2}$ in period $t = 2$.

In period $t = 1$, Firm A is a monopolist, and its choices of price and quality do not affect the continuation game in $t = 2$. After period $t = 1$ ends, Firm A chooses its quality for period $t = 2$. An option for Firm A is to overprovide quality, choosing $q_{A,2} = \widehat{q}_A$, capturing the high status niche and pushing its opponent to the low status market niche. Let $\widetilde{\pi}_{AH}$ and $\widetilde{\pi}_{BL}$ denote the equilibrium profits of firms in this case.

Another option for Firm A is to choose a relatively low quality in $t = 2$, focusing on the low status market niche, allowing Firm B to produce and sell the high status good. Let $\widetilde{\pi}_{AL}$ and $\widetilde{\pi}_{BH}$ be the equilibrium profits of firms in this alternative case.

The pricing subgame is the same as before. Lemmas 4 and 5 compute the equilibrium prices as functions of qualities.

Firm B's best reply quality is also the same as before, as described by equation (24). If Firm A's choice of quality in period $t = 2$ is $\widehat{q}_A$ or above, then Firm B is discouraged from seeking the high status niche, and simply plays $\widetilde{q}_{BL}(q_A) = (1 - q_A)/(8c - 2)$, for any $q_A \geq \widehat{q}_A$. Anticipating this, Firm A's plays $\widehat{q}_A$, if it wants to capture the high status market niche. In this case, Firm A plays $\widehat{q}_A$, Firm B plays $\widetilde{q}_{BL}(\widehat{q}_A) = (1-\widehat{q}_A)/(8c-2)$, and, by equation 7 with $q_A = \widehat{q}_A$, the profit of Firm A in period $t = 2$ becomes:

$$\widetilde{\pi}_{AH} = \frac{(1 + \widehat{q}_A)^2}{4} - c\widehat{q}_A^2.$$

Suppose Firm A targets the low status market niche. By equation 20, Firm B's best reply quality is $\widetilde{q}_{BH} = 1/(4c - 1)$, if $q_A < 1/(4c - 1)$, and some quality q_B just marginally above q_A if $1/(4c - 1) \leq q_A < \widehat{q}_A$. Anticipating this reaction by its opponent, by equation 15, Firm A simply chooses the quality $q_A < \widehat{q}_A$ that maximizes its profit in period $t = 2$. However, it is optimal for Firm A to choose quality equal to or above $1/(4c-1)$ if it still going to be the low status producer. Hence, Firm A chooses a quality smaller than $1/(4c-1)$, and Firm B plays $\widetilde{q}_{BH} = 1/(4c - 1)$. In this case, the profit maximization problem of Firm A becomes:

$$\max_{0 \leq q_A < 1/(4c-1)} \left(\frac{\left(1 - \dfrac{1}{4c-1} + 2q_A\right)^2}{16} - cq_A^2 \right). \tag{32}$$

Lemma 10 ***(Firm A's maximization when it can change its quality between periods)*** *Suppose that Firm A targets the low status/low quality market niche in period $t = 2$. Then, the solution of Firm A's profit maximization problem 32 in period $t = 2$ is:*

$$\widetilde{q}_{AL} = \frac{2c - 1}{(4c - 1)^2}. \tag{33}$$

The corresponding profit is:

$$\widetilde{\pi}_{AL} = \frac{c(2c - 1)^2}{(4c - 1)^3}.$$

Once we know the two possible profit levels for Firm A, the next step is to compare them to one another to determine the optimal choice of quality for Firm A overall in period $t = 2$.

Proposition 7 ***(Firm A's market niche choice when it can change quality between periods)*** *Suppose Firm A can change its quality between periods and must pay the development cost for each period. Then, Firm A, the Pioneer, targets the low status market niche, leaving the high status good to Firm B, the challenger.*

9 Conclusion

This study sought to analyze a two-period duopolistic market for indivisible status goods in which two firms, the pioneer and the challenger, enter the market sequentially. Which firm occupies the market niche of high status in equilibrium depends on the structure of the quality development costs. It also depends on the timing of the game.

If firms have to pay development costs in every period, then the pioneer's best strategy is to settle for the low status niche of the market after the challenger's entry. In the second period, the pioneer's good has lower status and lower quality than the good produced by the challenger.

If it does not need to pay the development costs again in the second period, then the pioneer firm retains high status. However, the pioneer needs to overprovide quality to disincentivize the challenger from capturing the high status niche of the market.

The model is extended to evaluate the case in which the pioneer can change its quality between the two periods of the game. In this case, the challenger always takes the high-status market niche, while the pioneer occupies the low-status market niche. This last scenario fits the case in which the status good production is intensive in innovation, always requiring new investments, and both firms have the similar cost functions. Our model predicts that in industries where innovation is important to the production of a status good, the challenger tends to capture the high status market niche. For markets where new and frequent high investments are not necessary, the model predicts that the pioneer dominates the high end of the market.

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