Wine Futures and Advance Selling under Quality Uncertainty

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Appendix

Proof of Proposition 1. As noted in Li and Huh (2011; see Theorem 1), $\Pi(q_f)$ is concave (shown below for completeness):

$$\Pi'\left(q_f\right)=\left(\theta-\phi\right)s_1+\beta\ln\left[\frac{M\left(s_1\right)-q_f}{2q_f}\right]-\frac{\beta M\left(s_1\right)}{M\left(s_1\right)-q_f}$$

$$\Pi''\left(q_f\right)=\beta\left[\frac{-M\left(s_1\right)}{q_f\left(M\left(s_1\right)-q_f\right)}\right]-\frac{\beta M\left(s_1\right)}{\left(M\left(s_1\right)-q_f\right)^2}=-\frac{\beta M\left(s_1\right)^2}{q_f\left(M\left(s_1\right)-q_f\right)^2}<0.$$

Note that $p_f\left(q_f\right)=\theta s_1+\beta\ln\left[\frac{M\left(s_1\right)-q_f}{2q_f}\right]$ (see (2)). Thus, the first-order condition is

$$p_f\left(q_f\right)=\phi s_1+\frac{\beta M\left(s_1\right)}{M\left(s_1\right)-q_f}=\beta+\phi s_1+\frac{\beta q_f}{M\left(s_1\right)-q_f},$$

and the optimal unconstrained profit is

$$\rho^{\mathrm{o}}=q_f\left(\phi s_1+\frac{\beta M\left(s_1\right)}{M\left(s_1\right)-q_f}\right)-q_f\phi s_1+\phi s_1 Q \tag{12}$$

$$=M\left(s_1\right)\left(\beta+\phi s_1+\frac{\beta q_f}{M\left(s_1\right)-q_f}\right)-M\left(s_1\right)\left(\beta+\phi s_1\right)+\phi s_1 Q$$

$$=M\left(s_1\right)\left(p_f^{\mathrm{o}}-\beta-\phi s_1+\frac{\phi s_1 Q}{M\left(s_1\right)}\right),$$

which implies

$$p_f^{\mathrm{o}} = \frac{\rho^{\mathrm{o}} + M(s_1)\beta + \phi s_1 (M(s_1) - Q)}{M(s_1)}. \tag{13}$$

We rewrite (12) as

$$\rho^{\mathrm{o}} = M(s_1)\left(\frac{\beta q_f / M(s_1)}{1 - q_f / M(s_1)}\right) + \phi s_1 Q \tag{14}$$

and note

$$\frac{q_f}{M(s_1)} = \frac{e^{(\theta s_1 - p_f)/\beta}}{2 + e^{(\theta s_1 - p_f)/\beta}} \tag{15}$$

(see (1)), and thus

$$\frac{q_f / M(s_1)}{1 - q_f / M(s_1)} = \frac{e^{(\theta s_1 - p_f)/\beta}}{2}. \tag{16}$$

Substituting (13) and (16) into (14), we get

$$\rho^{\mathrm{o}} = M(s_1)\beta\left(\frac{e^{\left(\theta s_1 - \frac{\rho^{\mathrm{o}} + M(s_1)\beta + \phi s_1 (M(s_1) - Q)}{M(s_1)}\right)/\beta}}{2}\right) + \phi s_1 Q$$

and rearrange to get

$$\frac{\rho^{\mathrm{o}} - \phi s_1 Q}{M(s_1)\beta} e^{\left(\frac{\rho^{\mathrm{o}} - \phi s_1 Q}{M(s_1)\beta}\right)} = \frac{e^{(\theta - \phi)s_1/\beta}}{2e},$$

which implies

$$\rho^{\mathrm{o}} = M(s_1)\left[\beta W\left(\frac{e^{(\theta - \phi)s_1/\beta}}{2e}\right) + \phi s_1 \frac{Q}{M(s_1)}\right]. \tag{17}$$

Substituting (13) and (17) into (15), we get the optimal unconstrained futures quantity

$$q_f^{\mathrm{o}} = \frac{M(s_1) e^{-1} e^{\left(M(s_1)(\theta - \phi)s_1 + \phi s_1 Q - \rho^{\mathrm{o}}\right)/\left(M(s_1)\beta\right)}}{2 + e^{-1} e^{\left(M(s_1)(\theta - \phi)s_1 + \phi s_1 Q - \rho^{\mathrm{o}}\right)/\left(M(s_1)\beta\right)}} = M(s_1)\left(\frac{e^{\left(M(s_1)(\theta - \phi)s_1 + \phi s_1 Q - \rho^{\mathrm{o}}\right)/\left(M(s_1)\beta\right)}}{2e + e^{\left(M(s_1)(\theta - \phi)s_1 + \phi s_1 Q - \rho^{\mathrm{o}}\right)/\left(M(s_1)\beta\right)}}\right)$$

$$= M(s_1)\left(\frac{e^{(\theta - \phi)s_1/\beta - W\left(\frac{e^{(\theta - \phi)s_1/\beta}}{2e}\right)}}{2e + e^{(\theta - \phi)s_1/\beta - W\left(\frac{e^{(\theta - \phi)s_1/\beta}}{2e}\right)}}\right).$$

Thus, if $q_f^{\mathrm{o}} \leq Q$, then $q_f^* = q_f^{\mathrm{o}}$, $\rho^* = \rho^{\mathrm{o}}$, and

$$p_f^* = \theta s_1 + \beta \ln\left[\frac{M(s_1)/q_f^* - 1}{2}\right] = \theta s_1 + \beta \ln\left[\frac{1}{2}\left(\frac{2e + e^{(\theta-\phi)s_1/\beta - W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)}}{e^{(\theta-\phi)s_1/\beta - W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)}} - 1\right)\right]$$

$$= \theta s_1 + \beta \ln\left[\frac{e}{e^{(\theta-\phi)s_1/\beta - W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)}}\right] = \phi s_1 + \beta\left[1 + W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)\right].$$

If $q_f^o \geq Q$, then the supply constraint is binding, $q_f^* = Q$, and the optimal price and profit are obtained by substituting $q_f^* = Q$ into (2) and (3). ❐

Proof of Proposition 2. First consider the case where the supply constraint is binding. From the fact that the supply constraint is binding, it follows that ρ^* is increasing in Q. The remainder of the results follow directly from (8) – (10) and $M'(s_1) \geq 0$.

Now suppose the supply constraint is not binding. From implicit differentiation of $z = W(z)e^{W(z)}$, we get $1 = W'(z)e^{W(z)} + W(z)W'(z)e^{W(z)}$, which yields

$$W'(z) = \frac{1}{e^{W(z)} + W(z)e^{W(z)}} = \frac{W(z)}{z(1+W(z))} > 0 \text{ for all } z > 0. \tag{18}$$

Multiplying both sides of (18) by z, we get

$$zW'(z) = \frac{W(z)}{1+W(z)} < 1. \tag{19}$$

Let $x = \frac{(\theta-\phi)s_1}{\beta}$ and $y = x - W\left(\frac{e^x}{2e}\right)$ and note

$$y'(x) = 1 - \left(\frac{e^x}{2e}\right)W'\left(\frac{e^x}{2e}\right) > 0 \qquad \text{(due to (19))}$$

$$\frac{\partial}{\partial y}\left(\frac{e^y}{2e+e^y}\right) = \frac{\partial}{\partial y}\left(\frac{1}{2e^{1-y}+1}\right) = \frac{2e^{1-y}}{\left(2e^{1-y}+1\right)^2} > 0.$$

Therefore, the sign of

$$\frac{\partial \alpha^*}{\partial \bullet} = \frac{\partial}{\partial \bullet}\left(\frac{e^y}{2e+e^y}\right) = \frac{2e^{1-y}}{\left(2e^{1-y}+1\right)^2} \times y'(x) \times \frac{\partial x}{\partial \bullet}$$

is determined by the sign of $\frac{\partial x}{\partial \bullet}$, which leads to the results for α^* (in column 3).

For the signs of $\frac{\partial q_f^*}{\partial \bullet}$, it is clear that with the exception of parameter s_1, the results for q_f^* are identical to the results for α^* (i.e., $q_f^* = M(s_1)\alpha^*$). If $\theta = \phi$, then q_f^* is the product of $M(s_1)$ and a constant, and thus $\frac{\partial q_f^*}{\partial s_1} \geq 0$. If $\theta > \phi$, then q_f^* is the product of two terms that are increasing in s_1, and thus $\frac{\partial q_f^*}{\partial s_1} \geq 0$. If $\theta < \phi$, then q_f^* is the product of two terms, one of which is that are increasing s_1 and the other that is decreasing in s_1. Thus the sign of $\frac{\partial q_f^*}{\partial s_1}$ is parameter-dependent.

Next we consider the signs of $\frac{\partial p_f^*}{\partial \bullet}$. For $\frac{\partial p_f^*}{\partial (\theta - \phi)}$, we see that the second term in (6) is increasing in $(\theta - \phi)$ (due to (18)). However, without additional requirements on the value of ϕ as $(\theta - \phi)$ changes, the first term in (6) may decrease as $(\theta - \phi)$ increases, causing the direction of the change in p_f^* to be parameter-dependent. Similar reasoning can be used to conclude that p_f^* is increasing in θ. From $p_f^* = \theta s_1 + \beta \ln\left[\frac{M(s_1) - q_f^*}{2q_f^*}\right]$ (see (2)), we get

$$\frac{\partial p_f^*}{\partial \phi} = \ln\left[\frac{M(s_1) - q_f^*}{2q_f^*}\right] - \beta\left(\frac{2q_f^*}{M(s_1) - q_f^*}\right)\left(\frac{M(s_1)}{2q_f^{*2}}\right)\frac{\partial q_f^*}{\partial \phi}$$

$$= \ln\left[\frac{M(s_1) - q_f^*}{2q_f^*}\right] + \beta\left(\frac{M(s_1) q_f^*}{M(s_1) - q_f^*}\right)\left(-\frac{\partial q_f^*}{\partial \phi}\right).$$

The second term is positive due to $M(s_1) > q_f^*$ and $\frac{\partial q_f^*}{\partial \phi} < 0$. However the first term can be negative, leading to a sign that is parameter-dependent. The value of Q doesn't affect the price. If $\theta = \phi$, it is clear from (6) that p_f^* is increasing in s_1 and β. For $\theta > \phi$, it is clear from (18) and (6) that p_f^* is increasing in s_1. We rewrite (7) as

$$\frac{\rho^*}{M(s_1)} = \beta W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right) + \phi s_1 \frac{Q}{M(s_1)}$$

and rewrite (6) as

$$p_f^* = \phi s_1\left(1 - \frac{Q}{M(s_1)}\right) + \beta + \beta W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right) + \phi s_1 \frac{Q}{M(s_1)}$$

$$=\phi s_1\left(1-\frac{Q}{M\left(s_1\right)}\right)+\beta+\frac{\rho^*}{M\left(s_1\right)}. \tag{20}$$

Taking the derivative with respect to β,

$$\frac{\partial p_f^*}{\partial \beta}=1+\left(\frac{1}{M\left(s_1\right)}\right)\left(\frac{\partial \rho^*}{\partial \beta}\right).$$

We will show below in our analysis of the sign $\frac{\partial \rho^*}{\partial \beta}$ that, when $\theta > \phi$, $\frac{\partial \rho^*}{\partial \beta} < 0$ for small β (approaching negative infinity at β approaches zero) and $\frac{\partial \rho^*}{\partial \beta} > 0$ for large β. Therefore, p_f^* is initially decreasing in β and eventually increasing in β. If $\theta < \phi$, then we begin by considering the case of $M'(s_1) = 0$ for all s_1. From (20) we see that price is the sum of two terms. As shown below, ρ^* is increasing in s_1, and thus both terms are increasing in s_1. If $M'(s_1) > 0$, then the sign of p_f^* is parameter dependent. If $\theta < \phi$, then as shown below, $\frac{\partial \rho^*}{\partial \beta} > 0$, and it is clear from (20) that $\frac{\partial p_f^*}{\partial \beta} > 0$.

Lastly, we consider the signs of $\frac{\partial \rho^*}{\partial \bullet}$. The arguments showing that the sign of $\frac{\partial p_f^*}{\partial\left(\theta-\phi\right)}$ is parameter-dependent can be used to show that the sign of $\frac{\partial \rho^*}{\partial\left(\theta-\phi\right)}$ is parameter-dependent. From (7) it is clear that ρ^* is increasing in θ. The term in brackets in (7) is sum of two terms—one that is decreasing in ϕ and the other that is increasing in ϕ—leading to a sign that is parameter-dependent. We can conclude that ρ^* is increasing in s_1 regardless of the relationship between θ and ϕ because, as s_1 increases, profit increases with no change in the optimal futures quantity and price (i.e., the retail price is increasing in s_1). Re-optimization of quantity and price after an increase in s_1 cannot decrease profit.

We are left with analyzing the impact of changes in β on ρ^* for the three conditions: $\theta = \phi$, $\theta > \phi$, and $\theta < \phi$. If $\theta = \phi$, then it is clear from (7) that ρ^* is increasing in β. Taking the derivative of (7) with respect to β,

$$\frac{\partial \rho^*}{\partial \beta}=M\left(s_1\right)\left[W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)-\beta\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)W'\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)\left[\frac{\left(\theta-\phi\right)s_1}{\beta^2 2e}\right]\right]$$

$$=M\left(s_1\right)\left[W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)-W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)\left[\frac{\left(\theta-\phi\right)s_1}{\beta}\right]\Big/\left(W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)+1\right)\right] \quad \text{(due to (19))}$$

$$= \left(\frac{M(s_1) W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e} \right)}{W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e} \right) + 1} \right) \left(W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e} \right) + 1 - \frac{(\theta-\phi)s_1}{\beta} \right).$$

Thus, the sign of $\frac{\partial \rho^*}{\partial \beta}$ is determined by the sign of $W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e} \right) + 1 - \frac{(\theta-\phi)s_1}{\beta}$. If $\theta < \phi$, then the sign is positive, and we have $\frac{\partial \rho^*}{\partial \beta} > 0$. If $\theta > \phi$, then the sign of $W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e} \right) + 1 - \frac{(\theta-\phi)s_1}{\beta}$ approaches negative infinity as β approaches zero and is assured to be positive when $\beta \geq (\theta - \phi)s_1$, i.e., ρ^* is initially decreasing in β and eventually increasing in β. ❒

Proof of Proposition 3. Taking the first- and second-order derivatives of (6) and (7) with respect to β provides the result. We start with the profit expression in (7):

$$\frac{\partial \rho^*}{\partial \beta} = M(s_1) K(\beta)$$

where $K(\beta) = W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e} \right) + \beta \frac{\partial W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e} \right)}{\partial \beta}$.

Notice that this first-order condition reaches zero when $K(\beta) = 0$. Let us define β_{ρ^*} as the value of consumer heterogeneity that makes the first-order condition equal to zero, i.e., $K(\beta_{\rho^*}) = 0$. We next show that the profit function in (7) is convex in β.

$$\frac{\partial \rho^*}{\partial \beta} = M(s_1) \left[-\left[\frac{1}{\beta} (\theta - \phi) s_1 \right] \frac{W\left(\frac{e^{(\theta s_1 - \phi s_1)/\beta}}{2e} \right)}{\left(1 + W\left(\frac{e^{(\theta s_1 - \phi s_1)/\beta}}{2e} \right) \right)} + W\left(\frac{e^{(\theta s_1 - \phi s_1)/\beta}}{2e} \right) \right]$$

Let $g(\beta) = (\theta - \phi) s_1 / \beta$, where $g'(\beta) = -(\theta - \phi) s_1 / \beta^2 < 0$, from the property of (19), we can show that $\frac{\partial W\left(e^{g(\beta)} / 2e\right)}{\partial \beta} = g'(\beta) \frac{W\left(e^{g(\beta)} / 2e\right)}{1 + W\left(e^{g(\beta)} / 2e\right)} < 0$. Rewriting the above:

$$\frac{\partial \rho^*}{\partial \beta} = M(s_1)\left[-g(\beta)\frac{W\left(\frac{e^{g(\beta)}}{2e}\right)}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)} + W\left(\frac{e^{g(\beta)}}{2e}\right)\right]$$

Taking the second-order derivative with respect of β provides:

$$\frac{\partial^2 \rho^*}{\partial \beta^2} = M(s_1)\left\{\begin{array}{l} -g(\beta)\left[g'(\beta)\frac{W\left(\frac{e^{g(\beta)}}{2e}\right)}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)^2} - g'(\beta)\frac{W\left(\frac{e^{g(\beta)}}{2e}\right)}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)^2}\cdot\frac{W\left(\frac{e^{g(\beta)}}{2e}\right)}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)}\right] \\ -g'(\beta)\frac{W\left(\frac{e^{g(\beta)}}{2e}\right)}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)} + g'(\beta)\frac{W\left(\frac{e^{g(\beta)}}{2e}\right)}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)} \end{array}\right\}$$

$$\frac{\partial^2 \rho^*}{\partial \beta^2} = -M(s_1)\frac{g(\beta)g'(\beta)}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)^2}\cdot\left[W\left(\frac{e^{g(\beta)}}{2e}\right) - \frac{W\left(\frac{e^{g(\beta)}}{2e}\right)^2}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)}\right]$$

$$= -M(s_1)\frac{g(\beta)g'(\beta)\cdot\left[\frac{W\left(\frac{e^{g(\beta)}}{2e}\right) + W\left(\frac{e^{g(\beta)}}{2e}\right)^2 - W\left(\frac{e^{g(\beta)}}{2e}\right)^2}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)}\right]}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)^2}$$

$$= -M(s_1)\frac{g(\beta)g'(\beta)\cdot\left[\frac{W\left(\frac{e^{g(\beta)}}{2e}\right)}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)}\right]}{\left(1+W\left(\frac{e^{g(\beta)}}{2e}\right)\right)^2} > 0$$

Therefore, β_{ρ^*} is the unique point of consumer heterogeneity that makes the first-order condition equal to zero.

We next consider how the optimal futures price changes with respect to β. Taking the first- and second-order derivatives of (6) with respect to β provides:

$$\frac{\partial p_f^*}{\partial \beta} = 1 + W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right) + \beta \frac{\partial W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)}{\partial \beta} = 1 + K(\beta).$$

$$\frac{\partial p_f^*}{\partial \beta} = \frac{1}{M(s_1)}\frac{\partial \rho^*}{\partial \beta} + 1 \text{ and } \frac{\partial^2 p_f^*}{\partial \beta^2} = \frac{\partial^2 \rho^*}{\partial \beta^2} > 0.$$

Thus, the optimal futures price expression is also convex in β. Moreover, consider the first-order derivative at the point at $\beta_{\rho*}$: $\frac{\partial p_f^*}{\partial \beta}\Big|_{\beta=\beta_{\rho^*}} = \frac{1}{M(s_1)}\frac{\partial \rho^*}{\partial \beta}\Big|_{\beta=\beta_{\rho^*}} + 1 = 1 > 0$. Thus, we are already in the positive region of a convex function, which implies that the point that makes the first-order condition of the optimal price equal to zero is to the left of $\beta_{\rho*}$. Let us define the value of consumer heterogeneity that makes the first-order condition of (6) equal to zero by β_{pf}^*, then we have $\beta_{pf}^* < \beta_{\rho*}$. ❐

The Impact of Speculators

The model presented in (1)–(3) ignores the influence of speculators, and this section shows the consequence of incorporating speculators in the market on the optimal decisions. Speculators might have a different risk-adjusted discount rate, denoted θ_s, resulting in a threshold futures price, denoted p_s. When the winemaker's futures price p_f^* as expressed in (6) and (21) go below p_s, speculators would flood the market. Assuming the market size of speculators is larger than the amount of wine produced, the profit expression in (3) becomes:

$$\Pi(q_f) = q_f \max\{p_s, p_f(q_f)\} + \phi E[p_r(\tilde{s}_2 \mid s_1)](Q - q_f). \tag{22}$$

Proposition A1. *In the presence of speculators, when* $p_s > \left\{\phi s_1 + \beta\left[1 + W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)\right], \theta s_1 + \beta \ln\left[\frac{M(s_1) - Q}{2Q}\right]\right\}$ *, the optimal decisions and the expected profit are:* $q_f^* = Q$, $p_f^* = p_s$, *and* $\rho^* = p_sQ$.

Proof of Proposition A1. The proof follows from the fact that the objective function in (22) is increasing in q_f when $p_s > \left\{\phi s_1 + \beta\left[1 + W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)\right], \theta s_1 + \beta \ln\left[\frac{M(s_1) - Q}{2Q}\right]\right\}$. Note that $\frac{\partial \Pi(q_f)}{\partial q_f} = p_s - \phi s_1 > 0$ because of the condition $p_s > \phi s_1 + \beta\left[1 + W\left(\frac{e^{(\theta-\phi)s_1/\beta}}{2e}\right)\right] > \phi s_1$ (because $W(\cdot)$ is always positive). ❐

As Proposition A1 demonstrates, there are several consequences from incorporating speculators into the model. First, the winemaker has no incentive to reduce its futures price below what speculators are willing to pay (p_s). Second, when speculators enter the market ($p_s > p_f^*$ in (6) and (9)), the winemaker prefers to sell all of its wine in the form of futures, leading to the result $q_f^* = Q$. Thus, the winemaker leaves no inventory for retail sales. Third, the optimal expected profit becomes higher in the presence of speculators than in their absence in the regions of consumer heterogeneity that reduces the optimal futures price below the speculators price p_s.

Using the same data with Figure 6, Figure A1 shows the influence of speculators on the optimal futures quantity and price decisions and the optimal expected profit. Figure A1(a) is identical to the plots on the right in Figure 6 with the limited supply $Q = 4{,}165$ binding at lower values of consumer heterogeneity ($\beta \leq 2.75$). Figure A1(b) demonstrates how speculators' threshold price p_s puts a lower bound on the futures price decision when $p_s = 93$. Let us define the two threshold points where futures price p_f is equal to p_s as β_{ps1} and β_{ps2}; for the 2008 Cheval Blanc wine in Figure A1(b) $\beta_{ps1} = 0.75$ and $\beta_{ps2} = 6.25$. For consumer heterogeneity values in the range of $\beta_{ps1} \leq \beta \leq \beta_{ps2}$, the optimal futures price set to $p_f = p_s$ and the amount of wine allocated for futures is equal to Q, the expected profit is $\rho = p_s Q$, which is higher than the optimal profit that can be obtained in the absence of the speculators market.

The analysis in this section assumes that the number of speculators in the market is larger than the amount of wine produced by the winemaker. Similar observations can be made even if the size of the speculator market is smaller than the winemaker's production amount. When the optimal futures price goes below p_s, the winemaker prioritizes by serving the speculators first, and the remaining amount of wine is sold to the present consumers interested in wine futures. While the range of consumer heterogeneity values where speculators benefit the winemaker shrinks, the same price pressure is observed, leading to higher expected profits.

In sum, the winemaker can benefit from speculators with higher profitability at least at some levels of consumer heterogeneity.

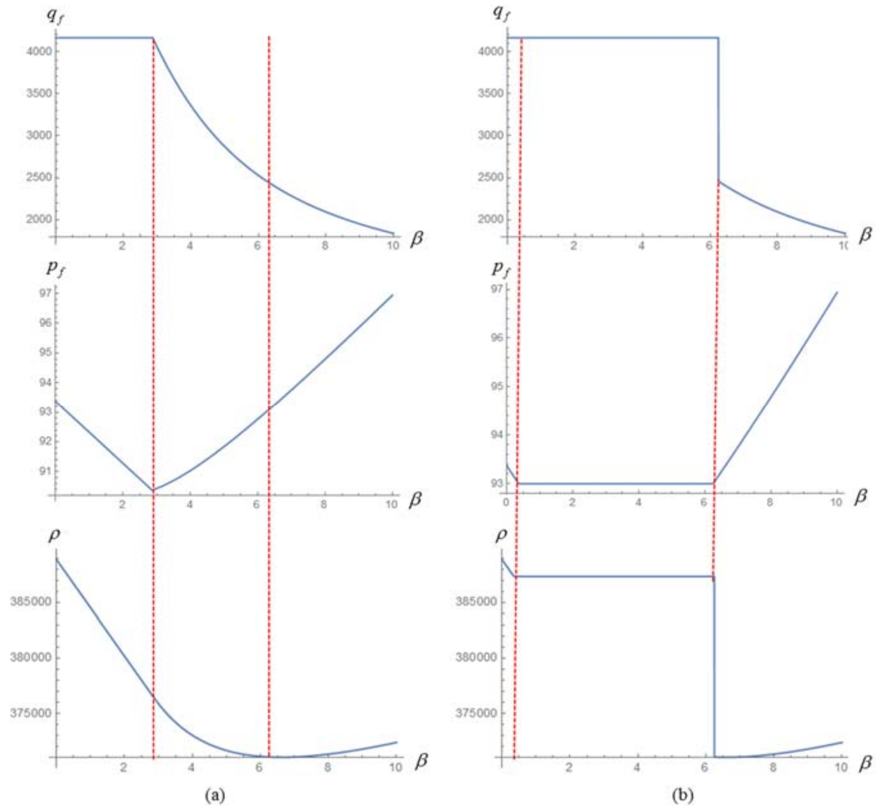

Figure A1. Impact of speculators for the 2008 Cheval Blanc vintage.