Commitment to commercialization and quality choices in the Champagne wine producer-distributor relationship

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Abstract

We study the interaction in the Champagne wine producer/distributor relationship between the commitment of the producer to commercialization of a low quality wine and the high quality adjustment of the distributor. We show that this commitment can allow the producer to acquire all the profit of the supply chain. However, at equilibrium, the distributor chooses a quality level that is superior to that obtained at the optimum of vertical integration, and manages to get a part of the profit. The results we obtain allow us to analyze the evolution of wine supply chains when a new distributor appears and enters in competition with the producer.

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1 Introduction

The emergence of groups of wine producers to defend the certification of their products in terms of geographic origin with labels like the French AOC, the Italian DOC or the Spanish DO[3] gives rise to several problems in the economical organization of agro-food supply chains. These problems concern the competitiveness against other types of producer-distributor relationships and against other types of quality signals, the anti-trust laws and the legitimacy of some procedures associated to the defense of these collective brands such as the control of the offer or vertical agreements, etc. The fundamental characteristics of certified wine supply chains are: *(i)* the right to signal that the product has been produced in a clearly defined geographical area as well as the duty to respect production conditions set in order to ensure that the product characteristics are common in all certified products. *(ii)* The presence of intermediaries involved in the transformation of the certified raw material.

In the French AOC, the intermediaries (distributors) involved in the transformation of raw material cover 60-90% of the commercialization in the final market, while the rest is commercialized by producers who are often grouped in cooperatives and vertically integrated in transformation/commercialization activities. The Champagne AOC case will serve us as a model throughout this article. Viet (2004) precisely describes the vertical structure of the Champagne AOC. Until 1930, almost only distributors ensured the Champagne wine commercialization. However, since the 50's the number of independent wine producers that directly sold their production in the final market was already above 1400. These wine producers commercialized 8% of the total volume of the Champagne wine sold. In 1970, the number of independent wine producers had already doubled and reached 5000 in the early 2000, which at the time represented a market share of 30%. Nowadays, this market share is stable around 25%. It is worth noting that the average price of a Champagne bottle coming from this kind of producer (around 11 euros) is 20% less expensive than the average selling price of a bottle of Champagne. Added to this, the market power of cooperatives and unions of cooperatives of producers is becoming more and more important. The development of industrial brands (Nicolas Feuillate, Jacquart, Goerg, and so on) places the corresponding firms in direct competition with the traditional distributors.

The dependence between producer and distributor for the commercialization of certified wines is peculiar for two reasons. First, the producers are simultaneously suppliers and competitors of the distributors. Second, the products that are

[3]Appellation d'Origine Controlée, Denominazione di Origine Controllata, Denominación de origen.

directly commercialized by producers (certification only) are often differentiated from those commercialized by distributors (certification and brand). As a result, on one hand, producers can have a tendency to free-ride distributors' commercial efforts by directly selling their products, which is more likely to happen when the notoriety of the certification label increases thanks to the commercial investments of the distributors. On the other hand, distributors will have a higher incentive to promote their own brand rather than the certification label. Even if this brand is initially associated with the ability to improve the standard quality of the certified raw material, it can also be used as a way to commercialize other products.

The study of vertical relationships with product differentiation has mainly been motivated by the rise of private labels in supermarket distribution and its consequences on the organization of the supply chain (Mills, 1995; Allain and Flochel, 2001; Giraud-Héraud et al., 2002; Bazoche et al., 2005; Bergès-Sennou and Waterson, 2005; Avenel and Caprice, 2006). In the specific context of wine origin certification, the seminal works are those of Giraud-Héraud et al. (1999) and Gaucher et al. (2002). Our paper is more closely linked to the first article, which we will come back to later. The second article proposes an incomplete contract approach with a focus on under-investments in production quality and promotional efforts, with aims to find conditions (in particular in the sequence of investments) that allow one to avoid this under-investment.

Our paper focuses on the producer/distributor vertical relationship in the Champagne-wine sector. Regulation of the way production levels are set and raw materials are priced constitute the essential negotiation issues among professionals. The negotiation takes into account that the distributors hold the brands that brought notoriety to Champagne-wine, while the producers have only recently developed their commercialization channel. Indeed, producers holding the raw material can transform the grapes and directly sell Champagne-wines "de propriété" *i.e.* "from the property" using cooperative or supermarket distribution. However, the quality of this type of Champagne-wine is perceived as low because only the distributors have access to technology and promotional means that allow them to develop the quality and the image of their products, leading to higher prices. The competition in the final market between the two types of Champagne-wines give rise to tensions in the producer/distributor relationships over the price and the quantities of the raw material in the intermediate market. Their long term commercial investments lead the distributors to seek for supply guarantees. However, if the producers abandon the direct commercialization channel they loose their power of negotiation, as the threat to come back in the market would not be credible due to the costs it would require. As a result, an interprofessional negotiation is necessary. A detailed description of the new contracts in the C.I.V.C. (interprofessional committee of Champagne-wines) is presented in Soler and Tanguy (1998). This motivated Giraud-Héraud et al. (1999) to study a vertical structure where the producer has the possibility to commit *ex ante* on the commercialized quantity. The quantities can be commercialized either directly through a low-quality commercialization channel or through an intermediary (distributor) that has the ability to give an added value to the wines (high-quality channel), resulting in a product differentiation. Giraud-Héraud et al. (1999) show that the control of the offer by a monopolistic syndicate of producers of certified products is not worse, from the consumers' welfare point of view, than a monopolistic distributor (firm brand), with all the power of negotiation in front of a fragmented production sector. The main impact of the origin certification is to change the profit repartition along the supply chain, and the efficiency of vertical integration can even be reestablished.

In our paper we use a similar vertical structure. We simplify it by assuming that the distributor has no access to the low-quality market, while we also focus on a complementary issue : What is the optimal choice of quality levels, disregarding the notoriety investments studied in Gaucher et al. (2002), but keeping the assumption of collective control of the offer and focusing on the induced profit repartition along the supply chain.

After a presentation of the model (section **??**), with the producer considered the Stackelberg leader in the market, we study in section 3 the role of threat from the producer to sell all the quantity that is not demanded by the distributor through a direct low-quality commercialization channel, leading to a competition in the final market. We show that this commitment allows the producer to increase the produced quantity at equilibrium. We also show that thanks to a high-quality adjustment, the distributor can get a better profit repartition along the supply chain. In section 4, the obtained results are applied to the study of the evolution of a wine supply chain where a producer of a wine with certification of origin is, at first stage, the only firm in place in the market, which then has to face, in the second stage, the entry of a distributor that has developed a brand. Finally, we make some concluding remarks in section 5. As benchmark scenarios, we study in the Appendices (section 6) three vertically-integrated structures (section 6.1) and the "double marginalization" phenomenon that occurs for one of them when there is no coordination between the producer and the distributor (section 6.2). Furthermore, a table synthesizing the results at equilibrium of the vertical structures studied in this article is provided in section 6.3 of the Appendices in order to be able to compare one scenario to another.

2 The model

We consider a vertical relationship between a producer and a distributor. The producer P (wine maker) can directly commercialize low-quality Champagne-wine (see figure 1). The low-quality is measured by $k_1 \geqslant 0$. The producer can also access the final market through a distributor D that owns a Champagne-wine brand. The distributor has access to more sophisticated production and commercialization techniques, which leads to higher notoriety. As a result, the distributor can produce Champagne-wine of high-quality $k_2 \geqslant k_1$. The subsequent product differentiation is denoted by $\delta = k_2 - k_1 \geqslant 0$. Let ε be the total produced quantity

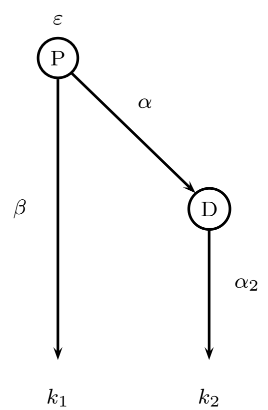

Figure 1: Vertical structure

of raw material (grapes). This quantity is divided in two: $\alpha \leqslant \varepsilon$ is sold to the distributor at a unit price p while $\beta = \varepsilon - \alpha$ is directly commercialized by the producer in low-quality. The distributor commercializes α_2 in high-quality[4] taking into account the constraint α.

The only costs that we consider in the model are the unit costs to transform grapes into wine depending on its quality. We choose a quadratic dependence, proportional to a parameter $\lambda \geqslant 0$: $c_i = \lambda k_i^2$.

The demand on the final market is inspired by Mussa and Rosen (1978). We normalize the size of the market to 1. Consumers are characterized by a taste

[4]For the sake of homogeneity with the notations of Giraud-Héraud et al. (1999), we denote β and not α_1 the quantity that is commercialized in low-quality by the producer. Indeed, α_1 is used in Giraud-Héraud et al. (1999) for the quantity that is commercialized in low-quality by the distributor.

θ for quality that is uniformly distributed along $[0, \bar{\theta}]$, where $\bar{\theta}$ represents the heterogeneity in consumers' tastes. We also suppose that this heterogeneity is big enough with respect to the qualities supplied in the market. More precisely, we make the hypothesis (H1): $\mu = \bar{\theta} - \lambda(k_1 + k_2) \geqslant 0$. Each consumer buys a unit of quality k_i and gets a utility θk_i. When prices p_1 and p_2 of the two types of Champagne-wines are fixed, the consumer θ chooses the quality that maximizes the surplus: $S(\theta, k_i, p_i) = \theta k_i - p_i$. The consumer θ buys a unit of good only if it gives a positive surplus. The hypothesis (H1) ensures that each type of Champagne-wines obtains a strictly positive market share when the prices p_i are equal to the marginal costs c_i. Indeed, $S(\theta, k_i, p_i) > 0 \Leftrightarrow \theta > p_i/k_i \Leftrightarrow \theta > c_i/k_i \Leftrightarrow \theta > \lambda k_i$. This expression is verified under (H1) for $i = 1, 2$. We consider that a consumer θ_0 is indifferent between the two qualities. Mathematically: $\theta_0 k_1 - p_1 = \theta_0 k_2 - p_2$, where: $\theta_0 = (p_2 - p_1)/\delta$. The consumers demanding low-quality Champagne-wine are those that have a taste for quality θ in the interval $[p_1/k_1, \theta_0]$. The consumers that prefer high-quality are characterized by $\theta \in [\theta_0, \bar{\theta}]$. The lengths of these intervals give us the expressions of the demand functions for the two types of wines: $D_1(k_1, k_2, p_1, p_2) = (\theta_0 - p_1/k_1)/\bar{\theta}$ and $D_2(k_1, k_2, p_1, p_2) = (\bar{\theta} - \theta_0)/\bar{\theta}$. We suppose that, at equilibrium, the total harvest is sold. By considering that the supply equals the demand ($D_1 = \beta$ and $D_2 = \alpha_2$) and that the market price is directly determined by the commercialized quantity, we obtain prices $p_1 = \bar{\theta} k_1(1 - \beta - \alpha_2)$ and $p_2 = \bar{\theta}[k_2(1 - \alpha_2) - k_1\beta]$. The total consumers' welfare is $W_c = \int_{p_1/k_1}^{\bar{\theta}} S(\theta, k, p) f(\theta) d\theta = \bar{\theta}(k_2\alpha_2^2 + k_1\beta^2 + 2k_1\beta\alpha_2)/2$.

We make another hypothesis (H2) that is necessary to solve the model: $\varepsilon \leqslant \bar{\varepsilon} = 1 - \lambda k_1/\bar{\theta}$. This ensures that selling all the quantity available in the market in low-quality would not lead to prices that are lower than the transformation costs. Indeed, if $\beta = \varepsilon$ and $\alpha_2 = 0$ (that is, when all the quantity is commercialized through the low-quality channel) : $p_1 > c_1 \Rightarrow \varepsilon \leqslant 1 - \lambda k_1/\bar{\theta}$ and $p_2 > c_2 \Rightarrow \varepsilon \leqslant k_2(1 - \lambda k_2/\bar{\theta})/k_1$, but $1 - \lambda k_1/\bar{\theta} \leqslant k_2(1 - \lambda k_2/\bar{\theta})/k_1$ under (H1).

As we have seen, the producer has the possibility to directly commercialize quantity $\beta \leqslant \varepsilon$ in low quality. We also consider that the producer can make a commitment[5] of commercialization on the total quantity ε. This means that the quantity of raw material that is not demanded by the distributor can be transformed in low-quality Champagne-wine, entering in competition with the high-quality one in the final market. This commitment on the quantity is made in function of the quality chosen by the distributor. Indeed, the investment to produce high-quality is a long term one, known by the producer. In order to study

[5]For a detailed justification of the credibility of this commitment and the sequence of stages 2 and 3 of the game Γ presented in this section, see Giraud-Héraud et al. (1999).

the consequences of this commitment, we define a 6-stages game Γ that we solve by backward induction in section 3:

(t=1): The producer chooses the low-quality level k_1 (section 3.6).
(t=2): The distributor sets[6] the high-quality level k_2 (section 3.5).
(t=3): The producer sets the quantity ε (section 3.4).
(t=4): The producer proposes a linear contract in price and sets price p of the raw material in the intermediate market[7] (section 3.3).
(t=5): The distributor demands $\alpha = D_\varepsilon(p) \leqslant \varepsilon$ of the quantity ε. We suppose that there is no rationing from the producer (without this assumption, the producer could higher the raw material price for the same quantity sold). The producer supplies α to the distributor and commercializes $\beta = \varepsilon - \alpha$ in low-quality (section 3.2).
(t=6): The distributor chooses the quantity $\alpha_2 \leqslant \alpha$ to be commercialized in high-quality (section 3.1).

3 Solving the game with commitment to commercialization

The six following sections correspond to a backward induction solving game Γ, from $(t = 6)$ down to $(t = 1)$.

3.1 Quantity commercialized by the distributor

In structure *(iv)*, the distributor commercializes $\min(\sigma, \alpha)$. The presence of the producer in the final market has a negative impact on the price of high-quality wines. As a result, the distributor reduces, at equilibrium, the supply of high-quality wines.

Proposizione 1 *There exists a switching value $\tilde{\alpha}(\varepsilon) = (2k_2\sigma - k_1\varepsilon)/(2k_2 - k_1)$ under which the distributor commercializes all the quantity demanded to the producer, and over which the optimal commercialized quantity amounts to $\sigma - k_1(\varepsilon - \alpha)/2k_2$.*

Proof. The choice of quantity α_2 commercialized in low-quality k_2 by the distributor depends on the profit $\Pi_D = (p_2 - c_2)\alpha_2 - p\alpha = (\bar{\theta}[k_2(1-\alpha_2) - k_1\beta] - c_2)\alpha_2 - p\alpha$. The maximization in α_2 of this profit gives the optimal commercialization level

[6] We also study the case where the distributor sets the high-quality level first.

[7] In reality ε and p are chosen by the certification syndicate. Nevertheless, producers remain individually free to sell or not the quantities that are not demanded by the distributors (even though it is evidently in their interest to do so).

$\sigma - k_1(\varepsilon - \alpha)/2k_2$. Moreover, $\alpha \geqslant \sigma - k_1(\varepsilon - \alpha)/2k_2 \Leftrightarrow \alpha \geqslant \tilde{\alpha}(\varepsilon) = (2k_2\sigma - k_1\varepsilon)/(2k_2 - k_1)$. $\tilde{\alpha}(\varepsilon)$ is the switching value over which the distributor does not commercialize all the raw material demanded to the producer. $\tilde{\alpha}(\varepsilon) \geqslant 0$ under (H2), so that $\alpha_2^* = \alpha$ if $\alpha \in [0, \tilde{\alpha}(\varepsilon)]$ and $\alpha_2^* = \sigma - k_1(\varepsilon - \alpha)/2k_2$ if $\alpha \in [\tilde{\alpha}(\varepsilon), \varepsilon]$. We can easily find the equivalences $\tilde{\alpha}(\varepsilon) < \sigma \Leftrightarrow \varepsilon > \sigma \Leftrightarrow \tilde{\alpha}(\varepsilon) < \varepsilon$. If $\varepsilon < \sigma$, the quantity commercialized is α for all $\alpha \in [0, \varepsilon]$, like it was the case for the structure *(iv)*. If $\varepsilon > \sigma$, the demanded quantity α is entirely commercialized until the switching value $\tilde{\alpha}(\varepsilon)$ is reached. Over this switching value, the slope of the function $\alpha_2^*(\alpha)$ is smaller and α_2^* only reaches the quantity σ for $\alpha = \varepsilon$ because $\alpha_2^*(\varepsilon) = \sigma$. ■

3.2 Distributor's demand function

Proposizione 2 *If $\varepsilon \leqslant \sigma$, there exists a switching price $\hat{p}$ under which the total quantity ε is demanded by the distributor. Over this price, the distributor demands $\alpha^- = [\bar{\theta}(k_2 - k_1\varepsilon) - c_2 - p]/2\bar{\theta}\delta < \varepsilon$.*

Proof. For $\varepsilon \leqslant \sigma$, we adopt the notations p_i^- for the price, α^- for the quantity demanded to the producer and Π_D^- for the profit of the distributor. In this case $\varepsilon \leqslant \tilde{\alpha}(\varepsilon)$ and thus, $\alpha_2 = \alpha$. We can deduce the prices $p_1^- = \bar{\theta}k_1(1 - \varepsilon)$ and $p_2^- = \bar{\theta}(k_2 - k_1\varepsilon - \delta\alpha)$. Therefore, the profit of the distributor is $\Pi_D^- = -\delta\theta\alpha^2 + [\theta(k_2 - k_1\varepsilon) - c_2 - p]\alpha$. This profit is optimal for $\alpha^- = [\bar{\theta}(k_2 - k_1\varepsilon) - c_2 - p]/2\bar{\theta}\delta$. Of course, this quantity ε must be sufficient to supply this demand, which gives the switching price $\hat{p}$: $\alpha^- \leqslant \varepsilon \Leftrightarrow p \geqslant \hat{p} = \bar{\theta}[k_2(1 - 2\varepsilon) + k_1\varepsilon] - c_2$. Added to this, the demand should not be negative : $\alpha^- \geqslant 0 \Leftrightarrow p \leqslant \bar{p} = \bar{\theta}(k_2 - k_1\varepsilon) - c_2$. This price is the maximum price for the raw material, resulting in zero demand from the distributor. We can deduce the optimal demand in the case $\varepsilon \leqslant \sigma$: $alpha^{*-} = \varepsilon$ if $p \in [0, \hat{p}]$ and $alpha^{*-} = \alpha^-$ if $p \in [\hat{p}, \bar{p}]$. ■

Proposizione 3 *If $\varepsilon \geqslant \sigma$, there exists a unique switching price p_0 under which the total quantity ε is demanded by the distributor. Under this switching price, the distributor demands $\alpha^- = [\bar{\theta}(k_2 - k_1\varepsilon) - c_2 - p]/2\bar{\theta}\delta < \varepsilon$.*

Proof. Case $\varepsilon \geqslant \sigma$ (notations p_i^+, α^+et Π_D^+) :
In this case, $\tilde{\alpha}(\varepsilon) \leqslant \varepsilon$. For $0 \leqslant \alpha \leqslant \tilde{\alpha}(\varepsilon)$ and we are in the same situation as the case where $\varepsilon \leqslant \sigma$. But for $\tilde{\alpha}(\varepsilon) \leqslant \alpha$, we have $p_1^+ = \bar{\theta}k_1[1 - \sigma - (2k_2 - k_1)(\varepsilon - \alpha)/2k_2]$ and $p_2^+ = \bar{\theta}[k_2(1 - \sigma) - k_1(\varepsilon - \alpha)/2]$. As a result, the profit of the distributor is

$\Pi_D^+ = \Pi_D^-$ if $\alpha \in [0, \tilde{\alpha}(\varepsilon)]$ and $\Pi_D^+ = A\alpha^2 + B\alpha + C$ if $\alpha \in [\tilde{\alpha}(\varepsilon), \varepsilon]$, where $A = \bar{\theta}k_1^2/4k_2$, $B = \bar{\theta}k_1(\sigma - k_1\varepsilon/2k_2) - p$ and $C = \bar{\theta}k_2\sigma^2 - \bar{\theta}k_1\varepsilon(\sigma - k_1\varepsilon/4k_2)$. In figure 2, we draw this profit for different values of p. For a given price, we see that

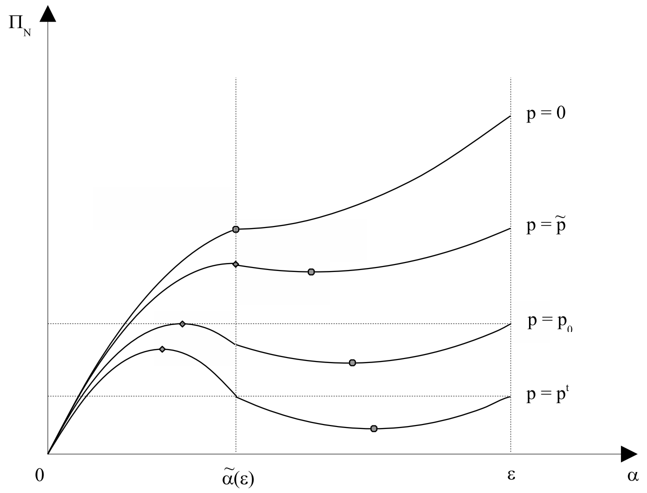

Figure 2: Distributor's profit

the profit is defined, by intervals, by two convex functions. This profit function is continuous as it is composed of continuous functions of α. The maximum of the first convex function is reached for α^-. This maximum applies only if $\alpha^- \leqslant \tilde{\alpha}$. This condition determines price $\widetilde{p}$, such that $\alpha^- \leqslant \tilde{\alpha} \Leftrightarrow p \geqslant \widetilde{p} = \bar{\theta}k_1\tilde{\alpha}(\varepsilon)$, with $0 \leqslant \widetilde{p} \leqslant \bar{p}$, which is true under hypothesis (H2). The coefficient in α^2 of the second convex function is positive, we can then say that if the profit reaches its maximum thanks to this function, it will be for the extremal value, that is to say for $\alpha = \varepsilon$. Moreover, $\Pi_D^+(\varepsilon) = -p\varepsilon + \bar{\theta}k_2\sigma^2$, which is continuous and decreases with p. Added to this, we remark that:

- in $p = \widetilde{p}$, $\Pi_D^+(\varepsilon) > \Pi_D(\tilde{\alpha}(\varepsilon)) = \Pi_D^-(\alpha^-)$, that is to say that $\Pi_D^+(\varepsilon)$ is superior to the maximum of the first convex function over $[0, \tilde{\alpha}(\varepsilon)]$.
- in $p = \bar{p}$, we have $\Pi_D^-(\alpha^-) = 0$ and, if we suppose that the differentiation in quality is sufficient, more precisely if $k_2 > 4k_1/3$, $\Pi_D^+(\varepsilon)$ is negative, then, $\Pi_D^+(\varepsilon) < \Pi_D(\tilde{\alpha}(\varepsilon))$. If $k_2 < 4k_1/3$, $\Pi_D^+(\varepsilon) > 0$ and the optimal demand is ε for all $p \in [0, \bar{p}]$.

As a result there exists a unique price $p_0 \in [\widetilde{p}, \bar{p}]$ verifying : $\Pi_D^-(\alpha^-) = \Pi_D^+(\varepsilon)$. The expression of this price is $p_0 = -\bar{\theta}\varepsilon(2k_2 - k_1 - 2\sqrt{\delta k_2}) + 2\bar{\theta}\sigma(k_2 - \sqrt{\delta k_2})$. As a result, the optimal demand is $\alpha^{*+} = \varepsilon$ if $p \in [0, p_0]$ and $\alpha^{*+} = \alpha^-$ if $p \in [p_0, \bar{p}]$.

If $k_2 < 4k_1/3$, $p_0 > \bar{p}$ and $\alpha^{*+} = \varepsilon$ for all $p \in [0, \bar{p}]$. ■

The distributor has the choice between two strategies. The first one consists in buying only the quantity they want to commercialize, accepting the competition if low-quality, since the producer will commercialize the quantity that is not demanded. The second one consists of avoiding this threat by acquiring all of the available quantity. The discontinuity of the demand function in p_0 is explained by the fact that, above this switching price, the distributor stops avoiding the producer's threat because it becomes too costly.

3.3 Producer's price choice

We will show that the producer has three possible strategies in function of the quantity ε.

Proposizione 4 *There exist two switching values ε_0, ε_1 of the quantity ε such that :*
- if $0 < \varepsilon < \varepsilon_0 = \mu/4\bar{\theta}$, then $p^* = \hat{p} = \bar{\theta}[k_2(1-2\varepsilon) + k_1\varepsilon] - c_2$.
- if $\varepsilon_0 < \varepsilon < \varepsilon_1$, where ε_1 is solution of the equation $\Pi_P(p^-) = \Pi_P(p_0)$, then $p^* = p^- = \bar{\theta}(k_1 + k_2 - 2k_1\varepsilon)/2 - (c_1 + c_2)/2$.
- if $\varepsilon_1 < \varepsilon < \bar{\varepsilon}$, then $p^* = p_0 = -\bar{\theta}\varepsilon(2k_2 - k_1 - 2\sqrt{\delta k_2}) + 2\bar{\theta}\sigma(k_2 - \sqrt{\delta k_2})$.

Proof. The producer's profit is written $\Pi_P = pD_\varepsilon(p) + (p_1 - c_1)(\varepsilon - D_\varepsilon(p))$. Let us first consider the case where $\varepsilon \leqslant \sigma$. Given that the distributor's optimal demand is α^{*-}, the profit is $\Pi_P = p\varepsilon$ if $p \in [0, \hat{p}]$ and $\Pi_P = p\alpha^- + [\bar{\theta}k_1(1-\varepsilon) - c_1](\varepsilon - \alpha^-)$ if $p \in [\hat{p}, \bar{p}]$. We have the continuity between these two expressions since $\alpha^-(\hat{p}) = \varepsilon$. The second expression is a convex function in p witch coefficient in p^2 is $-1/2\bar{\theta}\delta < 0$. Over the first interval, it is evident that the producer sets the intermediate price at $\hat{p}$. Over the second interval, the first order condition gives the price $p^- = \bar{\theta}(k_1 + k_2 - 2k_1\varepsilon)/2 - (c_1 + c_2)/2$. If $p^- \geqslant \hat{p}$, the maximum profit is reached in p^-. But we have the following condition determining the switching value in ε : $p^- \geqslant \hat{p} \Leftrightarrow \varepsilon \geqslant \varepsilon_0 = \mu/4\bar{\theta}$. Therefore, the maximization of the profit in p leads to $p^{*-} = \hat{p}$ if $\varepsilon \in [0, \varepsilon_0]$ and $p^{*-} = p^-$ if $\varepsilon \in [\varepsilon_0, \sigma]$.

Let us now consider the case $\varepsilon \geqslant \sigma$. This time the demand of the distributor is α^{*+}. Since $p_0 > \tilde{p}$, we are in the case $p_1 = p_1^-$. Therefore, the producer's profit is $\Pi_P = p\varepsilon$ if $p \in [0, p_0]$ and $\Pi_P = p\alpha^- + [\bar{\theta}k_1(1-\varepsilon) - c_1](\varepsilon - \alpha^-)$ if $p \in [p_0, \bar{p}]$. We find the interval in ε for which the producer adopts one or the other of these strategies by comparing the profits. We have the following equivalence : $\Pi_P(p^-) \leqslant \Pi_P(p_0) \Leftrightarrow 2\bar{\theta}(\delta - \sqrt{\delta k_2})\varepsilon^2 - (\delta\mu - 2\bar{\theta}\sigma\sqrt{\delta k_2})\varepsilon + \delta\mu^2/8\bar{\theta} \leqslant 0$. We show that setting the price p_0 is preferable outside the interval $[\varepsilon_1', \varepsilon_1]$ defined by the roots of the equation of second degree in ε. We also show that $\varepsilon_1' < \sigma$. This root is, thus, rejected. Moreover, we verify that over $[\sigma, \varepsilon_1]$, $p^- > p_0$. We can now define $p^{*+} = p^-$ if $\varepsilon \in [\sigma, \varepsilon_1]$ and $p^{*+} = p_0$ if $\varepsilon \in [\varepsilon_1, \bar{\varepsilon}]$.

We can synthesize the producer's price strategy $p^* = \hat{p}$ if $\varepsilon \in [0, \varepsilon_0]$, $p^* = p^-$ if $\varepsilon \in [\varepsilon_0, \varepsilon_1]$ and $p^* = p_0$ if $\varepsilon \in [\varepsilon_1, \bar{\varepsilon}]$.

Remark : If we consider that the quantity $\varepsilon < \bar{\varepsilon}$ is exogenous (for example ε can be considered to be the maximum produced quantity authorized by the appellation syndicate) :

- if $\varepsilon \in [0, \varepsilon_0]$, the producer sells the production at price $\hat{p}$. Since $\varepsilon < \varepsilon_0 < \sigma$ and $p = \hat{p}$, the distributor demands the total quantity ε. Then, given that $\varepsilon < \sigma \Leftrightarrow \tilde{\alpha}(\varepsilon) > \varepsilon$, the total quantity is commercialized by the distributor.

- if $\varepsilon \in [\varepsilon_0, \varepsilon_1]$, the selling price in the intermediate market is p^-. Two cases can emerge :
  1) if $\varepsilon_0 < \varepsilon < \sigma$, we know that in this case $p^- > \hat{p}$ and the distributor demands $\alpha^-(p^-) = [\bar{\theta}(k_2 - k_1\varepsilon) - c_2 - p^-]/2\bar{\theta}\delta < \varepsilon$. Since $\varepsilon < \sigma$, all the quantity $\alpha^-(p^-)$ is commercialized by the distributor. The quantity $\beta = \varepsilon - \alpha^-(p^-)$ is commercialized in low-quality by the producer.
  2) if $\sigma < \varepsilon < \varepsilon_1$, then $p^- > p_0$. It is once again the quantity $\alpha^-(p^-)$ that is demanded to the producer. However, $\varepsilon > \sigma$ and thus, $\tilde{\alpha}(\varepsilon) < \varepsilon$. In this case, the quantity commercialized by the distributor depends on $\tilde{\alpha}(\varepsilon)$. If $\alpha^-(p^-) < \tilde{\alpha}(\varepsilon)$, then all the quantity demanded $\alpha^-(p^-)$ is commercialized by the distributor. If, on the contrary, $\alpha^-(p^-) > \tilde{\alpha}(\varepsilon)$, the distributor only commercializes $\alpha_2 = \sigma - k_1(\varepsilon - \alpha^-(p^-))/2k_2$, the rest corresponds to a quantity that is demanded but not commercialized. Concerning the producer, the quantity that has not been demanded $\beta = \varepsilon - \alpha^-(p^-)$ is commercialized in low-quality.

- if $\varepsilon \in [\varepsilon_1, \bar{\varepsilon}]$, it is p_0 that is chosen by the producer. Since $\varepsilon_1 > \sigma$ and $p = p_0$, the distributor acquires the total produced quantity ε. Since $\tilde{\alpha}(\varepsilon) < \varepsilon$, the quantity $\alpha_2 = \sigma - k_1(\varepsilon - \varepsilon)/2k_2 = \sigma$ is commercialized by the distributor. The rest $\varepsilon - \sigma$, is demanded to the producer in order to avoid that the latter commercializes these quantities in low-quality.

3.4 Optimal produced quantity

The choice of the produced quantity is made by the producer in function of the high-quality level k_2 set by the distributor. The producer has two possible strategies:

Proposizione 5 *If the high-quality set by the distributor is below a switching value* $\widetilde{k}_2 = \bar{\theta}/\lambda - \sqrt{k_1(2\bar{\theta}/\lambda - k_1)}$*, then the producer chooses the quantity* $\varepsilon^o = \sigma(k_2 - \sqrt{\delta k_2})/(2k_2 - k_1 - 2\sqrt{\delta k_2})$*. Over this switching value, the chosen quantity is* $\varepsilon^- = (\bar{\theta}k_1 - c_1)/(2\bar{\theta}k_1)$*.*

Proof. To set the optimal quantity, taking into account the price strategy studied in the previous section, the producer has three profit functions to consider:

$$\Pi_P = \begin{cases} \hat{p}\varepsilon = (\bar{\theta}k_1 - 2\bar{\theta}k_2)\varepsilon^2 + 2\bar{\theta}k_2\sigma\varepsilon & \text{if} \quad \varepsilon \in [0, \varepsilon_0] \\ \Pi_P(p^-) = -\bar{\theta}k_1\varepsilon^2 + (\bar{\theta}k_1 - c_1)\varepsilon + \delta[\bar{\theta} - \lambda(k_1 + k_2)]^2/8\bar{\theta} & \text{if} \quad \varepsilon \in [\varepsilon_0, \varepsilon_1] \\ p_0\varepsilon = -\bar{\theta}(2k_2 - k_1 - 2\sqrt{\delta k_2})\varepsilon^2 + 2\bar{\theta}\sigma(k_2 - \sqrt{\delta k_2})\varepsilon & \text{if} \quad \varepsilon \in [\varepsilon_1, \bar{\varepsilon}] \end{cases}$$

The maximum of the first convex function that corresponds to the interval $[0, \varepsilon_0]$ is reached for $k_2\sigma/(2k_2 - k_1)$ which is superior to ε_0. Added to this, Π_P is continuous in ε_0. Hence, the optimal quantity cannot belong to the interval $[0, \varepsilon_0[$. The quantities associated to maxima corresponding to the convex functions of the intervals $[\varepsilon_0, \varepsilon_1]$ and $[\varepsilon_1, \bar{\varepsilon}]$ have the expressions $\varepsilon^- = (\bar{\theta}k_1 - c_1)/(2\bar{\theta}k_1)$ and $\varepsilon^o = \sigma(k_2 - \sqrt{\delta k_2})/(2k_2 - k_1 - 2\sqrt{\delta k_2})$, respectively. The profit of the producer is drawn in figure 3.

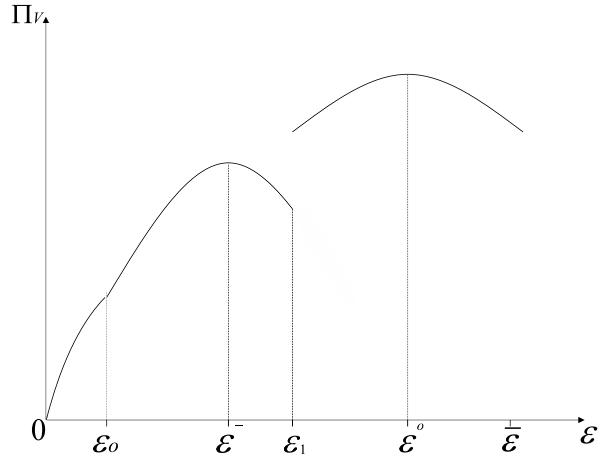

Figure 3: Producer's profit

We easily verify the following inequalities : $0 \leqslant \varepsilon_0 \leqslant \sigma \leqslant \varepsilon^- \leqslant \varepsilon_1 \leqslant \varepsilon^o \leqslant \bar{\varepsilon}$. Given that $\varepsilon_0 \leqslant \varepsilon^- \leqslant \varepsilon_1$, the strategy ε^- is linked to an intermediate price p^-. Added to this, since $\varepsilon_1 \leqslant \varepsilon^o$, the strategy ε^o comes with a an intermediate price strategy p_0. The producer's optimal profit is, thus, written: $\Pi_P^* = \max(\Pi_P(p^-, \varepsilon^-), p_0\varepsilon^o)$ with $\Pi_P(p^-, \varepsilon^-) = (\bar{\theta}k_1 - c_1)^2/(4\bar{\theta}k_1) + \delta\mu^2/8\bar{\theta}$ and $p_0\varepsilon^o = \bar{\theta}k_2\sigma^2$. The trade-off between these two strategies depends on the choice of quality k_2 made by the distributor (which will be studied in the next section). Their comparison puts in evidence the switching value $\widetilde{k}_2$: $p_0\varepsilon^o \geqslant \Pi_P(p^-, \varepsilon^-) \Leftrightarrow k_2 \leqslant \widetilde{k}_2 = \bar{\theta}/\lambda - \sqrt{k_1(2\bar{\theta}/\lambda - k_1)}$. ■

As a result, the producer has two price-quantity strategies in function of the high-quality set by the distributor: $(p, \varepsilon)^* = (p_0, \varepsilon^o)$ if $k_2 \in [4k_1/3, \widetilde{k}_2]$ and $(p, \varepsilon)^* = (p^-, \varepsilon^-)$ if $k_2 \in]\widetilde{k}_2, \bar{k}_2]$. The strategy (p_0, ε^o) is shown with a solid line and the strategy (p^-, ε^-) is shown in dashed line in figure 4:

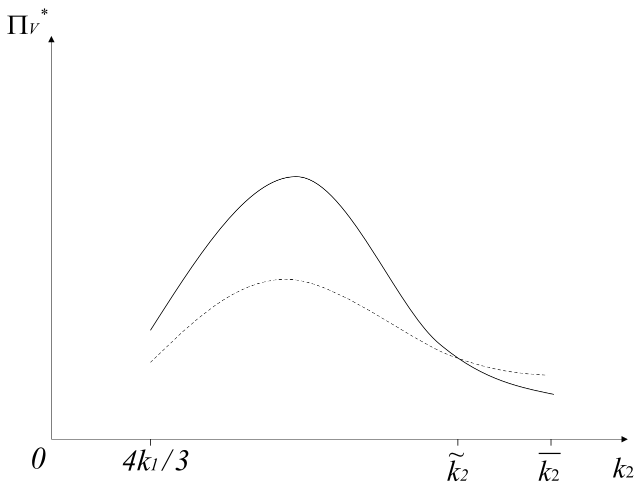

Figure 4: Producer's profit

3.5 Distributor's high-quality setting

To set the high-quality k_2, the distributor wants to maximize profit $\Pi_D = (p_2 - c_2)\alpha_2 - p\alpha$, in function of the strategy k_1 of the producer.

Proposizione 6 *If $k_1 \leqslant \bar{\theta}/5\lambda$ the distributor chooses quality $k_2^* = \widetilde{k}_2$, if $k_1 > \bar{\theta}/5\lambda$, the quality is set at the level $k_2^* = \bar{\theta}/3\lambda + k_1/3 > \widetilde{k}_2$.*

Proof. If the producer chooses strategy (p_0, ε^o), the distributor demands the quantity $\alpha = \varepsilon^o$. Since $\varepsilon^o > \tilde{\alpha}(\varepsilon)$, the distributor commercializes $\alpha_2 = \sigma$, at price $p_2 = p_2^+$. These values lead to profit $\Pi_D = [\bar{\theta}[k_2(1-\sigma-k_1(\varepsilon^o-\varepsilon^o)/2]-c_2]\sigma - p_0(\varepsilon^o)\varepsilon^o$. The profit of the distributor is zero in this case. If (p^-, ε^-) is chosen, since $p^- > p_0$, α amounts to $\alpha^-(\varepsilon^-, p^-) = \varepsilon_0$ that is inferior to $\tilde{\alpha}(\varepsilon^-)$. The quantity commercialized at price p_2^- is, thus, also ε_0. Therefore the profit is $\Pi_D = [\bar{\theta}[k_2(1-\varepsilon_0) - k_1(\varepsilon^- - \varepsilon_0)] - c_2 - p^-(\varepsilon^-)]\varepsilon_0$. This profit is positive, so the distributor always sets $k_2 > \widetilde{k}_2$. Profit Π_D is maximal for a high-quality $k_2^* = \bar{\theta}/3\lambda + k_1/3$, which is superior to $\widetilde{k}_2$ if and only if $k_1 > \bar{\theta}/5\lambda$. To resume, the distributor's strategy is $k_2^* = \widetilde{k}_2$ if $k_1 \leqslant \bar{\theta}/5\lambda$ and $k_2^* = \bar{\theta}/3\lambda + k_1/3$ if $k_1 > \bar{\theta}/5\lambda$. ■

Figure 5 draws the producer's profit for values of k_1 below and over the switching value $\bar{\theta}/5\lambda$:

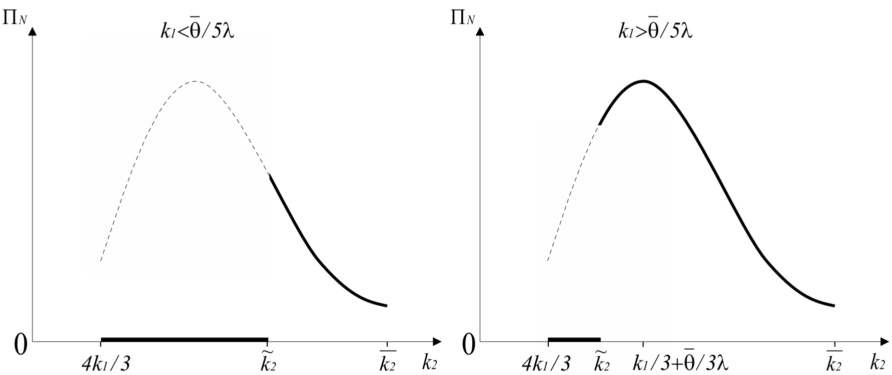

Figure 5: Producer's profit

3.6 Producer's low-quality choice

The producer's profit is: $\Pi_P(p^-, \varepsilon^-) = (\bar{\theta}k_1 - c_1)^2/(4\bar{\theta}k_1) + \delta\mu^2/8\bar{\theta}$ For $k_1 \leqslant \bar{\theta}/5\lambda$, the quality level $k_1 = \bar{\theta}/5\lambda$ gives to the producer the maximum profit $\Pi_P = 18\bar{\theta}^2/500\lambda$. For $k_1 > \bar{\theta}/5\lambda$ the optimal quality is $(10-3\sqrt{5})\bar{\theta}/11\lambda$ that brings to the producer profit $\bar{\theta}^2(5\sqrt{5}-2)/242\lambda$, which is superior to $18\bar{\theta}^2/500\lambda$. Hence: $k_1^* = (10-3\sqrt{5})\bar{\theta}/11\lambda$. A table that synthesizes these results at equilibrium is provided in the Appendices (section 6.3). Of course, the order of the quality choices in the game alters the results at equilibrium[8].

4 Study of the evolution of a certified supply chain

In this section, we apply the results obtained in the previous sections to a practical situation. We suppose that a syndicate of producers of a certified wine has to face the entry of a new partner/competitor that applies a strategy of "certification + brand". This is, for example, the case of the Bordeaux AOC with brands such as Mouton-Cadet or Malesan, or in the context of collective brands embedding many appellations (Duboeuf in the Burgundy region). In this case, the private brand brings new commercialization channels, which are economically vital for the sector. This is in particular the case for supermarket distribution channels and for export sales.

In the case where the syndicate is alone in the market, the results correspond to those obtained with the vertically integrated structure *(ii)*of figure 6. The syndicate produces and commercializes $(\bar{\theta} - \lambda k_1)/2\bar{\theta}$ that amounts to 1/3 since the optimal quality is $\bar{\theta}/3\lambda$. When the competitor that has developed a brand enters in the market, the situation is now similar to the one described by the vertical structure of figure 1, with the difference that we first suppose that the syndicate of producers is not able to optimally set the quality and keeps the quality $k_1 = \bar{\theta}/3\lambda$. This is more realistic, because of the administrative load that make it difficult to change the legal conditions ruling the production of certified products. However we will relax this assumption later. In this case, that we denote *(vi)*, the results obtained suggest that the distributor will choose the high-quality as a best reply to k_1, *i.e.*: $k_2 = \bar{\theta}/3\lambda + k_1/3 = 4\bar{\theta}/9\lambda$. The results obtained in this situation are

[8] *Structure (v) when the distributor sets the quality first.* We solve the two last stages of the backward induction since the previous ones are identical.

Choice of k_1: The strategy (p_0, ε^o) gives a profit that is independent from the low-quality k_1. The profit $\Pi_P(p^-, \varepsilon^-, k_1, k_2)$ is maximal for $\widehat{k_1} = 2\bar{\theta}/3\lambda + k_2/3 - (\sqrt{(\bar{\theta}/\lambda)^2 + 4\bar{\theta}k_2/\lambda - 2k_2^2})/3$. Moreover, we remark that $\Pi_P(p^-, \varepsilon^-, k_1^*, k_2) \geqslant p_0\varepsilon^o$ for all $k_2 \in \left[4k_1/3, \bar{k_2}\right]$. Thus, the producer chooses this quality, which corresponds to strategy (p^-, ε^-).

Choice of k_2: In order to set the high-quality k_2, the distributor considers profit $\Pi_D = (p_2 - c_2)\alpha_2 - p\alpha$. Since the strategy (p^-, ε^-) will be chosen by the producer and that $p^- > p_0$, α amounts to $\alpha^-(\varepsilon^-, p^-) = \varepsilon_0$ that is inferior to $\tilde{\alpha}(\varepsilon^-)$. The quantity commercialized at price p_2^- is, thus, also ε_0 and since the low-quality is in this case $\widehat{k_1}$, the profit of the distributor is $\Pi_D(k_2) = [\bar{\theta}[k_2(1-\varepsilon_0) - \widehat{k_1}(\varepsilon^- - \varepsilon_0)] - c_2 - p^-(\varepsilon^-)]\varepsilon_0$. Maximizing this profit in k_2 gives us the optimal high-quality $k_2^* = 2\bar{\theta}/3\lambda = \bar{k_2}(\widehat{k_1})$. We find that at equilibrium, the producer decides to not deal with the distributor and that the results are identical to those obtained in structure *(ii)* of vertical integration offering a single quality. The producer gets a better profit than in structure *(v)* thanks to the strategic advantage of successive adjustments of the quality, the quantity and the price. This case illustrates a fight for second place in the sequential game: players prefer to be the follower and set their quality in function of the quality of the competitor, rather than be the leader in the quality adjustment.

compared to those obtained in the initial situation in the following table:

	k_1^*	k_2^*	ε^*	α^*	β^*	p_1^*	p_2^*	p^*	Π_D^*	Π_P^*	W_c^*
(ii)	$\frac{\bar{\theta}}{3\lambda}$		$\frac{1}{3}$		$\frac{1}{3}$	$\frac{2\bar{\theta}^2}{9\lambda}$				$\frac{\bar{\theta}^2}{27\lambda}$	$\frac{\bar{\theta}^2}{54\lambda}$
(vi)	$\frac{\bar{\theta}}{3\lambda}$	$\frac{4\bar{\theta}}{9\lambda}$	$\frac{1}{3}$	$\frac{1}{18}$	$\frac{5}{18}$	$\frac{2\bar{\theta}^2}{9\lambda}$	$\frac{53\bar{\theta}^2}{18\times 9\lambda}$	$\frac{10\bar{\theta}^2}{81\lambda}$	$\frac{\bar{\theta}^2}{9\times 18^2\lambda}$	$\frac{55\bar{\theta}^2}{9^2\times 18\lambda}$	$\frac{109\bar{\theta}^2}{18^3\lambda}$

As we can see, the entry in the market of the intermediary that proposes a higher quality wine increases the profit of the producer. This is due to the fact that the high-quality distribution channel enables the supply chain to reach consumers with higher willingness to pay for quality (those with a taste for quality closer to $\bar{\theta}$). It becomes preferable for the producer to sell the part of the produced quantity that is demanded by the distributor, rather than using the direct commercialization channel, where the price is lower. Consumers also benefit, because of the heterogeneity of their taste for quality, from the entry of the distributor that leads to market segmentation.

Let us now relax the assumption made before, according to which the producers' syndicate is not able to optimally adjust the low-quality level. Given that the producer is able to choose the best quality, the results are identical to those obtained in the structure *(v)* (see the table in the Appendix). By comparing these results with those of the two previous situations, we see that the profit of the producer still increases, as well as the profit of the distributor. This increase of the profit of both agents of the supply chain comes with a degradation of consumers' surplus. Indeed, both agents readjust their qualities by lowering them compared to situation *(vi)*, while they increase the product differentiation at the same time. The quantities commercialized are greater and sold at a lower price, which shows that it is the quality adjustment that provokes the welfare transfer from the consumers to the supply chain.

If we compare this situation to the integrated supply chain offering two qualities *(iii)* (see table in the Appendices), we see that in the situation *(v)* the qualities are higher and less differentiated. This position is less effective because it exploits the heterogeneity in consumers' tastes for quality less. Despite a lower commercialized quantity at higher prices, the supply chain looses a part of the profit that could be reached with vertical integration, due to a lack of coordination along the supply chain. The consumers also have a lower welfare because the increase in the quality levels does not compensate the price increase and the decrease in the commercialized quantities. We study in the Appendices another game where the order of the quality adjustments of the structure *(v)* is inverted and where the producer manages to reestablish the efficiency of the single-quality vertically-integrated structure *(ii)*.

5 Discussion

In 2007 the Champagne wine represented more than one third of the value of French wine exports, although the surface of the wine yard represented only 14% of the total French AOC wine yard. The Champagne sector is therefore considered as an exceptional economic success in French agriculture. Most wine economists consider that this success is not only due to the quality of the product (appreciated and valued by customers) but mainly due to the economic organization of the supply chain and the development of brands that most of the times preceded the creation of the AOC label[9], as described in Barrère (2003), Ménival and Charters (2008) and Ménival (2008). According to Deluze (2010), the emergence of the producers' entrepreneur behavior resulted in an increase in the number of firms, upstream the supply chain, that passed from 1055 in 1992 to 3524 in 2008 (234% increase). Due to these strategic behaviors, the stock of wine produced has also a tendency to increase, while reducing the proportion of the production sold to the distributors. Between 1950 and 1980, this proportion dropped from 70% to 50%.

In order to study a situation where the distributor precedes the creation of the AOC label we developed a model based on Giraud-Héraud et al. (1999), with the difference that the producer does not sell low quality wines, this channel being only used by the producer. Contrary to the result obtained in Giraud-Héraud et al. (1999), we find that the commitment to produce a given quantity and the commitment to commercialization of the producer are not enough to reestablish the efficiency of vertical integration obtained in the situation *(iii)*, where two qualities are supplied in the market. In Giraud-Héraud et al. (1999), when the distributor produces the two qualities, the excess of quantity could be commercialized in low-quality by the distributor. In our model, these quantities cannot be commercialized. We could, however, consider that in a two-stages repeated game, the distributor would be able to stock these quantities. In this case, the quality adjustment would be different. The results of our model underline the importance of the assumption according to which the distributor has access or not to a low-quality commercialization channel.

In our model, through a credible commitment to commercialization of the total quantity, the producer could force the distributor to demand the total harvest (if the distributor did not have the possibility to react by setting the high-quality level). However, the quality adjustment allows to the distributor to avoid a zero profit situation.

In the section 4, our model permits us to illustrate a different situation than

[9] A similar, yet less dramatic, explanation for the performance of the Porto supply chain can be found in Giraud-Héraud et al. (2004).

the one that implicitly motivated Giraud-Héraud et al. (1999). In their article, the distributor exists before the certification system and the producers' syndicate. The syndicate of producers is the initiator of the product differentiation, by developing a direct access to the market in low-quality, in order to exploit a segment of the market insufficiently supplied by the distributor due to the double marginalization phenomenon. In our article, we study the case where new brands or appellations are created : the direct commercialization of certified wines exists before a brand distributor gets interested in this market. We show that the distributor is welcomed by the syndicate of producers because the distributor opens new segments of the market. Consumers also benefit, because of the heterogeneity of their taste for quality, from the market segmentation. We also underline the importance of the quality levels adjustments.

Our article shows the interest of brands development, even though the latter are based ex-post on a pre-existing AOC. This is, for example, the case of the Bordeaux AOC (think of Mouton-Cadet or Malesan), or in the Bourgogne AOC (Duboeuf). In this case, the private brand does not enter in competition with the collective brand (represented by the AOC), but brings instead new commercialization channels (supermarket distribution, foreign markets), which are economically vital for the sector.

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6 Appendix

6.1 Vertically-integrated structures

We consider three vertically integrated structures, two where a single quality is proposed to the consumers and one where both qualities are supplied (see figure 6). In structure *(i)*, the producer and the distributor cooperate and choose to take profit of the technology of the distributor. This allows the supply chain to commercialize a Champagne-wine of high-quality k_2. They agree on the price, the quantity and the level of quality. The total harvest is transferred from the producer to the distributor. In structure *(ii)*, the producer chooses to avoid the distributor and supplies a Champagne-wine of low-quality k_1. In structure *(iii)*, the integrated supply chain takes profit of the possibility to produce the two types of Champagne-wines. The distributor is the only one to be able to produce high-quality wine, while the producer is only able to produce low-quality one, but we are in a context of coordination of the two agents on the quantity and quality levels to choose.

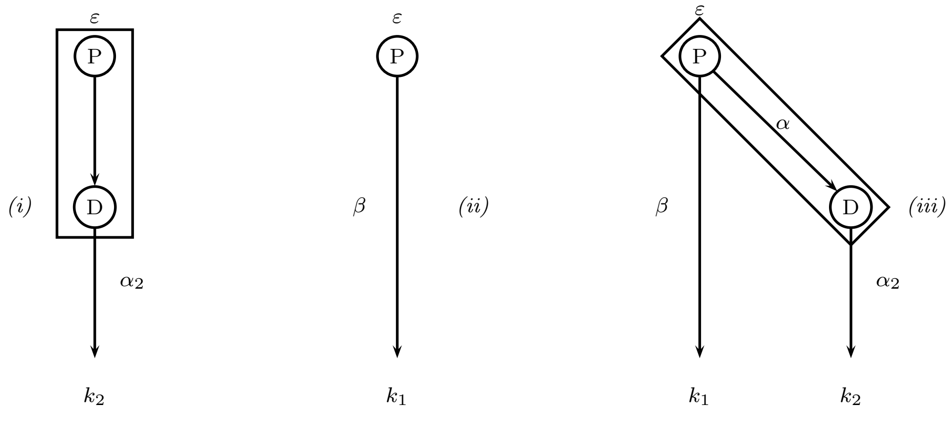

Figure 6: Vertically-integrated structures *(i)*, *(ii)* and *(iii)*

Structures *(i)* and *(ii)* are solved in the same way, the following proposition is valid for k_i, $i = 1, 2$, but we only write it for structure *(i)*.

Proposizione 7 *The integrated supply chain produces and commercializes the optimal quantity* $\sigma = (\bar{\theta} - \lambda k_2^*)/2\bar{\theta}$ *and chooses the optimal quality* $k_2^* = \bar{\theta}/3\lambda$.

Proof. The profit of the integrated supply chain is written: $\Pi_I = (p_2 - c_2)\alpha_2$. Given that $\beta = 0$, we have that $p_2 = \bar{\theta}[k_2(1 - \alpha_2) - k_1\beta] = \bar{\theta}k_2(1 - \alpha_2)$. If we consider $\sigma = (\bar{\theta} - \lambda k_2)/2\bar{\theta}$, the profit can be written : $\Pi_I = -\bar{\theta}k_2\alpha_2^2 + 2\bar{\theta}k_2\sigma\alpha_2$. In this vertical integration scheme, ε is simply a capacity constraint for the choice of the quality α_2^* that maximizes Π_I. We obtain : $\alpha_2^* = \varepsilon$ if $\varepsilon < \sigma$ and $\alpha_2^* = \sigma$ if $\varepsilon \geqslant \sigma$. In the case where the available harvest ε is such that $\varepsilon \geqslant \sigma$, the quantity $\varepsilon - \sigma$ is not commercialized. By replacing α_2^* in the profit function, we can write it as a function of the available quantity ε: $\Pi_I(\varepsilon) = (\bar{\theta}k_2(1-\varepsilon) - c_2)\varepsilon$ if $\varepsilon < \sigma$ and $\Pi_I(\varepsilon) = (\bar{\theta}k_2(1-\sigma) - c_2)\sigma$ if $\varepsilon \geqslant \sigma$. The graph of Π_I is made of a convex function (with a coefficient in ε^2 that is negative, reaching a maximum for $\varepsilon = \sigma$) and a constant function. The continuity in σ and the concavity of the profit function lead to an optimal quantity (produced and commercialized) which value is: $\varepsilon^* = \sigma$. For this quantity, the profit amounts to $\bar{\theta}k_2\sigma^2$. This corresponds to a cooperation scenario, where the producer only produces the quantity needed by the distributor. The quality k_2 can now be chosen in order to maximize $\bar{\theta}k_2\sigma^2$. We obtain an optimal quality: $k_2^* = \bar{\theta}/3\lambda$. This allows the integrated supply chain to reach profit: $\Pi_I^* = \bar{\theta}^2/27\lambda$. The consumers' surplus amounts to : $W_c^* = \bar{\theta}(k_2^*\alpha_2^{*2})/2 = \bar{\theta}^2/54\lambda$. ■

Proposizione 8 *The two-qualities integrated structure chooses, at equilibrium, to segment the market. The quantity $\varepsilon^* = \bar{\varepsilon}/2$ is split into a part $\alpha_2^* = \mu/2\bar{\theta}$ in high-quality, while the rest $\beta^* = \lambda k_2/2\bar{\theta}$ is devoted to furnish low-quality. At equilibrium, the optimal qualities are $k_1^* = \bar{\theta}/5\lambda$ and $k_2^* = 2\bar{\theta}/5\lambda$.*

Proof. The profit of the integrated supply chain is : $\Pi_I = (p_1 - c_1)\beta + (p_2 - c_2)\alpha_2$, where the market prices are given by: $p_1 = \bar{\theta}k_1(1-\varepsilon)$ and $p_2 = \bar{\theta}(k_2 - k_1\varepsilon) - \delta\mu/2$. For a produced quantity ε, the maximization of the integrated profit in (β, α_2) gives the optimal quantities. Under (H2), the high-quality k_2 is always present in the market. Moreover, once ε is bigger than $\mu/2\bar{\theta}$, it is optimal to segment the market by selling also wines of low-quality k_1. More precisely:
1) If $\varepsilon \leqslant \mu/2\bar{\theta}$, the quantities are $\beta = 0$ and $\alpha_2 = \varepsilon$. Only high-quality wines are provided by the integrated supply chain at price $p_2 = \bar{\theta}k_2(1 - \varepsilon)$.
2) If $\varepsilon \geqslant \mu/2\bar{\theta}$, the quantities are $\beta = \varepsilon - \mu/2\bar{\theta}$ and $\alpha_2 = \mu/2\bar{\theta}$.
The profit of the integrated supply chain can be written in function of the switching value: $\Pi_I(\varepsilon) = (\bar{\theta}k_2(1-\varepsilon) - c_2)\varepsilon$ if $\varepsilon < \mu/2\bar{\theta}$ and $\Pi_I(\varepsilon) = (\bar{\theta}k_1(1-\varepsilon) - c_1)\varepsilon + \delta\mu^2/4\bar{\theta}$ if $\varepsilon \geqslant \mu/2\bar{\theta}$. $\Pi_I(\varepsilon)$ is continuous in $\mu/2\bar{\theta}$. The optimal quantity is $\varepsilon^* = (\bar{\theta} - \lambda k_1)/2\bar{\theta} = \bar{\varepsilon}/2 > \mu/2\bar{\theta}$. The integrated supply chain chooses $\bar{\varepsilon}/2$ that leads to a market segmentation. The high-quality k_2 is then provided in quantity $\alpha_2^* = \mu/2\bar{\theta}$,

the low-quality k_1, in quantity $\beta^* = \lambda k_2/2\bar{\theta}$. By replacing these equilibrium quantities in the integrated profit function $\Pi_I(\varepsilon^*) = (p_1(\varepsilon^*) - c_1)\beta^* + (p_2(\varepsilon^*) - c_2)\alpha_2^*$, we obtain the following expression: $\Pi_I(k_1, k_2) = k_2((\bar{\theta} - \lambda k_2)^2 + \lambda^2 k_1 \delta)/4\bar{\theta}$. The integrated supply chain must choose the levels of qualities k_1 and k_2 in order to maximize $\Pi_I(k_1, k_2)$. The first order condition applied to each of these two variables gives two pairs of candidates: $\left(\bar{\theta}/3\lambda, 2\bar{\theta}/3\lambda\right)$ and $\left(\bar{\theta}/5\lambda, 2\bar{\theta}/5\lambda\right)$. The respective profits are then easily obtained: $\Pi_I\left(\bar{\theta}/3\lambda, 2\bar{\theta}/3\lambda\right) = \bar{\theta}^2/27\lambda$ and $\Pi_I\left(\bar{\theta}/5\lambda, 2\bar{\theta}/5\lambda\right) = \bar{\theta}^2/25\lambda$. As a result, the pair of quantities $(k_1^*, k_2^*) = (\bar{\theta}/5\lambda, 2\bar{\theta}/5\lambda)$ is chosen. ■

As a conclusion to this section we can say that when the producer and the distributor are able to agree on quantities and quality levels, the two-qualities vertically-integrated structure *(iii)* is preferred to structures *(i)* and *(ii)*. The consumers' welfare is also higher thanks to the market segmentation. However, a "double marginalization" phenomenon may appear when there is not such coordination, as studied in the following section.

6.2 Double marginalization

This section focuses on the coordination problems in the vertical relationship when only one quality is supplied, which corresponds to the vertical integration scheme *(i)* of the figure 6, with the difference that the producer and the distributor are no longer able to coordinate on the choice of quantity or quality levels. On the contrary, they behave like two successive monopolies. We denote by structure *(iv)* this non-cooperative supply chain. The producer is supposed to be a leader of Stackelberg since it is the only one to hold the raw material for the production of Champagne-wine. The linear contract in price provokes, in this non-cooperative framework, a phenomenon of "double marginalization" due to the fact that the agents of the supply chain maximize their own margin:

Proposizione 9 *The double marginalization reduces to the half (compared to the integrated supply chain) the quantity produced and commercialized at equilibrium $\sigma/2$. The optimal quality $k_2^* = \bar{\theta}/3\lambda$ remains unchanged. The loss of profit for the supply chain is 1/4 of the profit of the integrated supply chain and the consumers loose 3/4 of their welfare.*

gr:multiparab **Proof.** We adapt the game Γ to the single quality case and we solve it by backward induction :

(t=6): The distributor maximizes the profit: $\Pi_D = (p_2 - c_2)\alpha_2 - p\alpha$. The quantity commercialized α_2^* is the same as the one we found for the vertical structure *(i)* : $\alpha_2^* = \alpha$ if $\alpha \in [0, \sigma]$ and $\alpha_2^* = \sigma$ if $\alpha \in [\sigma, \varepsilon]$.

(t=5) : There exists a switching price $p^\dagger$, under which the distributor demands all the available quantity to the producer. For price $p > p^\dagger$, the distributor demands only $\sigma - p/2\bar{\theta}k_2$. Given α_2^*, the profit of the distributor is $\Pi_D = \bar{\theta}k_2(1-\alpha) - c_2)\alpha - p\alpha$ if $\alpha \in [0, \sigma]$ and $\Pi_D = (\bar{\theta}k_2(1-\sigma) - c_2)\sigma - p\alpha$ if $\alpha \in [\sigma, \varepsilon]$. The first expression is a convex function whose coefficient in α^2 is $-\bar{\theta}k_2 < 0$ and we have the continuity in σ with the second expression, a linear and decreasing function of α. The maximum of the convex function is reached for a demand : $\sigma - p/2\bar{\theta}k_2$. Therefore, the demand is $\max(\sigma - p/2\bar{\theta}k_2, \varepsilon)$. On the other hand, $\sigma - p/2\bar{\theta}k_2 \leqslant \varepsilon \Leftrightarrow p \geqslant p^\dagger = 2\bar{\theta}k_2(\sigma - \varepsilon)$. This demand must also be positive: $\sigma - p/2\bar{\theta}k_2 \geqslant 0 \Leftrightarrow p \leqslant \bar{p} = 2\bar{\theta}k_2\sigma$. Price $\bar{p}$ corresponds to the maximum price of the grapes over which the demand of the distributor becomes zero. We easily deduce the optimal demand of the distributor: $\alpha^* = \varepsilon$ if $p \in [0, p^\dagger]$ and $\alpha^* = \sigma - p/2\bar{\theta}k_2$ if $\alpha \in [p^\dagger, \bar{p}]$.

(t=4) : The producer has two possible strategies depending on the quantity. If $\varepsilon < \sigma/2$, the producer chooses to sell at price $p^\dagger$, if $\varepsilon > \sigma/2$, the price is $\bar{\theta}k_2\sigma$. The producer wants to maximize profit $\Pi_P = p\alpha$. If price $p \in [0, p^\dagger]$ is chosen, the distributor demands all the quantity ε and we have $\Pi_P = p\varepsilon$. If the producer chooses price $p \in [p^\dagger, \bar{p}]$, the distributor's demand is $\sigma - p/2\bar{\theta}k_2$ and $\Pi_P = -p^2/2\bar{\theta}k_2 + \sigma p$. The first expression is a linear and decreasing function in p and we have the continuity with the second expression (because $\sigma - p^\dagger/2\bar{\theta}k_2 = \varepsilon$) which is a convex function with a coefficient in p^2 that is negative. The maximum of this convex function is reached for price $p = \bar{\theta}k_2\sigma$. Moreover, we have the following equivalences: $\bar{\theta}k_2\sigma \geqslant p^\dagger \Leftrightarrow \varepsilon \geqslant \sigma/2$ and $p^\dagger \geqslant 0 \Leftrightarrow \varepsilon \leqslant \sigma$. Therefore, the optimal price set by the producer is : $p^* = p^\dagger$ if $\varepsilon \in [0, \sigma/2]$ and $p^* = bar\theta k_2\sigma$ if $\varepsilon \in [\sigma/2, \bar{\varepsilon}]$.

(t=3): At this point the producer's profit is $\Pi_P = p^\dagger\varepsilon = 2\bar{\theta}k_2(\sigma - \varepsilon)\varepsilon$ if $\varepsilon \in [0, \sigma/2]$ and $\Pi_P = \bar{\theta}k_2\sigma(\sigma - p/2\bar{\theta}k_2) = \bar{\theta}k_2\sigma^2/2$ if $\varepsilon \in [\sigma/2, \bar{\varepsilon}]$. The first expression is a convex function whose value is $\bar{\theta}k_2\sigma^2/2$ for $\sigma/2$, so that we have the continuity with the second expression that is constant in ε. The continuity and the concavity of the producer's profit function allow us to deduce the optimal quantity : $\varepsilon^* = \sigma/2$.

(t=2,1): Given the optimal quantity, the distributor's profit $\Pi_D = \bar{\theta} k_2 \sigma^2/4$ is maximal for quality $k_2^* = \bar{\theta}/3\lambda$. Therefore, the aggregated profit of the supply chain at equilibrium is $\Pi_A^* = \Pi_D^* + \Pi_P^* = 3(\bar{\theta}^2/27\lambda)/4 = 3\Pi_I^*/4$. ■

The double marginalization leads to a profit loss of 1/4 of the profit that the integrated supply chain could have obtained. This loss is due to the fact that the distributor maximizes their profit without taking into account the profit increase for the producer that a higher demand of raw material would ensure. It is also due to the fact that, at the same time, the producer does not take into account the externality linked to the setting of the price of the raw material on the choice of quantity by the distributor.

6.3 Synthesis

This table synthesizes the results obtained at equilibrium:

structure	i	ii	iii	iv	v	vi
k_1^*	–	$\frac{\bar{\theta}}{3\lambda}$	$\frac{\bar{\theta}}{5\lambda}$	–	$\frac{(10-3\sqrt{5})\bar{\theta}}{11\lambda}$	$\frac{\bar{\theta}}{3\lambda}$
k_2^*	$\frac{\bar{\theta}}{3\lambda}$	–	$\frac{2\bar{\theta}}{5\lambda}$	$\frac{\bar{\theta}}{3\lambda}$	$\frac{(7-\sqrt{5})\bar{\theta}}{11\lambda}$	$\frac{4\bar{\theta}}{9\lambda}$
ε^*	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{2}{5}$	$\frac{1}{6}$	$\frac{(3\sqrt{5}+1)\bar{\theta}}{22}$	$\frac{1}{3}$
α^*	$\frac{1}{3}$	–	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{2\sqrt{5}-3}{22}$	$\frac{1}{18}$
β^*	–	$\frac{1}{3}$	$\frac{1}{5}$	0	$\frac{\sqrt{5}+4}{22}$	$\frac{5}{18}$
p_1^*	–	$\frac{2\bar{\theta}^2}{9\lambda}$	$\frac{3\bar{\theta}^2}{25\lambda}$	–	$\frac{3\bar{\theta}^2(85-31\sqrt{5})}{11^2\times2\lambda}$	$\frac{2\bar{\theta}^2}{9\lambda}$
p_2^*	$\frac{2\bar{\theta}^2}{9\lambda}$	–	$\frac{7\bar{\theta}^2}{25\lambda}$	$\frac{5\bar{\theta}^2}{18\lambda}$	$\frac{\bar{\theta}^2(160-37\sqrt{5})}{11^2\times2\lambda}$	$\frac{53\bar{\theta}^2}{18\times9\lambda}$
p^*	0	–	0	$\frac{\bar{\theta}^2}{9\lambda}$	$\frac{\bar{\theta}^2(23+3\sqrt{5})}{11^2\times2\lambda}$	$\frac{10\bar{\theta}^2}{81\lambda}$
Π_D^*				$\frac{\bar{\theta}^2}{4\times27\lambda}$	$\frac{\bar{\theta}^2(94\sqrt{5}-207)}{11^3\times4\lambda}$	$\frac{\bar{\theta}^2}{9\times18^2\lambda}$
Π_P^*	$\Pi_I^* = \frac{\bar{\theta}^2}{27\lambda}$	$\frac{\bar{\theta}^2}{27\lambda}$	$\Pi_I^* = \frac{\bar{\theta}^2}{25\lambda}$	$\frac{\bar{\theta}^2}{2\times27\lambda}$	$\frac{\bar{\theta}^2(5\sqrt{5}-2)}{11^2\times2\lambda}$	$\frac{55\bar{\theta}^2}{9^2\times18\lambda}$
W_c^*	$\frac{\bar{\theta}^2}{54\lambda}$	$\frac{\bar{\theta}^2}{54\lambda}$	$\frac{\bar{\theta}^2}{50\lambda}$	$\frac{\bar{\theta}^2}{216\lambda}$	$\frac{\bar{\theta}^2(163+16\sqrt{5})}{11^3\times8\lambda}$	$\frac{109\bar{\theta}^2}{18^3\lambda}$