How to Promote Quality Perception in Wine Markets: Brand Advertising or Geographical Indication?

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Working Paper 06-WP 426
August 2006

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The authors appear in order of senior authorship. The authors thank Helen Jensen, Dermot Hayes, David Hennessy, and Bill Foster for discussions and comments.

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Abstract

In the context of the wine industry, we investigate producers' choice between geographical indications and brand advertising to convey information to consumers. Producers also decide whether or not to select an effort level for improving the quality of their products. We show that if this effort level is selected, a producer will prefer to rely on brand advertising for promoting its products and setting up its own reputation. Despite allowing the cost of promotion to be shared, a geographical indication does not sufficiently reward the effort to improve quality. Finally, the selection of both instruments by producers is examined.

Keywords: brand advertising, effort, geographical indication, GI, quality, wine.

JEL Classification: L15, L66, Q13

Introduction

Wine promotion has been modified recently with the emergence of "new-world" wine from Australia, California, and Chile. Wineries from these countries mainly use individual brand advertising (BA) to promote quality perception, while more traditional European wineries mainly rely on geographical indications (GIs) for signaling the quality of their products. Foreign consumers in Europe are often baffled by the profusion of wine GIs. Reliance on GIs to promote food and beverage products is widespread in Europe not only for wine but also for cheese, meat, and other products. For instance, nearly 700 products are registered with the European designations system under the so-called Protected Designation of Origin and Protected Geographical Indication (EC, 2006). These differences raise the issue of the efficiency of the GI system for promoting food products relative to the merits of BA.

We analyze the complex interaction between BA and GI and the rewards to quality improvements. We identify the relative effectiveness of BA and GI to reward producers[1] for improvements in quality of their products, using a stylized framework linking product promotion and quality efforts. In a two-period model, BA and GI enhance the quality perception and the willingness to pay of consumers. The BA allows a producer to develop an individual reputation. The GI allows producers to share the cost of promotion and to develop a common reputation. Besides the choice of BA or GI, producers choose whether or not to make an effort to improve the overall quality level that affects the consumers' purchase decision in the second period. Both signal and effort strategies influence the producers' profits.

Wine production is notoriously stochastic, with "good" and "bad" years, and taste attributes vary. New technologies allow control of the consistency of taste attributes (e.g.,

[1] Producers denote the supply chain (producers, wineries, firms) supplying wine to consumers.

controlled fermentation, varietal mix, and use of wood chips). These improvements are examples of what we mean by efforts to improve quality, i.e., investments in costly processes to improve the expected hedonic quality of a wine. We show that if the effort for improving quality is selected, a producer will prefer to rely on BA for promoting its products and setting up its own reputation. Despite the sharing of the cost of promotion, a GI does not sufficiently reward the effort for improving quality because of the common reputation. Conversely, when the producer avoids the effort, the GI is selected. Producers take advantage of sharing of the cost of promotion under collective reputation.

This paper is linked to two separate strands of the literature. The first strand includes numerous papers on quality signaling. The latter mainly considers prices (e.g., Mahenc, 2004) or advertising (e.g., Fluet and Garella, 2002) to signal higher quality. The second and more recent strand focuses on GI and collective reputation (e.g., Marette and Crespi, 2003; Zago and Pick, 2004; and Winfree and McCluskey, 2005). In this literature, producers' coordination or even price collusion through a GI may be necessary to improve quality when the fixed costs of certification or quality improvements are large. Our framework differs because we simplify the consumers' belief in higher quality by considering BA and GI as persuasive tools that change consumers' preferences. In addition, our framework contributes to the more recent strand of literature. Here, we abstract from any price collusion linked to a GI and introduce the possibility that producers chose to use BA. Indeed, our paper addresses the question of the relative efficiency of collective signals compared to that of a private brand and the possible combination of both instruments, an issue that was previously overlooked in the literature.

The next section expands on our contention that the emergence of "new-world" wine has relied on BA in contrast to the reliance of European wine on GIs. Then, in the third section, we

introduce the model. The main results are presented in the fourth section, while the fifth provides some extensions, and the final section offers conclusions. An appendix provides detailed derivations of results presented in the text.

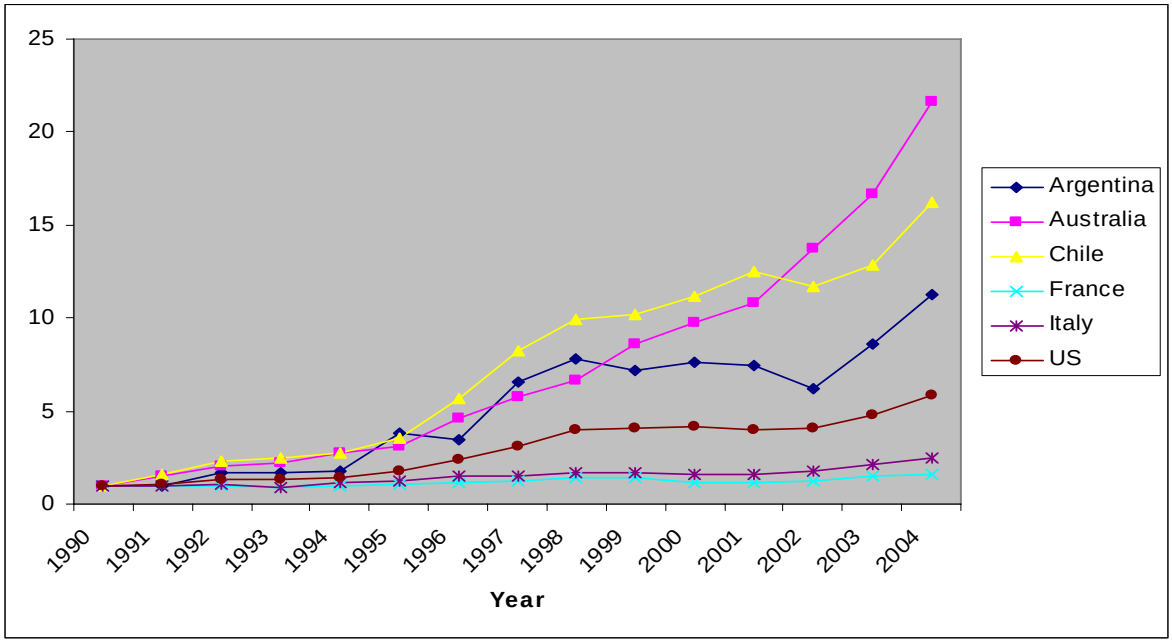
Promotion Strategies in the Wine Market

In the last 15 years, globalization and trade liberalization have entailed a new context of competition. While world consumption of wine has been increasing (WHO, 2006), wine exports of European countries such as France and Italy have leveled off. Conversely, the exports of Australia, Chile, Argentina, and the United States have steadily gained ground, as shown in Figure 1, and markedly so in recent years.[2] The European domination is being challenged by new producers from Chile and Australia. This new competition has modified strategies for signaling and promotion in the wine market (BA versus GI), accompanied by differences in cost structure, industry structure, and wine technology. The intellectual challenge is to elucidate the individual effect of these various elements. We focus on the noticeable efforts of these emerging competitors to improve quality through consistency and predictability of taste and the crucial role of their marketing strategies. The following stylized facts allow us to understand the differences between producers in Europe and in the emergent countries.[3]

First, several types of information such as the winery, the grape, or the origin are usually mentioned on most bottles. However, for a buyer, the most visible information in France is the GI for medium-quality wines, and the cumulative GI (appellation, grand cru, etc.) combined with the winery ("chateau") for high-quality wines. Conversely, the brand is the most visible

[2] Note that this figure exhibits aggregated volumes that neglect segmentation and quality heterogeneity.
[3] The stylized facts mainly concerned consumption wines that differ from collectible wines reserved to experts (Costanigro et al., 2005).

information for the Australian wines (e.g., Jacob's Creek, 2005). Wine promotion in Australia, Chile, and the United States favors private BA, which facilitates individual reputation and recognition by buyers.



Basis Data Source: UN Commodity Trade Statistics Database.

Figure 1. Wine exports value (basis 100 in 1990)

Second, the profusion and proliferation of GIs in Europe lead to some risks of confusion for consumers (Marette and Zago, 2003). Peri and Gaeta (1999) count more than 400 official appellations in the wine sector in Italy, 450 appellations in France, and 1,397 in the wine sector in Europe. Such profusion assures product diversity but certainly increases buyer confusion (*Consumer Reports,* 1997). The recognition of quality labels by French consumers is only 12% for Appellations d'Origine Contrôlée, the French GI system for high-quality products (Loisel and Couvreur, 2001). Berthomeau (2002) discusses the difficulty that some French GIs have in entering new export markets because of the absence of any clear specification of the label that

distinguishes one appellation from another in consumers' minds.[4] In sharp contrast, Jacob's Creek and Kendall Jackson wines can be found in most U.S. grocery stores.

Third, many European GIs impose numerous restrictions that often stifle the search for commercial efficiency and innovations in quality that would improve the predictability in taste and consistency over time. Grape production is regulated, with a maximum yield allowed per unit of land. Excessive regulation for linking origin and quality seems problematic when the international competition is intense (Zago and Pick, 2004; and Ribaut, 2005). Conversely, the main features of regulations in the United States, Chile, and Australia are the lack of detailed rules and the freedom to experiment with new techniques; the production and marketing of wines according to single varieties of grapes, sometimes associated with a relatively large production region; and an intense use of marketing investments.[5]

Fourth, wineries in Australia are much bigger than the ones in Europe, and the industry in the "new world" has been dominated by relatively large producers. The average vineyard size in France is less than 2 hectares compared with 111 hectares in Australia. Four producers dominate the Australian market, namely, Foster, Southcorp, Hardy, and Orlando Wyndham. The combined production share of the four largest producers in New Zealand is 85%, while the combined production share of the two largest producers in South Africa is 80%. Unlike the industry in Australia, Chile, or other new world competing countries, the wine industry in Europe is fragmented. Indeed, apart from some notable exceptions, e.g., Champagne (*The Economist*,

[4] The collective reputation of French wines plummeted during the last decade (Conan, 2005; Echikson, 2005; and Ribaut, 2005). Giraud-Heraud et al. (2002) and Ribaut (2005) mentioned the need for winery consolidation and/or reform of the French GI system.

[5] In September 2005, the United States and the European Union reached a wine-trade agreement that makes some U.S. practices, such as adding wood chips to wine barrels, legitimate in the European Union. U.S. companies will stop using some GIs, such as Champagne, Sherry, and Port. Some EU lawmakers are not satisfied with this agreement because the European wine industry is strictly regulated and emphasizes traditional practices, while the U.S. industry emphasizes new technology that allows better control of taste characteristics and their identification by

2003), the wine industry in Europe is made up of many small producers that often lack adequate capital for the necessary investments in new technologies and marketing policies. In other words, small wineries are unable to reach the minimum-efficient scale since the quality improvement implies relatively large fixed costs.

Beyond these empirical facts, further effects of the origin and the role of the GI are less easily evaluated. Despite the limits previously mentioned, GI also indicates natural conditions such as the soils and the climate specific to a certain geographic area (Barham, 2003). Origins of product matters for consumers' purchase decisions. Orth et al. (2005) show that the origin of a bottle does affect the U.S. consumers' preference, as shown in Table 1.[6]

Table 1. Consumers' preference for wine origin

Origin	Mean rank	Standard Deviation
California	3.03	1.95
France	3.88	2.49
Italy	4.38	2.18
Australia	4.67	2.51
Oregon	4.78	2.55
Chile	5.75	2.32
Spain	5.87	1.98
Washington	6.02	2.42
New Zealand	6.51	1.89

Source: Table 1 in Orth, Wolf, and Dodd (2005).
Note: Scale from 1 = most preferred to 9 = least preferred

However, GIs can be an efficient tool for signaling collective reputation. The Champagne GI is an example of successful collective reputation in which the combination of famous brands (with large vineyard size and enough capital for advertising) and a prestigious GI matters for consumers ready to pay a large premium (Combris et al., 2003). Orth and Krska (2002) show

consumers (Locke, 2005).

[6] It should be noted that the origin in Table 1 corresponds to countries or U.S. states, as that would be the case for GIs in France or Italy, associations that often concern sub-regions or small areas.

that consumers rank country and region of origin at the top of wine attributes, while the producer name is lower. An "efficient" combination of brands and GI also characterizes the Napa Valley appellation, which generates a significant price premium compared to an equivalent-quality bottle with a different appellation (Bombrun and Sumner, 2003). The efficiency of GI compared to that of a private brand is an open question. Some empirical studies of wine have elucidated consumers' attitudes towards GIs and brands. With a parametric hedonic approach, Steiner (2004) shows that the decline of French wine in the British market is partly due to the consumers' low valuation of geographical appellation. Riley et al. (1999) show a positive correlation between consumers' attitudes (and perceptions) and relative brand size in the British wine market.

The debate about the strategies of producers and the appropriate regulation will likely gain momentum. This last point leads directly to the focus of our paper. Although the choice among tools for improving quality raises many questions, we focus on the central link between an effort for improving quality and different tools for quality signaling (BA versus GI and a combination of both). A stylized model is used to isolate the impact of alternative ways to signal quality with and without efforts to improve quality.

The Model

We assume purchases occur in two periods ($t=1, 2$) with two producers i and j who may offer products of high quality or low quality. In the first period, producers i and j choose whether or not to promote their products and/or whether or not to improve the quality of their products. The cost of promotion is A. If the producers choose the GI, each producer incurs the cost $A/2$ since they share the cost. If a producer individually chooses to use BA, it incurs the cost A. The cost of

product improvement is F. It is assumed that other costs of production are zero. For simplicity, it is also assumed that $A = \gamma F$, with $\gamma \leq 1$.

Each consumer only purchases one unit of the good per period t (Mussa and Rosen, 1978). A consumer who buys one unit of the product from producer i at price p_i^t has an expected indirect utility equal to $\theta E(q_i^t) - p_i^t$, where $E(q_i^t)$ is the expected quality. The mass of those consumers is normalized at 1, with a uniformly distributed parameter $\theta \in$ [0, 1]. For simplicity, we assume that consumers only want to get high quality (denoted q_H) and they get no satisfaction from getting low quality ($q_\ell = 0$).

Consumers have limited knowledge about quality. In the first period (*t=1)*, the consumer has a belief about the probability of getting high quality from producer i equal to $\overline{\lambda} + I_i^\alpha \alpha$, with $0 \leq \overline{\lambda} + I_i^\alpha \alpha \leq 1$. Parameter $\overline{\lambda}$ is the initial belief about wine quality in the absence of promotion, and I_i^α is an indicator linked to the promotion strategy. I_i^α =1 means that producer i invests in promotion (BA or GI) for enhancing the consumer's perception of quality in the first period, while I_i^α =0 means producer i avoids investing in promotion. Parameter α is the incremental probability of purchasing wine of high quality.

In the second period (*t=2*), consumers repeat their purchases by learning the average quality of the products because of an imperfect experience. Consumers can communicate with each other after the first period, so that common knowledge is formed regarding the average quality of the products among consumers. Consumers experience the product even if they know there is residual uncertainty that limits their knowledge. They learn about the probability of getting high-quality products by using complementary information (communication among the consumers, newspapers, and so forth). The probability of getting high-quality products depends

on the producer's decision for improving quality at cost F. The cost F implies an improvement of the probability of having high-quality products equal to e. Under BA, consumers are able to identify each producer's improvement since promotion is individual. If producer i chose BA, the probability of having high-quality products is $\lambda + I_i^e e$ (with $0 < \lambda + I_i^e e \leq 1$), where λ is the real probability of getting high-quality products in the absence of an effort. I_i^e is an indicator of the probability improvement (I_i^e =1 when F is incurred and zero otherwise). If both producers chose GI, consumers are not able to distinguish precisely the quality of both producers since the promotion is collective. Because GI leads to a collective reputation, the probability for consumers to get high-quality products in the absence of distinction between both producers is $(\lambda + I_i^e e)/2 + (\lambda + I_j^e e)/2 = \lambda + (I_i^e + I_j^e)e/2$, with $i \neq j$.

We summarize all the cases faced by producers and consumers in Table 2. Recall that the low quality is q_L =0, so that the expected quality for consumers is equal to their belief regarding the probability of getting high quality multiplied by the quality level, q_H.

Table 2. Producers' strategy and consumers' expectation of producers' quality (q_L = 0)

First Period			Second Period
Producer i's Strategy (Producer j's Strategy)	Cost incurred by producer i and j	Consumer's expected quality of producer i and j	Consumer's expected quality of producer i and j
No signal (No signal)*	$I_i^e F$	$\bar{\lambda}\ q_H$	$(\lambda + 0.5(I_i^e + I_j^e)e)\ q_H$
GI (GI)*	$I_i^e F$+0.5A	$(\bar{\lambda} + \alpha)\, q_H$	$(\lambda + 0.5(I_i^e + I_j^e)e)\ q_H$
BA (BA)*	$I_i^e F$+A	$(\bar{\lambda} + \alpha)\, q_H$	$(\lambda + I_i^e e)\ q_H$
BA (No signal)**	$I_i^e F$+A $(I_j^e F)$	$(\bar{\lambda} + \alpha)\, q_H$ $(\bar{\lambda}\ q_H)$	$(\lambda + I_i^e e)\ q_H$ $((\lambda + I_j^e e)\ q_H)$

*Identical values for i and j. **No signal/(BA) is obtained by switching the payoff rows of BA/(No signal).

The game proceeds in three stages in the first period. At the first stage, the producers make their decisions for promoting their products, namely GI, BA, or no signal. In the second stage, each producer decides whether or not to make an effort to improve the probability of producing high-quality goods. In the third stage of the first period, each producer selects a quantity (Cournot competition), and consumers decide on their consumption levels. They learn partial information through consumption. Stage 4 corresponds to the second period, whereby the consumers repeat their purchase and each producer selects a quantity (Cournot competition). The timeline of the stages is shown in Figure 2. We now turn to the presentation of the producers' choices.

The Producers' Choices

When producers choose the information strategy (in stage 1) and the effort strategies (in stage 2) that maximize their profits, they take into account the quantity choices in stages 3 and 4. The sub-game perfect equilibrium is detailed in Appendix 1 and 2.

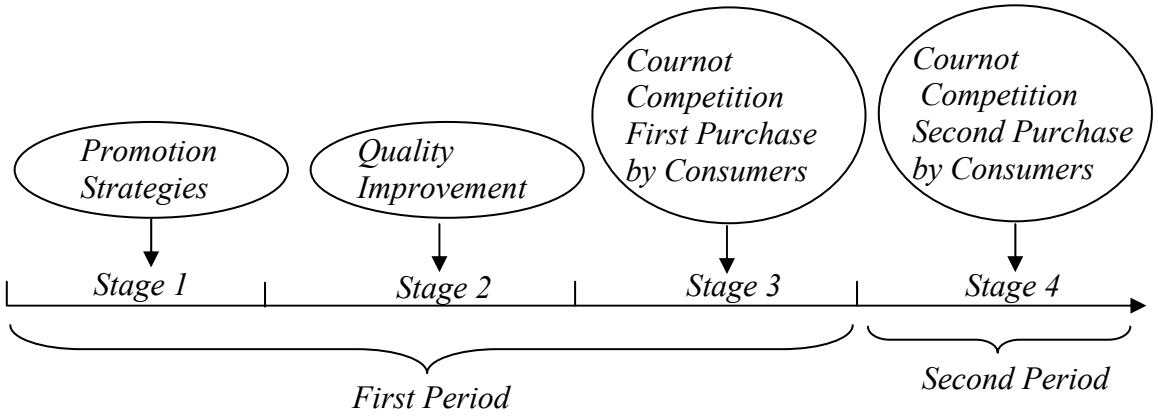


Figure 2. Timeline of the game

The incentive for a producer to select promotion and/or an effort balances two opposing effects. An information/effort strategy leads to higher demand for its products by increasing the consumer's willingness to pay. However, this positive effect may be offset by the fixed cost induced by these strategies or by the strategic interaction with the other producer. The producers' choices depend on the efficiency of both promotion (represented by parameters $\overline{\lambda}, \alpha$, and γ) and effort (represented by the parameter *e*).

The selection of the profit-maximizing strategies leads to a set of results (Propositions 1-4). The derivations are shown in the appendix. For sake of simplicity, we characterize the equilibrium strategies for alternative values of γ, namely, the relative cost of promotion compared to the cost of quality improvement (recall that $A=\gamma F$). Figures 3 and 4 illustrate the market equilibrium detailed in the propositions. The X-axis represents the quality level, q_H, and the Y-axis represents the fixed cost, *F*. The relative values of q_H and *F* determine the producers' optimal strategy and define the limits of different areas (the frontiers of these regions are detailed in the appendix). Below, we present the propositions and provide an intuitive interpretation. Let

$$\gamma_1 = \frac{\alpha(4e+3\lambda)^2(36\alpha^2+56\alpha\overline{\lambda}+21\overline{\lambda}^2)}{e(4\alpha+3\overline{\lambda})^2(36e^2+56e\lambda+21\lambda^2)} \qquad (1)$$

Proposition 1: *When the relative cost of signaling is low with $\gamma \le \gamma_1$, the producers' strategies are as follows (see Figure 3):*

(a) both producers choose no signal and no producer makes an effort in area 1,

(b) one producer chooses BA and no producer makes an effort in area 2,

(c) one producer chooses BA and makes an effort in area 3,

(d) one producer chooses BA and both producers make an effort in area 4.

The proof is given in Appendix 1.

In area 1, making the effort or using a signal is too costly, since the respective costs represented by F (and γF) are relatively large. When F decreases in areas 2, 3 and 4, the different strategies of an effort and signal become affordable for the producer(s). When the cost of signaling is low with $\gamma \leq \gamma_1$, each producer will try to use the BA alone, since it increases the perception differentiation and the profit by means of the parameter α in the first period and the individual reputation in the second period. This market mechanism leads one producer to choose BA instead of cooperating with the other producer to select GI since the cost of signaling is relatively small.

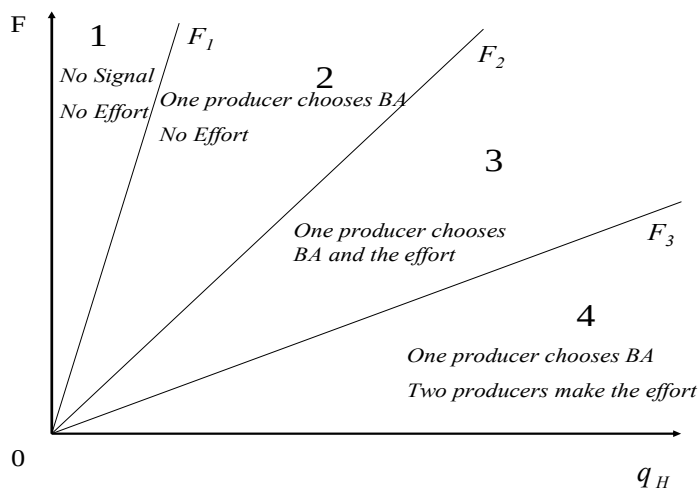


Figure 3. The strategies with low relative cost of signaling ($\gamma \leq \gamma_1$)

In area 2, one producer chooses BA because of the low cost of signaling (small γ), and no producer makes an effort because of the relatively high cost of the effort compared with the signal cost. When the relative value of F decreases further (area 3), the producer choosing the BA chooses to make an effort. In area 3, the fixed cost is still quite high for the other producer to select a signal or an effort. When F is relatively small (area 4), both producers make an effort.

Only one producer chooses the BA that allows a perceived increased quality differentiation in period 1.

As α, the incremental probability of purchasing wine of high quality coming from promotion, is assumed to be the same under BA and GI, the market equilibrium with the two producers selecting BA never emerges. Indeed, it is optimal for both sellers to join the GI and to share the cost of promotion.

We now turn to a situation in which the cost of promotion increases. Let

$$\gamma_2 = \frac{4\alpha^2(80e^3 + 81\alpha\lambda^2 + 24e\lambda(9\alpha+\lambda) + 4e^2(36\alpha+25\lambda))}{e(4\alpha+3\overline{\lambda})^2(16e^2+31e\lambda+15\lambda^2)} + \frac{(8\alpha\overline{\lambda}+3\overline{\lambda}^2)(60e^3+63\alpha\lambda^2+6e\lambda(28\alpha+3\lambda)+e^2(112\alpha+75\lambda))}{e(4\alpha+3\overline{\lambda})^2(16e^2+31e\lambda+15\lambda^2)} \quad (2)$$

Proposition 2: *For a medium relative cost of signaling with* $\gamma_1 < \gamma \le \gamma_2$, *area 2 in Figure 3 disappears.*

The proof is given in Appendix 1.

Since signaling is more costly, no producer selects the BA without making an effort. In other words, the BA is valuable only if an effort is made. Indeed compared to Proposition 1, area 2 disappeared when γ increased. We now turn to a situation in which the cost of promotion keeps increasing with $\gamma_2 < \gamma < \gamma_3$[7]. Let

$$\gamma_3 = \frac{4\alpha}{e} \quad (3)$$

$$\alpha_1 = \frac{3\overline{\lambda}}{4} \quad (4)$$

[7] The relative values of γ_2 and γ_3 depend on the relative values of $\lambda, \overline{\lambda}, e$, and α. If $\gamma_2 > \gamma_3$, Proposition 3 does not exist.

Proposition 3: *When the relative cost of signaling is of medium level with* $\gamma_2 < \gamma \leq \gamma_3$, *the producers' strategies are as follows (see Figure 4):*

(a) both producers choose no signal and no producer makes an effort in area 1',

(b) both producers choose GI but no producer makes an effort in area 5,

(c) both producers make an effort; one producer chooses BA if $\alpha > \alpha_1$ *and both of them choose GI if* $\alpha < \alpha_1$ *in area 6.*

The proof is given in Appendix 1.

When the cost of promotion continues to increase, the GI becomes more attractive compared to the BA because the producers share the cost of promotion. Areas 3 and 4 from Figure 3 disappear, since the cost of BA becomes too high for a single producer to afford. In Figure 4, the producers lean toward [choose] GI rather than doing BA individually. Some new equilibria appear in Figure 4.

In reference to area 4 of former Figure 3, here, in Figure 4, GI replaces BA for large values of *F*. The story in area 6 is the following: if signaling is not persuasive up to a certain level ($\alpha < \alpha_1$), producers would choose to cooperate with each other and do GI to share the fixed cost. However, if signaling is effective and α is greater than some certain level α_1, one producer would do BA to distinguish itself from the other in the first period to gain higher profit.

Proposition 4: *When the relative cost of signaling is high (*$\gamma > \max\{\gamma_2, \gamma_3\}$*) the producers' strategies are as follows (see Figure 4):*

(a) no producer chooses any signal strategy and no producer makes an effort in area 1',

(b) both producers make no signal but both producers make an effort in area 7, and

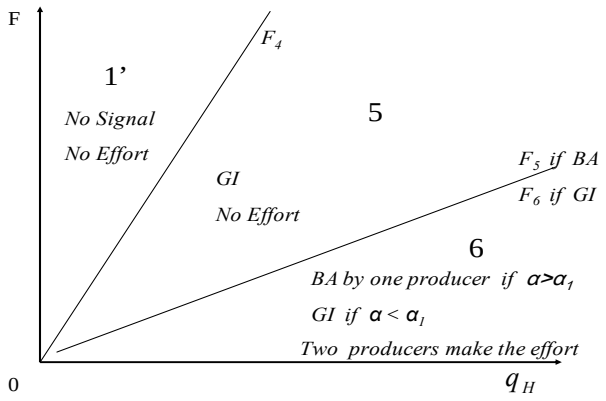


Figure 4. The strategies with medium relative cost of signaling ($\gamma_2 < \gamma \leq \gamma_3$)

(c) both producers make an effort; one producer chooses BA if $\alpha > \alpha_1$ and both of them choose GI if $\alpha < \alpha_1$ in area 6'.

The proof is given in Appendix 1.

Proposition 4 is illustrated in Figure 5. In this case, the cost of signaling is so large that even the effect of cost-sharing of GI does not work well. Therefore, area 5 in Figure 4 disappears. As the cost of making an effort continues to decrease, producers choose to make an effort instead of signaling in area 7. In reality, this corresponds to a new technology, which decreases the fixed cost of investing in quality improvements.

From the foregoing four propositions, we can conclude that the strategies of the producers depend on the relative effectiveness of providing quality improvements and signaling. When signaling is more effective and the fixed cost of providing a quality effort is large, producers tend not to make an effort; when quality improvement is more effective and the fixed cost of signaling is large, producers tend not to signal. We also conclude that BA provides producers with a higher incentive to make an effort than GI does, since GI is a collective

reputation. If the effort for improving quality is selected, a producer will prefer to rely on BA for promoting its wine and set up its own reputation. Despite the sharing of the cost of promotion, a GI does not sufficiently reward the effort for improving quality because of the common reputation. On the contrary, when the producer avoids making an effort, GI is selected to be the promotion strategy. In this case, producers take advantage of sharing of the cost of promotion and collective reputation.

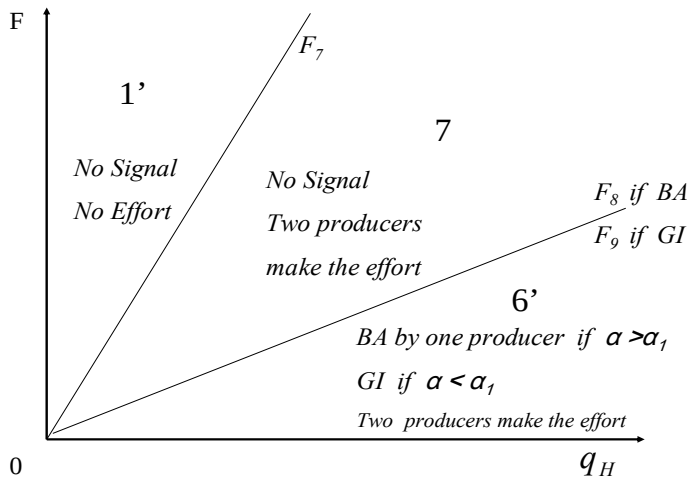


Figure 5. The strategies with high relative cost of signaling ($\gamma > \max\{\gamma_2, \gamma_3\}$ ***)***

Extensions

In defining the analytical framework, restrictive assumptions were made for simplicity. Some of the results of the model are robust if we consider the following extensions.

(i) In our model we abstract from the combination of GI and BA. One extension could be the incorporation of this combination. The following assumption could be made: In the first period, GI enhances the consumer's expectation by α and costs producers $\frac{A}{2}$; BA enhances the consumer's expectation by α as well but costs producers A; and the combination of the two

enhances the consumer's expectation by $c\alpha$ and costs producers $\frac{3A}{2}$. When the combination of these two are effective (high $c\alpha$ compared with the cost $\frac{3A}{2}$), the producers would choose the combination; if the combination were not effective enough, producers would choose GI or BA individually, which goes back to the propositions of this paper. Let $c_1 = \min\{1, \frac{32\alpha^4 + 24\alpha^3\overline{\lambda} - 19\alpha^2\overline{\lambda}^2 - 14\alpha\overline{\lambda}^3 - 14\alpha\overline{\lambda}^3}{3(16\alpha^4 + 24\alpha^3\overline{\lambda} + 9\alpha^2\overline{\lambda}^2)}\}$ and when $c < c_1$, the combination of BA and GI is dominated by BA or GI in equilibrium and it never emerges. (See the proof in Appendix 2 [point *viii*]).

(ii) In our model, signaling has an effect only in the first period. One extension could be the introduction of an effect of signaling on consumers' expectation in the second period. That is, the second period's expectation of consumers is the combination of the expectation of the first period and the real probability. For example, when producers choose GI, consumers' expectation in the second period is $[\varphi(\lambda + 0.5(I_i^e + I_j^e)e) + (1-\varphi)(\overline{\lambda} + \alpha)]q_H$, where $0 \le \varphi \le 1$. The higher the effectiveness of signals in the second period, the closer is consumers' expectation to the real probability. By doing this, we introduce an interaction effect of signaling and making an effort. We expect that producers' incentive to make an effort is lower when the second-period effectiveness of signaling is lower.

(iii) Our model abstracts from the discount of the second-period profit of the consumers. If there is a discount in the second period, the larger the discount, the lower is the producers' incentive to make an effort.

(iv) In the model, we abstracted from a context with numerous producers. Since GI has the property of cost-sharing, one natural question is, if there are numerous producers, will the

producers prefer GI to BA since they could share the promotion cost by doing GI? To answer this question, we abstract from the strategy of making an effort in this extension. Suppose there are n producers. They could choose to do GI together to share the signal cost in the first period. When the signal cost is not quite high, the producers have the incentive to deviate to do BA by themselves. Suppose initially all producers do GI and the first producer chooses to deviate from GI to BA only if $A < \frac{n(\bar{\lambda}+\alpha)\left(\frac{(n\alpha+\bar{\lambda})^2}{(2n\alpha+(n+1)\bar{\lambda})^2}-\frac{1}{(n+1)^2}\right)}{n-1}$. The results indicate that even though by doing GI a larger number of producers lower the cost of promotion for each producer, the producers still have an incentive to deviate to do BA if the promotion cost is not quite high. By doing GI, the producers share not only the cost but also the profit.[8]

(v) We considered only one region. One extension of our model is the introduction of several regions. Probabilities of producing high-quality goods are different across different regions. We expect that producers in a region with high probability have more incentive to do GI.

(vi) We assumed vertical differentiation. An alternative solution is to introduce horizontal differentiation. In this context with m consumers and perfect information, m_1 consumers prefer goods from producer 1 and (m-m_1) consumers prefer goods from producer 2. Using our model we expect that as m_1 increases, producer 1's incentive to signal and make an effort increases.

(vii) We assumed the BA and GI have the same α, which is the incremental probability of purchasing wine of high quality from consumers' subjective point of view. That is, BA enhances consumers' perception in the first period in the same way as GI. This leads to the conclusion that the case in which both producers choose BA as their promotion strategy and both make an effort

[8] The proof of the results is available from the authors upon request.

(or both producers make no effort) is dominated in equilibrium by the strategies that both producers choose GI and both producers make an effort (or both producers make no effort). (See the proof of point (iii) in Appendix 2.) One extension of our model is to assume that BA and GI have different effects on consumers' perception in the first period. Suppose we assume the incremental probability of purchasing wine of high quality in the first period for BA is α^{BA}, whereas for GI the value is α^{GI}. When $\alpha^{BA} - \alpha^{GI} > \frac{9A}{2}$ ($> \frac{(n+1)^2 A}{n}$ when there are n producers), the strategy that both producers choose BA emerges. That is, producers do BA instead of GI if BA is somewhat more effective in enhancing consumers' perception in the first period than GI.

Conclusions

In the context of the international wine market, we explored producers' choice between promotional strategies (BA and GI) and quality improvement strategies and how these strategic choices affect consumers' wine purchasing decisions. Although admittedly stylistic, our model nonetheless highlights the complicated strategies for monitoring uncertain quality.

We show that the producers' choice depends on the relative efficiency of promotional strategies compared with that of making an effort to improve quality. Another important result is that if the effort for improving quality is selected, a producer would like to use BA for promoting its wine and set up its own reputation. In spite of its advantage in allowing producers to share the cost of promotion, a GI does not sufficiently reward the effort for improving quality since it promotes a collective reputation. However, when the producer chooses not to make an effort to improve the quality, a GI is selected to be the promotion strategy. In the latter case, by using a GI, producers can take advantage of the sharing of the cost of promotion and collective

reputation. We further explored extensions of our analysis showing it is quite promising for further generalizations.

These results can be applied to draw some implications about the diverging fortunes of "new-world" and European wines. Emergence of wines from the new world leads to new contexts of competition that require the modification of signaling strategies. There are more incentives for producers to differentiate themselves by improving quality and revealing more information. Our paper, however, shows that GI is not necessarily compatible with quality improvement. This means that producers inside a GI should revamp their strategies for promotion, as, for instance, with the development of generic advertising for the world market based on a well-identified appellation. This may also result in the concentration of wine brands and advertising. Of course, the diverging fortunes of new-world and European wines hinge on additional factors, which we abstracted from to focus on promotion and quality improvement strategies. Beyond these two aspects, access to capital, regulations, cost structure, and size—all play an important role in the evolution of the international wine market.

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APPENDIX 1

The consumer's demand and producers' profits are presented before detailing the proof of propositions, with the characterization of the sub-game perfect Nash equilibrium of this four-stage game (solved by backward induction).

The consumer utility is $\sum_{t=1}^{2} \theta E(q_i^t) - p_i^t$ by consuming the product by producer i (i=1 or 2). In period t (t=1 or 2), if the two producers choose the same strategy, then $E(q_1^t) = E(q_2^t) = \overline{q}^t$ and $p_1^t = p_1^t = \overline{p}^t$. When $\theta\overline{q}^t - \overline{p}^t = 0$, the consumer is indifferent between buying and not buying a product in period t, implying that her taste parameter is $\overline{\theta}^t = \frac{\overline{p}^t}{\overline{q}^t}$. As the distribution of preference is uniform, the demand for the product is $\overline{x}^t = 1 - \frac{\overline{p}^t}{\overline{q}^t}$ and $\overline{p}^t = (1 - \overline{x}^t)\overline{q}^t$. In period t, if the two producers choose different strategies, then the expected quality of the products from two producers are different: $E(q_1^t) = \overline{q}_1^t$ and $E(q_2^t) = \overline{q}_2^t$. Suppose $\overline{q}_1^t > \overline{q}_1^t$ (indicating $p_1^t > p_2^t$); the consumer's demand for producer 1's product is $x_1^t = 1 - \frac{p_1^t - p_2^t}{\overline{q}_1^t - \overline{q}_2^t}$. The demand for producer 2's product is $x_2^t = \frac{p_1^t - p_2^t}{\overline{q}_1^t - \overline{q}_2^t} - \frac{p_2^t}{\overline{q}_2^t}$. By solving the system of equations of $x_1^t = 1 - \frac{p_1^t - p_2^t}{\overline{q}_1^t - \overline{q}_2^t}$ and $x_2^t = \frac{p_1^t - p_2^t}{\overline{q}_1^t - \overline{q}_2^t} - \frac{p_2^t}{\overline{q}_2^t}$ for p_1^t and p_2^t, we get $p_1^t = \overline{q}_1^t(1 - x_1^t) - \overline{q}_2^t x_2^t$ and $p_2^t = \overline{q}_2^t(1 - x_1^t - x_2^t)$.

In stage 2, each producer chooses a level of quantity, taking into account the quantity of the other producer. For the case in which the two producers' strategies are different, the profit for

the higher expected quality producer is

$$\pi_1 = \sum_{t=1}^{2} p_1^t \bar{q}_1^t - I_1^e F - I_1^\alpha A' = \sum_{t=1}^{2} (\bar{q}_1^t (1 - x_1^t) - \bar{q}_2^t x_2^t) x_1^t - I_1^e F - I_1^\alpha A'$$

and the profit for the lower expected quality producer is

$$\pi_2 = \sum_{t=1}^{2} p_2^t \bar{q}_2^t - I_2^e F - I_2^\alpha A' = \sum_{t=1}^{2} \bar{q}_2^t (1 - x_1^t - x_2^t) x_2^t - I_2^e F - I_2^\alpha A'.$$

A' is the fixed cost associated with information strategies: $A' = A$ if BA is chosen and $A' = \frac{A}{2}$ if GI is chosen. The first-order conditions for the maximization of π_1 with respect to x_1^t (namely, $\frac{\partial \pi_1}{\partial x_1^t} = 0$) and π_2 with respect to x_2^t (namely, $\frac{\partial \pi_2}{\partial x_2^t} = 0$) lead to equilibrium prices x_1^{t*} and x_2^{t*}. The substitution of these equilibrium quantities into π_1 and π_2 leads to the following respective profits for producer 1 and producer 2:

$$\pi_1^* = \sum_{t=1}^{2} \frac{\bar{q}_1^t (2\bar{q}_1^t - \bar{q}_2^t)^2}{(4\bar{q}_1^t - \bar{q}_2^t)^2} - I_1^e F - I_1^\alpha A' \qquad \text{(A1.1)}$$

$$\pi_2^* = \sum_{t=1}^{2} \frac{\bar{q}_2^t \bar{q}_1^{t\,2}}{(4\bar{q}_1^t - \bar{q}_2^t)^2} - I_2^e F - I_2^\alpha A' \qquad \text{(A1.2)}$$

A particular case of (A1.1) and (A1.2) is when both producers choose the same strategies in both periods (which leads to $\bar{q}_1^t = \bar{q}_2^t = \bar{q}^t$):

$$\bar{\pi}_i^* = \sum_{t=1}^{2} \frac{\bar{q}^t}{9} - I_i^e F - I_i^\alpha A' \quad i\text{=1 or 2} \qquad \text{(A2)}$$

The decision on the choice of strategies in stage 1 depends on these profits, which in turn depends on the expected quality and fixed costs listed in Table 2 of the main text. In stage 1, each producer faces the choices of strategies listed in the first column of Table 2. The decision

depends on the comparison among the profits. Table 2 lists all the cases of the expected qualities and associated costs by choosing different strategies for the two producers. If the expected qualities for the two producers are the same, substitute them in (A2) and get the profits for the two producers. If the expected qualities for the two producers are different, substitute them in (A1.1) and (A1.2) and get the profits for the two producers.

We use $\pi^{i}_{strategy1(I_1^e)+strategy2(I_2^e)}$ to denote producer *i*'s profit, with producer 1 choosing strategy 1 and producer 2 choosing strategy 2 and an effort-making decision ($I_i^e = 1$ means making an effort; $I_i^e = 0$ means avoiding making an effort). Among the strategies, no signal is denoted by n, GI is denoted by GI, and BA is denoted by BA. For example, $\pi^{2}_{BA(1)+n(1)}$ denotes producer 2's profit when producer 1 chooses BA and makes an effort and producer 2 chooses no signal but makes an effort.

The Frontiers Determination and Proof of Propositions

We now turn to the equilibrium strategies that lead to Propositions 1, 2, 3, and 4.

The Nash equilibrium is such that a producer will choose a strategy that leads to a higher profit than all other available strategies given the other producer's strategy.

Proof of Proposition 1

If no signal and no effort is a Nash equilibrium, the producers have no incentive to deviate to other strategies; that is, the corresponding profits should be largest. Therefore, the following conditions have to be satisfied:

$$\pi^{1}_{n(0)+n(0)} > \pi^{1}_{n(1)+n(0)} \text{ and } \pi^{2}_{n(0)+n(0)} > \pi^{2}_{n(0)+n(1)} \qquad \text{(A2.1)}$$

$$\pi^1_{n(0)+n(0)} > \pi^1_{BA(0)+n(0)} \text{ and } \pi^2_{n(0)+n(0)} > \pi^2_{n(0)+BA(0)}; \qquad \text{(A2.2)}$$

$$\pi^1_{n(0)+n(0)} > \pi^1_{GI(0)+GI(0)} \text{ and } \pi^2_{n(0)+n(0)} > \pi^2_{GI(0)+GI(0)}; \qquad \text{(A2.3)}$$

Applying *point(i)* in Appendix 2, (A2.1) leads to the inequality

$$F > f_1 = \frac{e}{18} q_H;$$

(A2.2) leads to

$$F > f_2 = \frac{\alpha(36\alpha^2 + 56\alpha\bar{\lambda} + 21\bar{\lambda}^2)}{9\gamma(4\alpha + 3\bar{\lambda})^2} q_H;$$

and (A2.3) leads to

$$F > f_3 = \frac{2\alpha}{9\gamma} q_H.$$

No matter what value γ takes, the condition $f_2 - f_3 = \frac{\alpha(4\alpha^2 + 8\alpha\bar{\lambda} + 3\bar{\lambda}^2)}{\gamma(4\alpha + 3\bar{\lambda})^2} q_H > 0$ is satisfied, which implies $f_2 > f_3$. By comparing f_1 and f_3, we have when $\gamma < \gamma_3 = \frac{4\alpha}{e}$, $f_1 < f_3$.

If producer 1 choosing BA and no effort and producer 2 making no signal and no effort is Nash equilibrium, the following conditions have to be satisfied after applying *point (iii)* in Appendix 2 (the strategy that both producers choose BA is dominated in equilibrium)*:*

$$\pi^1_{BA(0)+n(0)} > \pi^1_{n(0)+n(0)} \qquad \text{(A3.1)}$$

$$\pi^1_{BA(0)+n(0)} > \pi^1_{BA(1)+n(0)} \qquad \text{(A3.2)}$$

$$\pi^1_{BA(0)+n(0)} > \pi^1_{BA(0)+n(1)} \qquad \text{(A3.3)}$$

$$\pi^1_{BA(0)+n(0)} > \pi^1_{GI(0)+GI(0)} \qquad \text{(A3.4).}$$

(A3.1) leads to

$$F < f_2 = \frac{\alpha(36\alpha^2 + 56\alpha\bar{\lambda} + 21\bar{\lambda}^2)}{9\gamma(4\alpha + 3\bar{\lambda})^2} q_H;$$

(A3.2) leads to

$$F > f_4 = \frac{e(36e^2 + 56e\lambda + 21\lambda^2)}{9(4e+3\lambda)^2} q_H ;$$

$f_2 > f_4$ implies $\gamma < \gamma_1 = \frac{\alpha(4e+3\lambda)^2(36\alpha^2 + 56\alpha\bar{\lambda} + 21\bar{\lambda}^2)}{e(4\alpha+3\bar{\lambda})^2(36e^2 + 56e\lambda + 21\lambda^2)}$; otherwise, we have $f_2 < f_4$.

According to *point(iv)* in Appendix 2, the strategy that one producer chooses BA and makes no effort and the other producer makes no signal and makes an effort is dominated in equilibrium so (A3.3) is ignorable.

(A3.4) leads to

$$F < f_5 = \frac{8\alpha(5\alpha^2 + 8\alpha\bar{\lambda} + 3\bar{\lambda}^2)}{9\gamma(4\alpha+3\bar{\lambda})^2} q_H ;$$

$f_5 - f_2 = \frac{2\alpha(4\alpha^2 + 8\alpha\bar{\lambda} + 3\bar{\lambda}^2)}{9\gamma(4\alpha+3\bar{\lambda})^2} q_H > 0$, which implies $f_5 > f_2$.

Therefore, only when $\gamma < \gamma_1 = \frac{\alpha(4e+3\lambda)^2(36\alpha^2 + 56\alpha\bar{\lambda} + 21\bar{\lambda}^2)}{e(4\alpha+3\bar{\lambda})^2(36e^2 + 56e\lambda + 21\lambda^2)}$ does the case emerge that one firm makes BA and no firm makes the effort to improve quality. By comparing γ_1 and γ_3 we have $\gamma_1 < \gamma_3$ for sure, which implies $f_2 > f_3 > f_1$ when $\gamma < \gamma_1$. Therefore, when $\gamma < \gamma_1$, we have

$$F_1 = f_2 = \frac{\alpha(36\alpha^2 + 56\alpha\bar{\lambda} + 21\bar{\lambda}^2)}{9\gamma(4\alpha+3\bar{\lambda})^2} q_H$$

and

$$F_2 = f_4 = \frac{e(36e^2 + 56e\lambda + 21\lambda^2)}{9(4e+3\lambda)^2} q_H .$$

So if $\gamma < \gamma_1$ when $F > F_1$, the strategy emerges in equilibrium that both producers make no signal and no effort and when $F_2 < F < F_1$, the strategy emerges in equilibrium that one producer chooses BA and makes no effort and the other producer makes no signal and no effort.

If producer 1 choosing BA and making an effort and producer 2 making no signal and no effort is Nash equilibrium, the following conditions have to be satisfied (when the second producer does not deviate to make an effort to improve quality):

$$\pi^1_{BA(1)+n(0)} > \pi^1_{BA(0)+n(0)} \qquad \text{(A4.1)}$$

$$\pi^2_{BA(1)+n(0)} > \pi^2_{BA(1)+n(1)} \qquad \text{(A4.2)}$$

$$\pi^1_{BA(1)+n(0)} > \pi^1_{GI(1)+GI(0)} \qquad \text{(A4.3)}$$

$$\pi^1_{BA(1)+n(0)} > \pi^1_{n(1)+n(0)} \qquad \text{(A4.4).}$$

(A4.1) leads to

$$F < F_2 = f_4 = \frac{e(36e^2 + 56e\lambda + 21\lambda^2)}{9(4e+3\lambda)^2} q_H ;$$

(A4.2) leads to

$$F > f_6 = \frac{e(16e^2 + 31e\lambda + 15\lambda^2)}{9(4e+3\lambda)^2} q_H ;$$

(A4.3) leads to

$$F < f_7 = q_H \left(\begin{array}{l} \dfrac{8\alpha^2(112e^3 + 45\alpha\lambda^2 + 16e^2(5\alpha + 11\lambda) + 6e\lambda(20\alpha + 11\lambda))}{9\gamma(4e+3\lambda)^2} \\ + \dfrac{(8\alpha\bar{\lambda} + 3\bar{\lambda}^2)(168e^3 + 72\alpha\lambda^2 + 8e^2(16\alpha + 33\lambda) + 3e\lambda(64\alpha + 33\lambda))}{9\gamma(4e+3\lambda)^2} \end{array} \right).$$

According to *point(vii)* in Appendix 2, (A4.4) is ignorable.

$f_4 - f_6 = \dfrac{e(20e^2 + 25e\lambda + 6\lambda^2)}{9(4e+3\lambda)^2} q_H > 0$, which implies $f_4 > f_6$. And we also have $f_7 > f_4$.

One producer choosing BA and making effort and the other producer choosing no signal but making effort is a Nash equilibrium when the following conditions are satisfied:

$$\pi^2_{BA(1)+n(1)} > \pi^2_{BA(1)+n(0)} \qquad \text{(A5.1)}$$

$$\pi^1_{BA(1)+n(1)} > \pi^1_{n(1)+n(1)} \qquad \text{(A5.2)}$$

$$\pi^1_{BA(1)+n(1)} > \pi^1_{GI(1)+GI(1)} \qquad \text{(A5.3)}$$

(A5.1) leads to

$$F < f_6 = \frac{e(16e^2 + 31e\lambda + 15\lambda^2)}{9(4e+3\lambda)^2} q_H ;$$

(A5.2) leads to

$$F < f_2 = \frac{\alpha(36\alpha^2 + 56\alpha\bar{\lambda} + 21\bar{\lambda}^2)}{9\gamma(4\alpha + 3\bar{\lambda})^2} q_H .$$

According to the *point(v)* in Appendix 2, GI is dominated by BA when $\gamma < \gamma_1$; (A5.3) is ignorable. Since $f_2 > f_4$ and $f_4 > f_6$, we have $f_2 > f_6$. Therefore, we have the frontier

$$F_3 = f_6 = \frac{e(16e^2 + 31e\lambda + 15\lambda^2)}{9(4e + 3\lambda)^2} q_H .$$

Proof of Proposition 2

When $\gamma > \gamma_1$, $F_2 > F_1$, the strategy in which one producer chooses BA and makes no effort and the other producer makes no signal and no effort does not emerge in equilibrium, which leads to Proposition 2. The frontier F_1 becomes the border between area 1 and area 3, so when $\gamma > \gamma_1$,

$$F_1 = q_H \left(\begin{array}{c} \dfrac{4\alpha^2(144e^3 + 81\alpha\lambda^2 + 12e\lambda(18\alpha + 7\lambda) + 16e^2(9\alpha + 14\lambda))}{9(1+\gamma)(4e + 3\lambda)^2(4\alpha + 3\bar{\lambda})^2} \\ + \dfrac{(8\alpha\bar{\lambda} + 3\bar{\lambda}^2)(108e^3 + 63\alpha\lambda^2 + 21e\lambda(8\alpha + 3\lambda) + 56e^2(2\alpha + 3\lambda))}{9(1+\gamma)(4e + 3\lambda)^2(4\alpha + 3\bar{\lambda})^2} \end{array} \right) .$$

We need to compare F_3 and this new F_1. Area 3 emerges only if $F_1 > F_3$; otherwise, area 3 disappears. $F_1 > F_3$ only if $\gamma < \gamma_2$, where

$$\gamma_2 = \frac{4\alpha^2(80e^3 + 81\alpha\lambda^2 + 24e\lambda(9\alpha + \lambda) + 4e^2(36\alpha + 25\lambda))}{e(4\alpha + 3\bar{\lambda})^2(16e^2 + 31e\lambda + 15\lambda^2)} + \frac{(8\alpha\bar{\lambda} + 3\bar{\lambda}^2)(60e^3 + 63\alpha\lambda^2 + 6e\lambda(28\alpha + 3\lambda) + e^2(112\alpha + 75\lambda))}{e(4\alpha + 3\bar{\lambda})^2(16e^2 + 31e\lambda + 15\lambda^2)}$$

and $\gamma_1 < \gamma_2$.

Proof of Proposition 3

When $\gamma > \gamma_2$, area 2 and area 3 in Figure 3 disappear. It's possible that GI emerges in

equilibrium (it was dominated when area 2 and area 3 emerge according to *point(v)* in Appendix 2). The strategy that both producers choose no signal and none of them makes an effort to improve quality emerges in equilibrium if the following conditions are satisfied:

$$\pi^1_{n(0)+n(0)} > \pi^1_{GI(0)+GI(0)} \text{ and } \pi^2_{n(0)+n(0)} > \pi^2_{GI(0)+GI(0)}; \qquad \text{(A6.1)}$$

$$\pi^1_{n(0)+n(0)} > \pi^1_{n(1)+n(0)} \quad \text{and } \pi^2_{n(0)+n(0)} > \pi^2_{n(0)+n(1)}. \qquad \text{(A6.2)}$$

(A6.1) leads to

$$F > f_3 = \frac{2\alpha}{9\gamma} q_H;$$

(A6.2) leads to

$$F > f_1 = \frac{e}{18} q_H.$$

When $\gamma > \gamma_2$, the strategy that both producers choose GI and none of them makes an effort to improve quality emerges in equilibrium if the following conditions are satisfied:

$$\pi^1_{GI(0)+GI(0)} > \pi^1_{n(0)+n(0)} \text{ and } \pi^2_{GI(0)+GI(0)} > \pi^2_{n(0)+n(0)}; \qquad \text{(A7.1)}$$

$$\pi^1_{GI(0)+GI(0)} > \pi^1_{GI(1)+GI(0)} \text{ and } \pi^2_{GI(0)+GI(0)} > \pi^2_{GI(0)+GI(1)}. \qquad \text{(A7.2)}$$

(A7.1) leads to

$$F < f_3 = \frac{2\alpha}{9\gamma} q_H;$$

(A7.2) leads to

$$F > f_1 = \frac{e}{18} q_H.$$

GI would emerge only if $f_1 < f_3$, which implies $\gamma < \gamma_3 = \frac{4\alpha}{e}$. We cannot rank γ_2 and γ_3. So if

$\gamma_2 > \gamma_3$, GI would not emerge, either.

So when $\gamma_2 < \gamma < \gamma_3$,

$$F_4 = f_3 = \frac{2\alpha}{9\gamma} q_H .$$

The strategy that both producers choose GI and both of them make an effort to improve quality emerges in equilibrium if the following conditions are satisfied:

$$\pi^1_{GI(1)+GI(1)} > \pi^1_{n(1)+n(1)} \text{ and } \pi^2_{GI(1)+GI(1)} > \pi^2_{n(1)+n(1)} ; \qquad \text{(A8.1)}$$

$$\pi^1_{GI(1)+GI(1)} > \pi^1_{GI(0)+GI(1)} \text{ and } \pi^2_{GI(1)+GI(1)} > \pi^2_{GI(1)+GI(0)} ; \qquad \text{(A8.2)}$$

$$\pi^1_{GI(1)+GI(1)} > \pi^1_{BA(1)+n(1)} \text{ and } \pi^2_{GI(1)+GI(1)} > \pi^2_{n(1)+BA(1)} . \qquad \text{(A8.3)}$$

(A8.1) leads to

$$F < f_3 = \frac{2\alpha}{9\gamma} q_H ;$$

(A8.2) leads to

$$F < f_1 = \frac{e}{18} q_H ;$$

(A8.3) leads to

$$\alpha < \alpha_1 = \frac{3\overline{\lambda}}{4} .$$

When $\gamma < \gamma_3$, we have $f_1 < f_3$, so

$$F_5 = f_1 = \frac{e}{18} q_H .$$

When $\alpha > \alpha_1$, F_6 is the border between area 5 and the strategy that both producers make an effort and one of them uses BA:

$$F_6 = \frac{8\alpha^2(4e+5\alpha)+(16\alpha\bar{\lambda}+6\bar{\lambda}^2)(3e+4\alpha)}{9(2+\gamma)(4\alpha+3\bar{\lambda})^2}.$$

$F_6 < F_4$ only when $\gamma > \gamma_4 = \dfrac{2\alpha(4\alpha+3\bar{\lambda})^2}{4\alpha^2(4e+\alpha)+(8\alpha\bar{\lambda}+3\bar{\lambda}^2)(3e+\alpha)}$, where $\gamma_4 < \gamma_3$.

Proof of Proposition 4

When $\gamma > \max\{\gamma_2, \gamma_3\}$, we have $f_1 > f_3$ so the strategy that both producers choose GI and make no effort does not emerge; that is, area 5 in Figure 4 disappears. Both producers choose no signal and both of them make an effort to improve quality if the following conditions are satisfied:

$$\pi^1_{n(1)+n(1)} > \pi^1_{GI(1)+GI(1)} \text{ and } \pi^2_{n(1)+n(1)} > \pi^2_{GI(1)+GI(1)}; \qquad \text{(A9.1)}$$

$$\pi^1_{n(1)+n(1)} > \pi^1_{n(0)+n(1)} \text{ and } \pi^2_{n(1)+n(1)} > \pi^2_{n(1)+n(0)}; \qquad \text{(A9.2)}$$

$$\pi^1_{n(1)+n(1)} > \pi^1_{BA(1)+n(1)} \text{ and } \pi^2_{n(1)+n(1)} > \pi^2_{n(1)+BA(1)}. \qquad \text{(A9.3)}$$

(A9.1) leads to

$$F > f_3 = \frac{2\alpha}{9\gamma} q_H;$$

(A9.2) leads to

$$F < f_1 = \frac{e}{18} q_H;$$

(A9.3) leads to

$$F > f_2 = \frac{\alpha(36\alpha^2+56\alpha\bar{\lambda}+21\bar{\lambda}^2)}{9\gamma(4\alpha+3\bar{\lambda})^2} q_H.$$

So, in Figure 5,

$$F_7 = f_1 = \frac{e}{18} q_H;$$

$$F_8 = f_3 = \frac{2\alpha}{9\gamma} q_H ;$$

$$F_9 = f_2 = \frac{\alpha(36\alpha^2 + 56\alpha\bar{\lambda} + 21\bar{\lambda}^2)}{9\gamma(4\alpha + 3\bar{\lambda})^2} q_H .$$

$F_9 < F_7$ only when $\gamma > \gamma_5 = \dfrac{2\alpha(36\alpha^2 + 56\alpha\bar{\lambda} + 21\bar{\lambda}^2)}{e(4\alpha + 3\bar{\lambda})^2}$, where $\gamma_5 > \gamma_3$.

APPENDIX 2

The following strategies are dominated:

(i) Both producers choose no signal, and one of them chooses to make an effort.

(ii) Both producers choose GI, and one of them chooses to make an effort.

(iii) Both producers choose BA.

(iv) The strategy in which one producer chooses BA and makes no effort and the other producer makes no signal and makes an effort is dominated in equilibrium.

(v) The strategy in which both producers choose GI and make no effort is dominated by the strategy in which one producer chooses BA and makes no effort and the other producer chooses no signal and no effort if the latter strategy emerges (the emergence of the latter strategy depends on the values of the parameters).

(vi) The strategy in which both producers choose GI and make an effort is dominated by the strategy in which one producer chooses BA and the other producer chooses no signal and both producers make an effort when $\alpha > \alpha_1 = \frac{3\bar{\lambda}}{4}$.

(vii) The strategies in which both producers choose GI and make an effort, or both producers choose no signal but make an effort are dominated by the strategy in which one of them could choose BA and make an effort and the other producer chooses no signal and makes no effort if the latter strategy emerges.

(viii) One producer chooses the combination of GI and BA; another producer chooses GI alone; and both of the producers choose the combination of GI and BA.

Proof of Points (i) and (ii)

The strategy in which both producers use no signal, producer 1 makes an effort, and producer 2 makes no effort is not dominated when the following conditions are satisfied. Producer 1 does

not deviate to make no effort and producer 2 does not deviate to make an effort. That is,

$$\pi^1_{n(1)+n(0)} > \pi^1_{n(0)+n(0)}, \qquad \text{(B1.1)}$$

$$\pi^2_{n(1)+n(0)} > \pi^2_{n(1)+n(1)}. \qquad \text{(B1.2)}$$

(B1.1) is satisfied by $F < \frac{e}{18} q_H$ and (B1.2) is satisfied by $F > \frac{e}{18} q_H$; these two cannot be satisfied at the same time, so the strategy is dominated in equilibrium. Similar proof applies to point *(ii)*.

Proof of Point (iii)

$\pi^i_{BA(1)+BA(1)} = \frac{(\bar{\lambda}+\alpha)+(\lambda+e)}{9} q_H - A - F$, which is always less than

$\pi^i_{GI(1)+GI(1)} = \frac{(\bar{\lambda}+\alpha)+(\lambda+e)}{9} q_H - \frac{A}{2} - F$, i=1,2. So the producers would rather choose GI and make an effort to achieve the same profit with a lower cost.

Proof of Point (iv)

The case in which producer 1 chooses BA and makes no effort and producer 2 makes no signal but makes an effort is not dominated when the following necessary conditions are satisfied: producer 1 does not deviate to make an effort and producer 2 does not deviate to make no effort. That is,

$$\pi^1_{BA(0)+n(1)} > \pi^1_{BA(1)+n(1)}, \qquad \text{(B2.1)}$$

$$\pi^2_{BA(0)+n(1)} > \pi^2_{BA(0)+n(0)}. \qquad \text{(B2.2)}$$

(B2.1) is satisfied by F> $f_6 = \frac{e(16e^2+31e\lambda+15\lambda^2)}{9(4e+3\lambda)^2} q_H$ and (B2.2) is satisfied by

F< $f_8 = \frac{e^2 + e\lambda}{4e + 3\lambda} q_H$, but $f_6 - f_8 = -\frac{4e(5e^2 + 8e\lambda + 3\lambda^2)}{9(4e + 3\lambda)^2} q_H$ <0, so the necessary conditions cannot be satisfied.

Proof of Point (v)

The strategy in which producer 1 chooses GI and makes no effort is not dominated when the following necessary conditions are satisfied: producer 1 does not deviate to make no signal and make no effort, and producer 1 does not deviate to choose BA alone. That is,

$$\pi^1_{GI(0)+GI(0)} > \pi^1_{n(0)+n(0)}, \qquad \text{(B3.1)}$$

$$\pi^1_{GI(0)+GI(0)} > \pi^1_{BA(0)+n(0)}. \qquad \text{(B3.2)}$$

(B3.1) is satisfied by $F < f_3 = \frac{2\alpha}{9\gamma} q_H$, and (B3.2) is satisfied by

F> $f_5 = \frac{8\alpha(5\alpha^2 + 8\alpha\bar{\lambda} + 3\bar{\lambda}^2)}{9\gamma(4\alpha + 3\bar{\lambda})^2} q_H$, but $f_3 < f_5$, which cannot satisfied.

Proof of Point (vi)

The case in which producer 1 chooses BA and makes an effort and producer 2 makes no signal but makes an effort is not dominated when the following necessary conditions are satisfied: producer 1 does not deviate to choose GI and make an effort and producer 2 does not deviate to choose GI and make an effort. That is,

$$\pi^1_{BA(1)+n(1)} > \pi^1_{GI(1)+GI(1)} \qquad \text{(B4.1)}$$

$$\pi^2_{BA(1)+n(1)} > \pi^2_{GI(1)+GI(1)} \qquad \text{(B4.2)}$$

(B4.1) is satisfied by $F < f_5 = \frac{8\alpha(5\alpha^2 + 8\alpha\bar{\lambda} + 3\bar{\lambda}^2)}{9\gamma(4\alpha + 3\bar{\lambda})^2} q_H$ and (B4.2) is satisfied by

$F > f_9 = \frac{2}{\gamma}\left(\frac{\bar{\lambda}+\alpha}{9} - \frac{\bar{\lambda}(\bar{\lambda}+\alpha)^2}{(3\bar{\lambda}+4\alpha)^2}\right)q_H$. When $f_4 < f_9$ (which indicates $\alpha > \alpha_1 = \frac{3\bar{\lambda}}{4}$), the strategy in which producer 1 chooses BA and makes an effort and producer 2 makes no signal but makes an effort is not dominated, but the strategy in which both choose GI and make an effort is dominated. When $f_4 > f_5$ (which indicates $\alpha < \alpha_1 = \frac{3\bar{\lambda}}{4}$), the strategy that producer 1 chooses BA and makes an effort and producer 2 makes no signal but makes an effort is dominated, but the strategy in which both choose GI and make an effort is not dominated.

Proof of Point (vii)

Both producers choose GI and make an effort when the following necessary conditions are satisfied: producers do not deviate to make no effort and one of the producers does not deviate to choose BA and make an effort conditional on the other producer choose no signal and make no effort. That is:

$$\pi^1_{GI(1)+GI(1)} > \pi^1_{BA(1)+n(0)} \qquad \text{(B5.1)}$$

$$\pi^1_{GI(1)+GI(1)} > \pi^1_{GI(0)+GI(1)} \qquad \text{(B5.2)}$$

(B5.1) is satisfied by $F > f_{10} = \frac{2}{\gamma}\left(\frac{(\bar{\lambda}+\alpha)(\bar{\lambda}+2\alpha)^2}{(3\bar{\lambda}+4\alpha)^2} - \frac{\bar{\lambda}+\alpha}{9} + \frac{(\lambda+e)(\lambda+2e)^2}{(3\lambda+4e)^2} - \frac{\lambda+e}{9}\right)q_H$

and (A7.2) is satisfied by $F < f_1 = \frac{e}{18}q_H$. But

$f_{10} - f_1 = \frac{16e^3(5-\gamma)+45\alpha\lambda^2+8e^2(10\alpha+(16-3\gamma)\lambda)+3e\lambda(40\alpha+(16-3\gamma)\lambda)}{18(3\lambda+4e)^2}q_H$ >0. So the necessary conditions cannot be satisfied. Similar proof could apply to the case that both producers make no signal but make an effort.

Proof of Point (viii)

The necessary condition for producer 1 to choose the combination of GI and BA as the marketing strategy if it has no incentive to deviate to do BA alone, which means:

$$\pi^1_{GIBA(0)+GI(0)} > \pi^1_{BA(0)+n(0)} \qquad \text{(B6.1)}$$

The condition above leads to the frontier below whereby the strategies in which one producer chooses the combination of GI and BA and another producer chooses GI alone will emerge in equilibrium.

$$f_{11} = \frac{2}{\gamma}\left(\frac{(\bar{\lambda}+c\alpha)((2c-1)\alpha+\bar{\lambda})^2}{((4c-1)\alpha+3\bar{\lambda})^2} - \frac{(\bar{\lambda}+\alpha)(2\alpha+\bar{\lambda})^2}{(4\alpha+3\bar{\lambda})^2}\right)q_H$$

When this frontier is below the horizontal axis in Figure 3 of the main text, the strategy that one producer chooses the combination of GI and BA, the other producer chooses GI alone, and none of them makes an effort is dominated by the strategy that one producer chooses BA, the other producer makes no signal, and none of them makes an effort. That is, f_{11}<0, which generates c<$c_{11} \approx \frac{32\alpha^4 + 24\alpha^3\bar{\lambda} - 19\alpha^2\bar{\lambda}^2 - 14\alpha\bar{\lambda}^3 - 14\alpha\bar{\lambda}^3}{3(16\alpha^4 + 24\alpha^3\bar{\lambda} + 9\alpha^2\bar{\lambda}^2)}$. The exact value of c_{11} is rather complex.

The expression above gives the approximate value by ignoring the smaller order of this value. Similarly, the strategy in which both producers choose the combination of GI and BA is dominated by the one in which both of the producers choose GI in equilibrium when *c<1*.

Then, $c_1 = \min\{1, \frac{32\alpha^4 + 24\alpha^3\bar{\lambda} - 19\alpha^2\bar{\lambda}^2 - 14\alpha\bar{\lambda}^3 - 14\alpha\bar{\lambda}^3}{3(16\alpha^4 + 24\alpha^3\bar{\lambda} + 9\alpha^2\bar{\lambda}^2)}\}$.