Risk management of the agricultural income: the inter-Rhône reserve

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Abstract

Purpose – Agricultural risks will tend to increase in the future, but risk management instruments and techniques at the disposal of wine companies are relatively limited. This paper aims to present an original risk protection mechanism implemented by the federation of Côte du Rhône (Inter-Rhône) wine producers to build up a wine stock, or "reserve", so as to protect their incomes against fluctuation in prices and production.

Design/methodology/approach – Using the VaR (value-at-risk) methodology, the stock level that will protect producers against a fall in their incomes is determined. More specifically, the probability that a given producer's current income falls lower than a target minimum income must be inferior or equal to a given (small) wine stock level. An agricultural income depends on price and production, so the reserve amount is expressed according to price and production quantity risk (measured by standard deviation), and the correlation between the two. The wine stock reserve is compared with a reserve invested in financial assets.

Findings – A static comparative analysis is made using simulations of the two types of reserves (wine stock and financial assets) according to the various explanatory variables. Empirical study makes it possible to calculate reserve amounts for each category of wine managed by Inter-Rhône. The study reveals a strong disparity in the amount of reserves of each wine.

Originality/value – The reserve system is considered by some to give to the producer federation the power to control supply below the equilibrium level in order to receive monopoly rents. To avoid this occurring the constitution of a mutual fund is recommended. This solution allows producers to profit from diversification gains and greater managerial flexibility.

Keywords Risk management, Wines, Viticulture, Income, France

Paper type Research paper

Introduction

According to an EC study conducted in 2001, agricultural risks in Europe will, in the foreseeable future, steadily increase. Production risks will grow because of an increase in quality requirements, environmental protection measures and climatic change. Price risk will also increase because of EU Agricultural Policy modifications, agricultural trade liberalization, and increased worldwide competition. However, the mechanisms of risk management currently at the disposal of European wine companies are relatively limited (European Commission (2001); Bacquet *et al.* (1997); Boehlje and Lins (1998)).

Derivative products (futures contracts, swaps, and options) on agricultural goods are still little developed in Europe. The lack of derivative products in the wine industry is primarily due to product differentiation, the low number of traders or potential speculators, and professionals' suspicion of these products which, they fear, destabilize the market by increasing the underlying volatility of prices and by competing with existing distribution channels.

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Contracts exist between producers and their customers (wine merchants and country stores) but are unstable because they generate conflicts over risk sharing and remuneration. The renewal of contracts, which are valid for three years, is opposed by producers should prices rise, and by producers should they fall. In general, producers think that the fixed prices are too low, and that insurance against price fluctuations is too expensive.

Diversification strategies are difficult to implement because they generate significant additional costs, notably investment in additional equipment and loss of economies of scale. Moreover, diversification requires an investment in technical and managerial expertise that is beyond the reach of the family companies that dominate the Rhône Valley wine industry.

Financial methods of risk management, such as positive bank accounts or unused debt capacity, not only carry traditional opportunity costs, but also are difficult to implement because of the highly capitalist-intensive nature of the wine industry and the predominantly small, family-based units of production. As investment and working capital immobilise significant capital resources, it is difficult for firms to raise funds from stockholders or banks and even more so to build up financial reserves. Moreover, stockage is an expensive strategy in the context of yield constraint. The building up of stock following an abundant harvest is made more difficult when authorized maximum yields exist.

Agricultural insurances are not developed because only seldom are the following insurability conditions taken into account when agricultural risks are calculated (Skees, 1997; Skees and Barnett, 1999):

- Low information asymmetries between insurer and policyholders.
- Independent or slightly correlated risks between the policyholders providing a good risk diversification to insurers (law of large numbers).

However in the agricultural industry, a significant part of risk comes from management rather than constituting an "Act of God". Information asymmetry is strong and has well-known consequences:

- Adverse selection derives from the difficulty the insurer experiences in classifying risks before the signature of contract. The insurer cannot separate good from bad risks, with the consequence that the insurance premium is too high for some and too low for others.
- Moral hazard occurs if the vine grower changes his behaviour following the signature of the insurance contract; for example, should he insure himself against frost damage but subsequently fail to protect his vines against frost.

Agricultural risks are often systemic over an extended geographical area and there exists a strong correlation between them.

In response to the lack of risk-management instruments in the wine industry, the inter-professional federation of Rhône Valley wine producers has proposed the creation of an original mechanism of collective stock management: the inter-professional reserve. The federation defines an annual yield ceiling for AOCs (Appellation d'Origine Contrôlée – Controlled Denomination of Origin, wines of an officially defined quality) and places the surplus in reserve. Releasing wine from the reserve can be done in two ways:

(1) Through an Inter-Rhône decision to sell wine quickly in order to regulate market activity.
(2) By an individual wine grower deciding to release some of his production early: should a wine grower experience a significant fall in production, he may seek authorization to market all or part of his reserve in order to attain the level of income he would derive from a normal harvest.

The Inter-Rhône reserve has several significant features:

(1) It generates a marginal storage cost which is relatively weak (the current reserve accounts for approximately 15 per cent of an average harvest) but which can increase abruptly if storage capacities require specific investments.
(2) The harvest percentage put in reserve is identical for all the producers whatever their individual risk characteristics (prices and production quantity risk), if, for example, the price risk of a given producer is above the average, the reserve amount calculated by Inter-Rhône is too low for him.
(3) The trigger income, which is used as reference, is related to a "normal harvest", but "normal harvest" criteria are not specified in a formal way. If the normal income is not precisely defined, you cannot tell precisely when you are below this income!

This paper proposes a model of the reserve mechanism so as to better understand the impact of explanatory variables on the reserve amount and advocates the adoption of a new "financial asset" reserve mechanism to improve the existing one. The paper is divided into four sections. In the first, we construct a model to explain the determinants of the reserve amount and the risk-reduction impact of the existing intervention mechanism. In the second, we analyse a new intervention mechanism in which wine is replaced by financial assets in the reserve. The third section is devoted to simulations that illustrate the impact of determinant variables on the reserve amount and in the last section we present the results of an empirical analysis of Côte du Rhône wines.

Analysis of the intervention mechanism

The value-at-risk (VaR) measure, which is considered to be a "state-of-the-arts" tool in risk measurement, is receiving considerable attention in banking, finance and, more recently, in agricultural economics (Boehlje and Lins, 1998; Manfredo and Leuthold, 1999). VaR predicts, with a reasonable degree of confidence, potential losses that may be encountered over a specified time period due to adverse movements of prices and/or quantities. Taking the VaR concept as a starting point, we assume that Inter-Rhône defines an annual minimum income to be protected, meaning that any real income must not fall below this minimum. Hence, at the beginning of a given year, Inter-Rhône will build up a reserve amount to a level at which the probability is low that the following year's income would fall below the defined minimum income.

The reserve mechanism can be schematized for the following scenarios:

- The annual agricultural income is higher than the minimum income, so no intervention is necessary.
- The annual agricultural income is lower than the minimum income, but the sale of the reserve allows the current income to reach or exceed the minimum income.
- The annual agricultural income is lower than the minimum income in spite of the sale of the reserve.

From a risk-management viewpoint, the third scenario is very significant because it indicates that, in spite of regulating authority intervention, a residual income risk remains. Thus a possibility remains that the effective agricultural income could fall below the desired minimum income. The reserve amount must be such as to maintain residual income risk below a specified limit.

The regulating authority must decide between:

- a significant reserve which because of storage costs is expensive but which minimizes income risk; and
- a lower reserve which offers imperfect protection of agricultural income.

The intervention mechanism therefore requires the determination of two parameters: a minimum guaranteed income and a critical level of probability, namely the probability that the effective income will be lower than the minimum income. These parameters depend on the risk aversion of producers.

Reserve objective

Once these two parameters are fixed, the problem to be solved is the following: What quantities have to be put in reserve so that the effective agricultural income is lower than the minimum income for the stated probability?

We must find the volume of the reserve, q_R, such as:

$$\text{prob}\left(\tilde{p}\tilde{q} + q_R\tilde{p} < RA_{\text{Min}}\right) = \alpha \tag{1}$$

where:

$\tilde{p}$: random selling price of the next harvest;
$\tilde{q}$: sold quantities of the next harvest – these are unknown because of yield and demand uncertainty;
q_R: quantities in reserves;
α: critical probability fixed by the regulating authority; and
RA_{Min}: minimum agricultural income fixed by the regulating authority.

As stated above, the protection level depends on two parameters:

(1) Minimum income; a high minimum income means high-income protection,

(2) Probability level: a low probability level means good protection.

This model assumes that the sale of the reserve (or a part of it) does not influence price. For example, a bad harvest will decrease supply so that additional supply will have little effect on prices.

Reserve level calculation

We will start by breaking up the objective function according to the statistical parameters of price and quantity time series. The wine quantities to be put in reserve depend on:

- Price and quantity expectations,
- Price and quantity standard deviation,
- Correlation between price and quantity.

The objective function can be written in differential form in the following way:

$$\text{prob}\left(d\left(\tilde{p}\tilde{q} + q_R\tilde{p}\right) < RA_{Min} - (q_0 + q_R)p_0\right) = \alpha \tag{2}$$

The probability that future income drops below the deviation between the target income and the present income is equal to α.

Let us differentiate the agricultural income within equation (2):

$$\frac{d\left(\tilde{p}\tilde{q} + q_R\tilde{p}\right)}{p_0 q_0} = \frac{d\tilde{q}}{q_0} + \frac{d\tilde{p}}{p_0} + \frac{q_R}{q_0}\frac{d\tilde{p}}{p_0} = \frac{d\tilde{q}}{q_0} + \frac{d\tilde{p}}{p_0}\left(1 + \frac{q_R}{q}\right)$$
$$\tilde{R}_A = \tilde{R}_q + \tilde{R}_p(1 + \pi) \tag{3}$$

where:

π: quantities put in reserves expressed as a proportion of current production – this does not necessarily mean a share of the current production put in reserve because part of the reserve can come from preceding harvests;
$\tilde{R}_A$: relative variation of the agricultural income;
$\tilde{R}_q$: relative variation of quantities; and
$\tilde{R}_p$: relative variation of prices.

Objective function become:

$$\text{prob}\left(\tilde{R}_A < R_{\text{Min}} - \pi\right) = \alpha \tag{4}$$

$$R_{\text{Min}} = \frac{RA_{\text{Min}} - q_0 p_0}{q_0 p_0}$$

This equation means that, if the minimum income is fixed at 90 per cent of the current income ($R_{\text{Min}} = -10$ per cent), the amount of the reserve must be such that a fall of income higher than 10 per cent occurs in only α per cent of cases.

If linear approximation of agricultural income follows a normal distribution, then equation (4) becomes:

$$\pi = R_{Min} - \left[z_\alpha \sigma\left(\tilde{R}_A\right) + E\left(\tilde{R}_A\right)\right] \tag{5}$$

z_α: quantile of the standard normal distribution (for the probability α:

$$z_\alpha = F^{-1}(\alpha)$$

where:

$E(.)$: expectation operator; and
$\sigma(.)$: standard deviation operator.

It is now necessary to express the first two moments of $\tilde{R}_A$ according to π using equation (3) and expectation and variance properties:

$$E\left(\tilde{R}_A\right) = E\left(\tilde{R}_q\right) + (1 + \pi)E\left(\tilde{R}_p\right) \tag{6}$$

$$\sigma(\tilde{R}_A) = \left[\sigma^2(\tilde{R}_q) + (1+\pi)^2\sigma^2(\tilde{R}_p) + 2(1+\pi)r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p)\right]^{1/2} \quad (7)$$

where:

$Cov(.,.)$: covariance between prices and quantities; and
r: correlation coefficient between prices and quantities.

By replacing the expectation and the variance of agricultural income in equation (5) by their expression given in equations (6) and (7), we obtain:

$$\begin{aligned} R_{\text{Min}} - \pi = z_\alpha\left[\sigma^2(\tilde{R}_q) + (1+\pi)^2\sigma^2(\tilde{R}_p) + 2(1+\pi)r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p)\right]^{1/2} \\ + E(\tilde{R}_q) + (1+\pi)E(\tilde{R}_p)R^C_{\text{Min}} = z_\alpha\left[\sigma^2(\tilde{R}_q) + (1+\pi)^2\sigma^2(\tilde{R}_p)\right. \\ \left. + 2(1+\pi)r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p)\right]^{1/2} + (1+E(\tilde{R}_p))\pi \end{aligned} \quad (8)$$

$$R^C_{\text{Min}} = R_{\text{Min}} - E(\tilde{R}_q) - E(\tilde{R}_p)$$

Is the target minimum income corrected from the trends of prices and quantities.

A general solution of equation (8), if (Δ) is strictly positive, is ([1]):

$$\pi = \frac{-B \pm \sqrt{\Delta}}{A} \quad (9)$$

$$\begin{aligned} A &= z_\alpha\sigma^2(\tilde{R}_p) - \left(E(\tilde{R}_p)+1\right)^2 \\ B &= z_\alpha\left(\sigma^2(\tilde{R}_p) + r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p)\right) + R^C_{\text{Min}}\left(E(\tilde{R}_p)+1\right) \\ \Delta &= \left\{z_\alpha\left(\sigma^2(\tilde{R}_p) + r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p)\right) + R^C_{\text{Min}}\left(E(\tilde{R}_p)+1\right)\right\}^2 \\ &\quad - \left\{z_\alpha\sigma^2(\tilde{R}_p) - \left(E(\tilde{R}_p)+1\right)^2\right\}\left\{z_\alpha V\left(\tilde{R}^N_A\right) - \left(R^C_{\text{Min}}\right)^2\right\} \end{aligned}$$

This solution is rather complicated to interpret. To facilitate interpretation, we propose to carry out a sensibility analysis using simulations.

A necessary condition for intervention

It is clear that the reserve is necessary only if the agricultural income falls below the stated minimum income with a probability higher than the fixed threshold. The income variation, which renders a reserve unnecessary, is given by the formula:

$$R^N_{\text{Min}} = z_\alpha\left[\sigma^2(\tilde{R}_q) + \sigma^2(\tilde{R}_p) + 2r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p)\right]^{1/2} + E(\tilde{R}_q) + E(\tilde{R}_p) \quad (10)$$

If $R_{\text{Min}} < R^N_{\text{Min}}$, a reserve is unnecessary since the natural growth of the agricultural income already respects the condition fixed by a regulating authority. In short, risk management is necessary if:

$$
\begin{aligned}
R_{\text{Min}} &\geq z_\alpha \left[\sigma^2(\tilde{R}_q) + \sigma^2(\tilde{R}_p) + 2r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p) \right]^{1/2} + E(\tilde{R}_q) + E(\tilde{R}_p) \\
R_{\text{Min}} &\geq z_\alpha \sigma\left(\tilde{R}_A^N\right) + E\left(\tilde{R}_A^N\right)
\end{aligned} \tag{11}
$$

The tolerated relative fall of income must be lower than its natural fall or, more precisely, the fixed minimum income must be higher than the minimum income reached by natural growth in prices and quantities.

Financial reserve

Instead of a wine stock, a reserve of financial assets could be constituted, which we will call financial reserve. The wine in reserve is sold and the proceeds invested in financial assets. This mode of income risk management has several advantages:

- It removes the money value uncertainty of the intervention.
- It eliminates the storage cost of wine and the risk related to its detention.
- The amount put in reserve is invested, thus reducing the opportunity cost of detention.
- It is of much greater flexibility.
- It makes it possible to benefit from diversification gains.

We will calculate first give the new reserve in terms of cash, and subsequently the associated diversification effect.

Financial reserve amount

The constitution of a financial reserve doesn't influence the generation of agricultural income. The objective function is slightly modified (see Appendix).

The problem is to find the cash amount M such as:

$$
\text{prob}\left(\tilde{p}\tilde{q} + M < RA_{\text{Min}}\right) = \alpha \tag{12}
$$

By carrying out the same analysis as in the first section:

$$
\text{prob}\left(\tilde{R}_A < R_{\text{Min}} - m\right) = \alpha
$$

$$
m = \frac{M}{RA_0}
$$

Reserve amount expressed as a percentage of the current income.

The reserve to be constituted is given by the following equation:

$$
\begin{aligned}
m &= R_{\text{Min}} - E(\tilde{R}_q) - E(\tilde{R}_p) - z_\alpha \left[\sigma^2(\tilde{R}_q) + \sigma^2(\tilde{R}_p) + 2r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p) \right]^{1/2} \\
m &= R_{\text{Min}} - R_{\text{Min}}^N
\end{aligned} \tag{13}
$$

The amount put in reserve is exactly equal to the anticipated loss of income (cf. equation (10)). If the target income is fixed at 90 per cent of the current income, and if there is a 5 per cent probability that the agricultural income falls below 85 per cent of the current income, it is necessary to lay out a reserve equal to 5 per cent of the current income.

The main technical difference between the two reserve forms is that for the financial reserve the amount of money available is known from the beginning whereas for the wine reserve, price uncertainty remains until the reserve is sold.

Diversification effects

Because of product differentiation, the wine reserve does not allow for income transfer between the producers so it is difficult to compensate for a fall in "wine A" producers' income by selling a "wine B" stock. Even between "wine A" producers, compensation is difficult because of the differences between individual producers in terms of quality, variety, and reputation. A financial reserve does not pose this kind of problem. Sales of financial assets can help every producer (or groups of producers). The reserve can therefore be calculated to cover the income risk of Rhône Valley producers as a whole. A single reserve makes it possible to capture diversification gains since income correlation between producers is not perfect. The total reserve will thus be lower than the sum of the individual reserves.

The income growth rate of Rhône Valley producers as a whole is equal to the sum of individual producer growth rates weighted by their relative incomes.

That is to say:

$$\tilde{R}_{AVR} = \sum_{i=1}^{n} x_i \tilde{R}_{Ai} \tag{14}$$

where:

CA_i: turnover of producer i;
CA_{VR}: turnover of all Rhône valley producers of the Rhône; and
$\tilde{R}_{Ai}$: turnover for producer i.

From equations (12) and (14), we can write the objective function for Rhône Valley producers as a whole:

$$\mathrm{prob}\left(\tilde{R}_{AVR} < R_{Min} - m_{VR}\right) = \alpha \tag{15}$$

And, with the normality assumption (15) becomes:

$$m_{VR} = R_{\mathrm{Min}} - E\left(\tilde{R}_{AVR}\right) - z_\alpha \sigma\left(\tilde{R}_{AVR}\right) \tag{16}$$

Using expectation and variance properties we can write:

$$m_{VR} = R_{\mathrm{Min}} - X^T \bar{R} - z_\alpha \left(X^T \Omega X\right)^{1/2} \tag{17}$$

where:

$\bar{R}$: expectations vector;
Ω: matrix of variances covariances between incomes;
X: vector of weightings x_i,
T: transposition operator.

From equation (13), the sum of individual reserves is:

$$\sum_{i=1}^{n} m_i = R_{\text{Min}} - X^T\bar{R} - z_\alpha X^T\bar{S} \tag{18}$$

where:

$\bar{S}$: standard deviation vector of income returns.

The diversification gain is measured by the difference between the sum of individual reserves (equation (18)) and total reserve (equation (17)):

$$\sum_{i=1}^{n} m_i - m_{VR} = -z_\alpha\left(X^T\bar{S} - \left(X^T\Omega X\right)^{1/2}\right) \tag{19}$$

$$\left(X^T\bar{S} - \left(X^T\Omega X\right)^{1/2}\right)$$

Measures the diversification gain, which is positive.

The quantile of the normal distribution is negative, but the right-hand term in the equation (19) is positive. The sum of the individual reserves is thus higher than the total reserve. Diversification gains can be realised by the creation of a mutual fund for members. This fund can be seen as a specific insurance mechanism. If one member sustains a loss, he will be completely or partially compensated from the fund. The premiums paid must also cover administrative costs and reinsurance. Producers are likely to be attracted by the idea of a regional fund because they know and trust one another and can exert a mutual control so as to reduce the consequences of information asymmetries between fund manager and producers. On the other hand, the diversification gain is weaker for regional than for national or international funds. With a regional fund, a risk exists that losses might exceed the value of the fund. A mechanism of reinsurance thus appears necessary. In The Netherlands this type of fund exists in the horticulture, potato and poultry industries while the European Commission has also encouraged the creation of mutual fund to stabilize incomes in the hog industry (European Commission, 2000, 2001).

Simulations

Using simulations, we carry out a sensitivity analysis of reserve amounts for each variable.

The reference scenario is as follows:

$$E(\tilde{R}_p) = 1\% E(\tilde{R}_q) = 0 \sigma(\tilde{R}_p) = 5\% \sigma(\tilde{R}_q) = 10\% r = -0,6$$

$$R_{\text{Min}} = 0 \alpha = 5\%$$

We propose a positive trend in prices, but stable quantities because yields must be under a prescribed level to obtain the AOC label. We suppose that, as is common in the agricultural sector, the quantity risk (10 per cent) is higher than the price risk (5 per cent). According to the law of supply and demand, the correlation between price and quantity is negative. The protected income is the current income, which means a high level of protection. The reserve must be such that the probability of falling below the minimum income is 5 per cent ($\alpha = 5$ percent).

Figures 1-5 give the reserve amount in wine or in financial assets according to the various variables of the model. All of the graphs are organized in the same way:

- The reserves, in wine or in financial assets (cash), expressed in percentages (as in equations (11) and (13)), are on the vertical axis.
- The different explanatory variables are on the vertical axis.

Whatever the reserve form, wine stock or financial asset, the development of reserve amounts are quite similar.

The reserve decreases when prices and quantities increase, and it then becomes easier to hit the target income (Figure 3).

The reserve decreases in a nonlinear way with the probability of falling below the minimum income (Figure 4): the more cover is required against the income risk, the greater the reserve amount must be. When the reserve is about 9 per cent of the current production, there exists a 10 per cent probability of falling below the minimum income but when it constitutes 18 per cent of the current production that probability falls to 1 per cent.

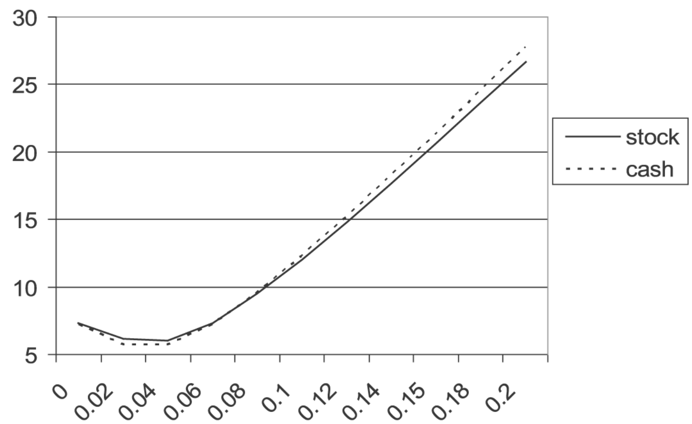

Figure 1.
Quantities standard deviation

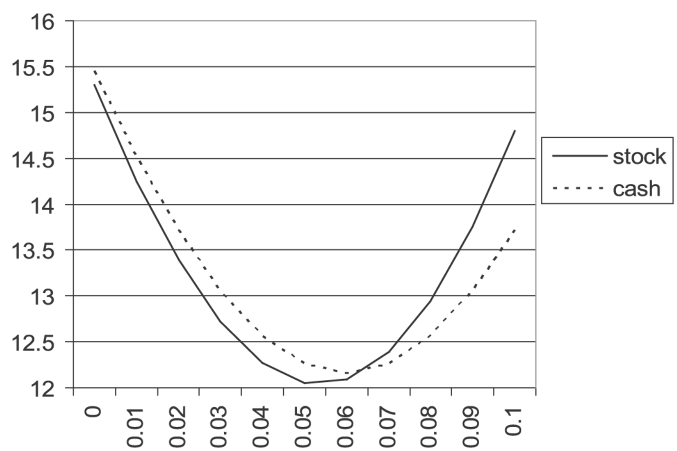

Figure 2.
Prices standard deviation

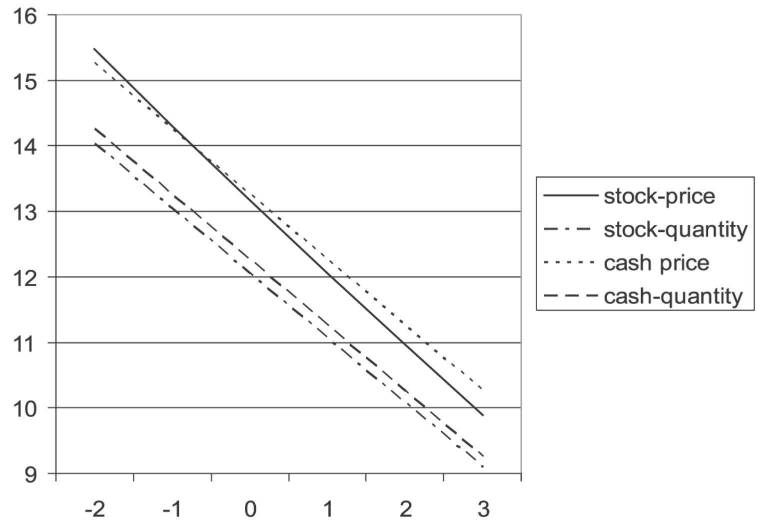

Figure 3.
Prices and quantities expectation

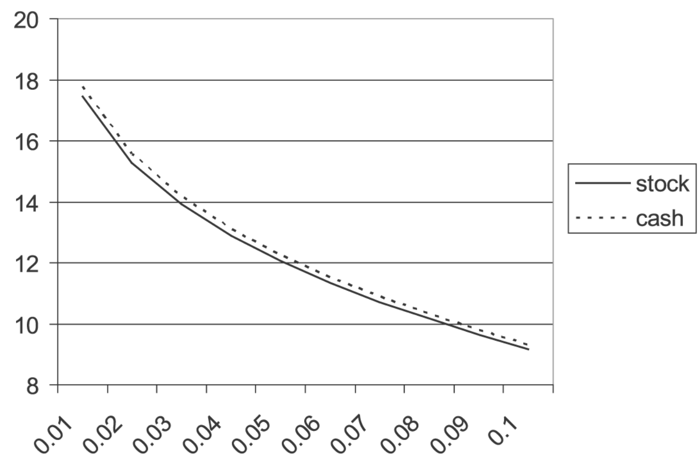

Figure 4.
Probability level

The reserve increases with the degree of correlation between prices and quantities (Figure 5) because when the correlation increases, compensation between price risk and quantity risk decreases so that income risk increases and a bigger reserve amount is needed. If the correlation is high, low prices are associated with low quantities so that the income is very low and the producer needs a big reserve. However, if the correlation is negative, low prices are compensated for by high quantities and the producer does not need an important reserve to protect his income.

We would expect that the reserve amount should increase as the price or quantity risk increases. However, there are some exceptions (Figures 1 and 2): when the initial risk is low, the reserve amount decreases while the gap between price and quantity

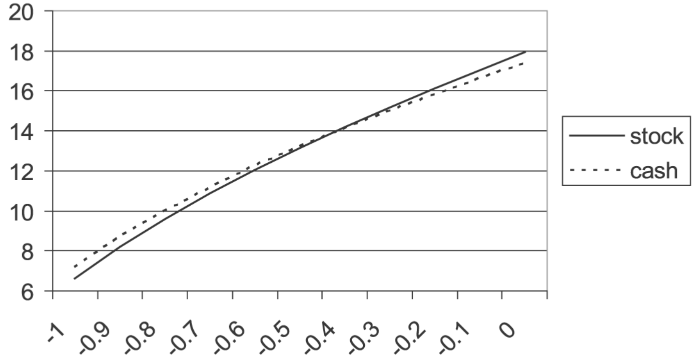

Figure 5.
Correlation coeffient

volatility decreases. This is because the natural coverage effect is greater when the volatility of prices and quantities is of the same order of magnitude.

The main difference between the two forms of the reserve comes from their sensitivity to the price trend (Figure 3). The reserve in wine stock is lower than the reserve in cash when the price growth rate is strong but greater when the price growth is negative. This is not a surprising result because the wine stock is sensitive to wine price, whereas cash is not.

The stock of wine increases income sensitivity to price volatility (Figure 2). This could be an advantage when the price volatility is lower than quantity volatility. In such a case, the stock of wine reduces the volatility gap between price and quantity; it is thus a more effective means of income protection than the financial reserve. On the other hand, when the price volatility is higher than quantity volatility, the financial reserve is preferable.

Lastly, when the correlation is strongly negative, the wine stock contributes to the compensation between price and quantity risks, and it is thus preferable to the financial reserve. As the correlation increases, the compensation effect decreases, and consequently the financial reserve is preferable.

An empirical study

The sample comprises price and quantity time series of 24 Rhône Valley wines over the period 1992-2002. Price and quantity are related in the following way: the prices for N correspond to quantities of the *N*-1 vintage sold in *N*. Annual price averages are calculated by Inter-Rhône. Table I presents the statistical characteristics of the price and quantity variation of each wine. The importance of the various wines contrasts greatly; red regional CDRs represent about two thirds of Rhône Valley wine sales, with seven wines that each represent less than 1 per cent of the sales. The average coefficient of variation of quantities (11.38) is higher than the average coefficient of prices (9.64).

The minimum income and the critical probability value are respectively fixed at 0 and 5 per cent to facilitate comparisons with the simulations. In Table II we present the calculation of reserve amounts (as a percentage), in wine (fourth column) and in financial assets (fifth column).

Risk is measured by the probability of falling below the minimum income without intervention. Thus the income of the red regional CDRs will fall below the minimum income targets in more than 40 per cent of cases.

Table I.
Distribution characteristics of prices and quantities

Wines	Percent of total	Quantity Mean	Quantity Standard deviation	Quantity CV (*)	Price Mean	Price Standard deviation	Price CV
CDR Régional Rouge	64.43	−0.0005	0.0966	6.91	0.0328	0.0750	9.46
CDR Régional Rouge Domaine	6.11	0.0125	0.1188	9.61	0.0325	0.0813	9.49
CDR Régional Rouge Château	2.71	0.0256	0.0959	13.04	0.0298	0.0617	8.66
CDR Régional Blanc	1.34	−0.0018	0.1192	10.23	0.0211	0.0515	7.33
CDR Régional Rosé	1.62	−0.0050	0.1835	13.70	0.0293	0.0680	8.42
CDR Village Rouge Communal	2.54	0.1345	0.4019	26.02	0.04	0.0322	11.33
CDR Village Blanc Communal	0.01	−0.0628	0.8306	50.80	0.0473	0.0610	12.96
CDR Village Rouge	6.74	0.099	0.1594	26.18	0.0189	0.0478	6.02
CDR Village Blanc	0.00	−0.1214	1.4246	112.79	0.0120	0.1575	13.39
Cote Rotie	1.31	0.0493	0.3494	27.13	0.0559	0.1480	21.20
Lirac Rouge	0.35	0.1855	0.5207	71.45	0.0326	0.0441	11.36
Lirac Rosé	0.00	−0.3072	0.9793	56.94	0.0416	0.0503	12.89
St Joseph Rouge	0.81	0.0815	0.5217	50.73	0.0625	0.1409	27.82
St Joseph Blanc	0.04	0.0857	0.6797	55.68	0.0434	0.1346	20.70
Vaqueyras Rouge	0.80	0.0582	0.2469	33.09	0.0687	0.1276	26.78
Ventoux Rouge	5.52	0.0509	0.1772	15.29	0.0379	0.0375	9.43
Ventoux Rosé	0.86	0.0408	0.1776	16.81	0.0355	0.0611	10.59
Ventoux Blanc	0.09	0.0298	0.5279	43.71	0.0235	0.0260	6.64
Tricastin Rouge	2.14	0.0304	0.2022	13.20	0.0247	0.0780	8.03
Tricastin Rosé	0.24	0.0858	0.4041	38.79	0.0279	0.0418	7.86
Tricastin Blanc	0.07	0.0594	0.6705	42.98	0.0348	0.0351	11.46
Costière de Nîmes Rouge	1.60	0.0283	0.1733	15.03	0.0290	0.0380	10.57
Costières de Nîmes Rosé	0.98	0.0786	0.2448	25.77	0.0166	0.0459	7.68
Costière de Nîmes Blanc	0.04	−0.0124	0.3833	40.02	0.0158	0.0862	7.91

Notes: (*)CV (coefficient of variation); CV = (standard deviation/mean)*100; CV are calculated on the absolute values and not on returns

The average reserve, whatever its nature (wine stock or financial assets) is about a quarter of current production. This high level can be explained by the high minimum income chosen (0 per cent corresponding to current income). We note significant differences in reserve levels between the various wines. It thus does not seem relevant to require an identical reserve level for all wine growers. Some will be penalized, by having too much wine in stock while others will continue to undergo a considerable income risk.

In accordance with our simulations analysis, the gap between the wine stock and the financial reserve widens as the correlation between price and quantity increases. High correlation coefficients indicate that the financial reserve is greatly preferable to the wine stock. We calculate the matrix of variances covariances between wines incomes. Then, starting from equation (17), we calculate the financial reserve so that the total Rhône Valley winemakers' income has a 5 per cent probability of being higher than the target minimum income. Diversification gains are significant; the total reserve is only 14.85 per cent of the current income compared with 23.47 per cent for the average financial reserve. Creation of a mutual fund seems to be a more effective income protection instrument than the Inter-Rhône reserve mechanism. It is thus likely to generate substantial savings in storage costs (compared to wine stock) and opportunity costs.

Wines	R(P,Q)	Risk	Wine (%)	Financial assets (%)
CDR Régional Rouge	0.1889	40.41	19.78	18.65
CDR Régional Rouge Domaine	0.7658	40.49	28.83	26.24
CDR Régional Rouge Château	0.0087	31.41	1.42	1.38
CDR Régional Blanc	−0.6462	41.92	4.81	5.02
CDR Régional Rosé	0.5412	45.75	25.96	24.53
CDR Village Rouge Communal	0.2166	33.52	60.69	62.12
CDR Village Blanc Communal	0.4717	50.72	137.09	135.89
CDR Village Rouge	−0.4328	20.86	23.26	23.89
CDR Village Blanc	0.7529	52.62	317.34	254.42
Cote Rotie	−0.1056	38.65	62.75	60.00
Lirac Rouge	0.0659	33.90	84.80	86.44
Lirac Rosé	−0.5470	60.98	144.91	156.70
St Joseph Rouge	−0.3248	38.54	77.40	81.30
St Joseph Blanc	−0.4285	41.93	96.91	104.25
Vaqueyras Rouge	0.5782	35.33	62.12	55.47
Ventoux Rouge	0.4796	32.68	32.61	32.56
Ventoux Rosé	0.7483	36.83	39.37	37.34
Ventoux Blanc	0.3537	46.05	87.93	88.44
Tricastin Rouge	−0.0967	39.31	33.09	33.44
Tricastin Rosé	0.0685	39.05	66.36	67.29
Tricastin Blanc	0.3331	44.51	111.06	112.35
Costière de Nîmes Rouge	−0.3963	36.16	25.66	26.66
Costières de Nîmes Rosé	0.2947	35.82	43.97	43.10
Costière de Nîmes Blanc	−0.2160	49.64	61.28	61.56
Mean			24.35%	23.47%
Weighted standard deviation			12.75%	13%

Table II. Financial reserve and wine stock

Conclusion

The Inter-Rhône reserve is a unique mechanism of agricultural income risk management. However, it could be improved in several ways. Because of the diversity of risk, it seems preferable to calculate a specific amount of reserve for each producer or at least for each category of wine. This being the case, it is difficult to understand how producers could gain by relinquishing control over their inventories to a third party (Inter-Rhône), unless the third party has the power to control supply below the equilibrium level in order to receive monopoly rents. Because of strong product differentiation, collective management of the reserve in the form of a wine stock does not permit wine producers to profit from diversification gains (coverage of one wine by another is difficult). By contrast, constitution of a mutual fund invested in financial assets would avoid suspicion of anti-competitive practices, make it possible to significantly decrease the amount needed to protect against the income risk, and simultaneously offer the possibility of more flexible instruments of management. This solution appears to suit a collective management of risks because the producers' federation obtains results, which could not be obtained by each producer individually.

However collective risk management has a major drawback; it can generate changes in firm strategies. Firms can take individual decisions to compensate for the measures adopted by Inter-Rhône. They can, for example, reorganize their activities so as to preserve the same risk exposure: should they lower their own stock, they would increase operational and financial risks by increasing fixed costs or financial leverage.

On the other hand, through reducing information asymmetries between the firm and its partners, collective risk income management could financially benefit the wine producer. The banker is more inclined to grant a loan if he knows that a part of the wine stock can be sold only with the federation of producers' agreement. The asset substitution risk is thus lower.

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Appendix. Solution of equation (7)

Equation (7) becomes:

$$z_\alpha\left[(1+\pi)^2\sigma^2(\tilde{R}_p)+2(1+\pi)r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p)+\sigma^2(\tilde{R}_q)\right]=\left(R^C_{\mathrm{Min}}-\pi(E(\tilde{R}_p)+1)\right)^2$$

$$R^C_{\mathrm{Min}}=R_{\mathrm{Min}}-E(\tilde{R}_p)-E(\tilde{R}_q)$$

Agricultural income growth corrected of the trend.

$$\begin{aligned}&\pi^2\left\{z_\alpha\sigma^2(\tilde{R}_p)-(E(\tilde{R}_p)+1)^2\right\}\\&+2\pi\left\{z_\alpha(\sigma^2(\tilde{R}_p)+r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p))+R^C_{\mathrm{Min}}(E(\tilde{R}_p)+1)\right\}\\&+z_\alpha V\left(\tilde{R}^N_A\right)-\left(R^C_{\mathrm{Min}}\right)^2=0\\&V\left(\tilde{R}^N_A\right)=\sigma^2(\tilde{R}_p)+\sigma^2(\tilde{R}_q)+2r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p)\end{aligned}$$

Variance of natural return of agricultural income.

$$\begin{aligned}\Delta=&\left\{z_\alpha(\sigma^2(\tilde{R}_p)+r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p))+R^C_{\mathrm{Min}}(E(\tilde{R}_p)+1)\right\}^2\\&-\left\{z_\alpha\sigma^2(\tilde{R}_p)-(E(\tilde{R}_p)+1)^2\right\}\left\{z_\alpha V\left(\tilde{R}^N_A\right)-\left(R^C_{\mathrm{Min}}\right)^2\right\}\end{aligned}$$

$$\Delta = z_\alpha \Big\{ z_\alpha \big(\sigma^2(\tilde{R}_p)\sigma^2(\tilde{R}_q)(r^2-1) \big) + R^C_{\mathrm{Min}}\sigma(\tilde{R}_p) \Big[2(E(\tilde{R}_p)+1)\sigma(\tilde{R}_p) + R^C_{\mathrm{Min}}\sigma(\tilde{R}_p) + 2(E(\tilde{R}_p)+1)\sigma(\tilde{R}_q)r \Big] + (E(\tilde{R}_p)+1)^2 V\big(\tilde{R}^N_A\big) \Big\}$$

If $\Delta > 0$, solutions are:

$$\pi = \frac{-B \pm \sqrt{\Delta}}{A}$$

$$A = z_\alpha \sigma^2(\tilde{R}_p) - (E(\tilde{R}_p)+1)^2$$

$$B = z_\alpha \big(\sigma^2(\tilde{R}_p) + r\sigma(\tilde{R}_q)\sigma(\tilde{R}_p) \big) + R^C_{\mathrm{Min}}(E(\tilde{R}_p)+1)$$