Contracting in the wine supply chain with bilateral moral hazard, residual claimancy and multi-tasking

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Abstract
This paper takes a quasi-case-study approach to stylised wine industry facts to assess predictions about the optimal sharing rule from a principal–agent model with residual claimancy. An optimal sharing contract is developed between a grape grower and a winery, when a risk-averse grower allocates efforts among multiple activities that differ in measurability, while double-sided moral hazard is assumed to be present. Several comparative static results regarding the Pareto optimal share are in line with certain production practices and properties of observed contracts that are found in markets where residual claimancy is used, namely in Australia, California, New Zealand and France.

Keywords: incentive contract, residual claimancy, wine, double-sided moral hazard, multi-tasking, supply chain

JEL classification: L22, M31, D23

1. Introduction
The choice of appropriate performance indicators aligning an agent’s actions with a principal’s objectives is one of the central problems that organisations face in implementing effective incentive contracts, particularly when agents perform multiple tasks (Holmstrom and Milgrom, 1991). In such an environment of multi-tasking, issues of internal organisational design of the firm may arise due to effort substitution, in particular when tasks differ in performance measurability (e.g. Holmstrom and Milgrom, 1991; Slade, 1996). Considering agricultural production, producers frequently need to allocate their efforts across a variety of tasks that differ in the measurability of their impact on the final good’s quality. When measurability differs between multiple tasks...
so that the resulting measurement bias can lead to distortions of efforts, the theoretical multi-tasking literature has established that the optimal contract offers weaker overall incentives (e.g. Holmström and Milgrom, 1991, 1994). Ackerberg and Botticini (2002) econometrically explore the role of multi-tasking in the context of the wine industry, and thereby add empirical evidence that multi-tasking can be an important factor in contract choice.

This paper expands the analysis of multi-tasking to a subset of contracts in the wine industry in order to shed further light on organisational design issues when bilateral moral hazard is present and residual claimancy is employed. Similar to the approach of Hennessy and Lawrence (1999) and Hueth and Melkonyan (2002, 2004), the paper takes a quasi-case-study approach to analyse contract specifications and their relationship with performance measurement and control in the wine industry. Stylised facts are employed from previous industry studies to explore the applicability of model predictions to a subset of firms in the wine industry. By exploring the extent to which this paper’s theoretical framework fits these stylised facts from previous wine industry studies, and by extending previous theoretical predictions beyond a risk-neutral and single-task setting, this paper makes both an empirical and a theoretical contribution.

The paper develops a sharing incentive contract, where residual claimancy is used through bottle-price indexing to align principal and agent, and where both agent (grape grower) and principal (winery) are assumed to perform multiple tasks. It is assumed that a grape grower contributes to final wine quality in terms of production efforts, and that the winery contributes in terms of processing and marketing efforts. Since it is further assumed that efforts are mutually imperfectly observed and their impact on final bottle quality can only be imperfectly measured, opportunism and monitoring are modelled on both sides.

While opportunism of grape growers could be associated with their input applications, opportunism of wineries could be associated with marketing grapes when marketing effectiveness cannot be fully observed by a grape grower or it could relate to grape quality assessment efforts incurred by the winery. As Fraser (2003) suggests, wineries have incentives to underestimate grape quality, since it lowers the price they have to pay to supplying growers. Given these information problems, the model accounts for monitoring and residual claimancy. There are further theoretical and empirical reasons to account for monitoring, starting with the observation that the relationship between monitoring and residual claims is linked to the very rationale for the existence and organisation of the classical firm (Alchian and Demsetz, 1972). Further, Holmström’s (1979) sufficient statistic result implies that outcome conditioning (e.g. via bottle price indexing) is not to be used in isolation, but in combination with input monitoring, as long as monitoring is informative.

We observe that the amount of monitoring of grape growers and the intensity of incentives are jointly chosen in actual grape supply contracts (Boyd et al., 2000; Fraser, 2005). This observation is also supported by theory as
setting intense incentives and carefully measuring performance can be Edgeworth complements (Milgrom and Roberts, 1995).

Further, monitoring can be rationalised in cases where there is scope for free-riding due to commingling (Holmström, 1982), for example when a single grape grower supplies multiple grape varieties, or when multiple growers supply their grapes to a single winery. Considering the nature of a bottle-price indexed contract, monitoring could also be rationalised because both parties may be reluctant to condition the sharing rule too heavily on the market valuation of the final bottle, since market risk and other exogenous factors make it desirable to construct a performance measure that is more closely tied to both the individual grower’s and winery’s contributions.

2. Literature

Several aspects differentiate the model in this paper from previous models and analyses of double-moral hazard and multi-tasking. As in Holmström and Milgrom (1991), the desirability of providing incentives for any one activity decreases with the difficulty of measuring performance in any other activity that makes competing demands on an agent’s effort. But whereas Holmström and Milgrom (1991) allow for a risk-averse agent in the presence of hidden action of agents only, this paper considers double-sided moral hazard and introduces a sharing contract to provide joint incentives through partial residual claimancy. The two latter assumptions are also explored in Bhattacharyya and Lafontaine (1995) and Brickley (2002). However, Bhattacharyya and Lafontaine (1995) explore the nature of share contracts in franchising under risk neutrality in the absence of multi-tasking and input monitoring. Although Brickley (2002) allows for risk-averse agents, the paper considers neither multi-tasking nor monitoring. The model in this paper includes input conditioning through effort monitoring and assumes multi-tasking and a risk-averse agent. Finally, and in contrast to the above-mentioned papers, the model specification also permits an analysis of strict sharing in double-moral hazard settings when agents are risk-averse.

There are several multi-tasking studies with empirical applications outside of the wine sector to which this paper is related to, including the analysis of Slade (1996) on gasoline-service stations, and Hueth and Melkonyan’s (2004) quasi-case-study approach to identity preservation issues in a multi-tasking model where agents perform one inside and one outside activity, in the context of the sugar beet and processed vegetable industries.

Since the following model is based on a second-best sharing contract in the context of multi-tasking, it also closely relates to the literature on share contracts (e.g. Eswaran and Kotwal, 1985; Luporini and Parigi, 1996; Dana and Spier, 2001). Pure risk sharing has been shown to motivate sharing arrangements when both agent and principal are risk averse and benefit from insurance (e.g. Stiglitz, 1974), but one-sided moral hazard has also been put forward to rationalise share contracts (e.g. Stiglitz, 1974; Mathewson and Winter, 1985). Furthermore, double-sided moral hazard as an explanation...
for sharing contracts has not only been employed in the economics of share-cropping (Stiglitz, 1974; Eswaran and Kotwal, 1985), but it has also been put forward to explain revenue sharing in the context of franchising and supply chain contracts (e.g. Rubin, 1978; Lal, 1990; Bhattacharyya and Lafontaine, 1995; Brickley, 2002; Corbett et al., 2005).

The remainder of the paper is structured as follows: Section 3 provides background information about the wine industry, focusing on contractual provisions used in real-world contracts. Section 4 develops a sharing contract under the assumptions of multi-tasking, double-moral hazard and effort monitoring, and derives propositions which are contrasted with stylised facts from previous empirical wine industry studies. Section 5 concludes the paper.

3. Background: contractual use in the wine industry

Formal wine grape supply contracts are used extensively in many key wine producing regions, including Australia (Fraser, 2005), California (Moulton, 1988; Bedwell, 2000; Goodhue et al., 2002, 2004), Argentina (Fares et al., 2002), Brazil (Zylbersztajn and Miele, 2005), New Zealand (Boyd et al., 2000), France (Montaigne and Sidlovits, 2003) and Spain (Olmos, 2008). As a result of producer surveys, the use of contracts has perhaps been best documented in the case of California (e.g. Goodhue et al., 2004) and Australia (e.g. Fraser, 2005).

3.1. Industry structure

In several key producing regions where formal contracts are in use, the wine industry has expanded significantly over the past two decades, resulting in changes in market structure. In Australia, the number of growers has increased by more than 30 per cent to 4,822 between 1994 and 1998. At the same time, the number of wineries expanded by nearly 50 per cent to 1,197 establishments (Shepherd and O’Donell, 2001). By 2005, the industry had expanded to approximately 6,000 grape growers and 2,000 wineries (AWBC, 2007; RMN, 2007). In California, during 2005 there were 2,275 wineries and 4,600 grape growers (2,972 wineries in 2009: Wine Institute, 2011), compared with 750 wineries and about 5,600 growers in 1987 (Moulton, 1988; Wine Institute, 2007a). Since vineyards also expanded considerably (1988: 297,000 acres; 2005: 445,141 acres; Wine Institute, 2007b), the growers’ average vineyard size increased significantly (by 73 per cent). At the same time, wine processing has become more consolidated in both California (Goodhue et al., 2008) and Australia (Smith and Marsh, 2007). Considering the above evidence on the differences in the total number of growers versus the total number of wine-processing firms (wineries) in a given region – suggesting that wineries are typically much larger operations than growers – it may be a reasonable assumption that a winery is generally less risk averse compared with a single grower (risk aversion is typically assumed to be inversely related to wealth; Laffont and Matoussi, 1995: 390). Thus, for
the following model, the simplifying assumption of a risk-neutral winery is made, an assumption which has also been applied to processors in principal-agent models that were employed to study other agricultural markets (Hueth and Ligon, 2002).

However, the above figures on firm numbers and size also raise the question of whether the bargaining power between grape growers and wineries is typically evenly or unevenly distributed when grape contracts are settled. This question is relevant with regard to the following model, since it implicitly assumes equal bargaining power between principal and agent. Evidence from California, New Zealand and Chile suggests that bargaining power is not only a function of scale (on both the grower’s and winery’s side), but also a function of perceived quality, as greater grower bargaining power was found in high-quality grape regions (Moulton, 1988; Gwynne, 2006). Fairweather et al. (1999) provide an extensive discussion of the New Zealand wine industry on the issue of tension between contracting grape growers and wineries. Their analysis suggests that there is no evidence for a one-sided, excessive bargaining power. Davis and Ahmadi-Esfahani (2005) suggest that a recent grape excess supply in Australia may also have been caused by lucrative grape contracts, which implies that wineries have not consistently extracted rents at the expense of growers. Other evidence from Australia (Scales et al., 1995) also suggests that the bargaining power of wineries, although generally of concern to growers, has at times shifted towards growers. Scales et al. (1995) report that grape growers’ bargaining power was found to have strengthened during times of growing export opportunities for wine, and when alternative markets expanded for grapes (i.e. markets for dried vine fruits). Nevertheless, we have evidence that the bargaining power rests on the buyer’s (winery’s) side in periods of excess (grape) supply (Fraser, 2005). Other documented evidence on the extent of bargaining power differences and their implications for contracting and pricing are scarce. A study of the New York State wine industry used a small survey among wineries to econometrically explore the relationship between grape prices and prices of wine (Hefetz and White, 1999). The study concludes that ‘The clear and significant relations between retail prices and grape prices result from the sharing of revenue from wine sales between the grape growers and the wine makers’ (Hefetz and White, 1999: 16). Thus, the study provides an example of a seemingly balanced bargaining power between growers and wineries.

### 3.2. Type of contract and contractual provisions

Surveys in the main grape-growing regions of Australia and California found that 85 per cent (2001) and 72 per cent (1999), respectively, of growers have written contracts (Goodhue et al., 1999; Fraser, 2005). These contracts are typically written over the supply of bulk wine, over grape must or over fresh grapes and have been observed to be offered on a take-it-or-leave-it basis (e.g. Sidlovits and Kator (2007) for documented evidence from Hungary). In California, fresh grape contracts between growers and wine
processors are most frequently used (Goodhue et al., 1999). From Fraser (2005) and Boyd et al. (2000) we have evidence that these contracts have typically a relatively low degree of customisation, which supports the modelling assumption of simple, uniform linear compensation schemes employed in this study.

Typical contract specifications include provisions on production practice (viticultural management, for example the documented use of chemical pesticides in grape production, as evidence from Spain, Australia and California suggests; Goodhue et al., 1999; Fraser, 2005; Olmos, 2008, respectively), price incentives (bonuses/penalties for quality attributes of fresh grapes) and monitoring (Moulton, 1988; Boyd et al., 2000; Goodhue et al., 2002; Benavente, 2004; Fraser, 2005; Olmos, 2008), or a subset thereof. However, Goodhue et al. (2004) suggest that requiring specific practices is uncommon in California. The same observation is made by Scales et al. (1995) in the context of Australia. Considering this observation together with the fact that winegrapes are not necessarily specific to a given vintner (Goodhue et al., 2004), it appears that relation-specific assets and the role of quasi-rents in grape contracting are generally not likely to be of major importance in the wine industry. This observation may lend support to the use of a standard linear principal agent model (Section 4) rather than analysing wine grape contracting through the lens of the property rights approach (e.g. Grossman and Hart, 1986; Hart and Moore, 1990).

Considering further contractual provisions, we have no evidence that grape supply contracts control for exogenous weather variables (rainfall, temperature) despite expectations in this respect that arise from Holmström (1979) as well as from previous empirical studies by Ashenfelter et al. (1995) and Byron and Ashenfelter (1995), who show that these weather variables can have a significant impact on price and wine quality.

Grape grower monitoring in the form of winery fieldmen is used extensively by the wineries (Boyd et al., 2000; Goodhue et al., 2002; Fraser, 2005; Zylbersztajn and Miele, 2005; Olmos, 2008). As a result of such monitoring efforts, wineries have been observed to generate historical performance scorecards for individual growers, which are used when new contracts are put into place (e.g. Zylbersztajn and Miele, 2005). However, we have also evidence for winery monitoring, such that growers infer winery processing and marketing efforts from trade publications, winery reports and other industry participants. Wineries also submit reports to growers about the composition of their grape juice, or about results from wine tastings (Montaigne and Sidlovits, 2003; Omond, 2003).

3.3. Use of residual claimancy in contracts

We expect to observe the use of residual claimancy in the wine industry under certain conditions. When free-riding occurs as a function of commingling grapes from several growers during processing, the
underlying moral hazard problem (Holmström, 1982) does not lend support to the use of contracts conditioning grape grower payments on the retail value of their individual output. However, when moral hazard remains an issue (in the absence of commingling) due to the imperfect ability of the winery to fully infer the quality contribution of the grower to the wine at grape processing, some form of residual claimancy could be expected to provide appropriate incentives. Under these circumstances, we would anticipate that the use of residual claimancy can in part substitute for quality monitoring (see Arruñada et al. (2005), for example, from franchising). But what empirical evidence do we have for the use of residual claimancy via bottle-price indexing?

Evidence from New Zealand suggests that mixed payment schedules composed of a base price and an incentive-related margin are common, where the grower compensation for a particular grape variety is related to the price of wine produced from that particular grape variety (Boyd et al., 2000). This combination of a base price plus commission with bottle-price indexing is reflected in the model developed further below.

The use of grape grower contracts conditioning grower compensation on wine retail prices is also documented for Australia, France and California (Moulton, 1988; Hueth et al., 1999; Fraser, 2002; Montaigne and Sidlovits, 2003). Australian evidence suggests that about 20 per cent of grape contracts use this form of residual claimancy (Fraser, 2002). Current figures for bottle price contracts in California are not available, although this figure has been estimated to have been below 5 per cent during the 1980s (Moulton, 1988). Exact figures for France and New Zealand are also not available (Boyd et al., 2000; Montaigne and Sidlovits, 2003). Documented evidence for the use of residual claimancy in other regions is missing, although some authors propose bottle price-indexing to be part of a solution to overcome future coordination issues in developing wine markets in Eastern Europe (Sidlovits and Kator, 2007: 9).

For those regions where we have documented evidence for residual claimancy, bottle retail prices enter the compensation scheme in different ways. In the USA and New Zealand, retail bottle prices are used from wines that originated from the same vineyard or the same grape variety, yet from wines that were released in the previous year (Moulton, 1988; Boyd et al., 2000). In Australia, grape growers are compensated based on retail prices of the forthcoming bottles from the current vintage (Fraser, 2005). In France, an average retail price is used to derive an index formula, based on forthcoming bottles from the current vintage, as well as from past vintages (Montaigne and Sidlovits, 2003).

4. Model

The following model assumes a one-shot game, in which a risk-averse grape grower contracts with a risk-neutral winery over the supply of fresh grapes. In addition to modelling multiple tasks on the grower’s and the winery’s side, the
model allows for moral hazard on both the grower’s and the winery’s part. Two factors are assumed to contribute to the performance indicator according to which both winery and grower agree to share the outcome from production, processing and marketing: the market valuation of the outcome from grape production and wine processing, as reflected in the bottle retail price, and information from effort monitoring.

The model shows that a sharing contract can provide incentives to both principal (winery) and agent (grower) such that the efficient contract maximises surplus for all incentive compatible contracts. An agency relationship is considered in which a grape grower allocates his total production efforts among several activities $n = 1, \ldots, N$, where the vector of efforts is denoted by $a = (a_1, \ldots, a_N)$. The winery allocates its processing and marketing efforts amongst activities $m = 1, \ldots, M$, where the vector of efforts is given by $e = (e_1, \ldots, e_M)$ and $a \in \mathbb{R}_+^N$, $e \in \mathbb{R}_+^M$, respectively. For both grower and winery, each element of her effort vector measures managerial effort in a distinct activity (variable inputs), such that $w = [a^T e^T]$. Assume that efforts are observed with noise,

$$\tilde{w} = \begin{bmatrix} a \\ e \end{bmatrix} + \begin{bmatrix} \varepsilon_{a,w} \\ \varepsilon_{e,w} \end{bmatrix}, \text{ such that } \tilde{w} = \begin{bmatrix} \tilde{a} \\ \tilde{e} \end{bmatrix}. \quad (1)$$

Observational error in measuring quality outcomes is present, such that the realisation of

$$\varepsilon_w = \begin{bmatrix} \varepsilon_{a,w} \\ \varepsilon_{e,w} \end{bmatrix},$$

normally distributed with zero mean and covariance matrix $\Sigma_w$, is unobserved by both parties. The degree of the winery’s inference problem regarding the grower efforts $a$ is given by the variance of $\varepsilon_{a,w}$, and the degree of the grower’s inference problem regarding the winery efforts $e$ is given by the variance of $\varepsilon_{e,w}$. An example for the former case could be the difficulty of the winery to observe the actual pesticide applications employed by the grower after signing the contract, which may deviate from the contractually specified pesticide applications. As an example for the latter, the grower may observe the marketing campaign of the winery in the marketplace, but the actual marketing budget that was allocated to specific wines and thus to the corresponding grape batches from a given grower, may be difficult to observe by the grower. Further, a second source of randomness is allowed for. It is assumed that both the winery and the grower are exposed to exogenous shocks that make it impossible for both sides to perfectly control their contribution to wine and grape quality, respectively:

$$\varepsilon_k = \begin{bmatrix} \varepsilon_{a,k} \\ \varepsilon_{e,k} \end{bmatrix},$$

with mean zero and covariance matrix $\Sigma_k$, $\varepsilon \sim N(0, \Sigma_k)$. These shocks provide scope for moral hazard, because although grower and winery
cannot affect the states-of-nature per se, they can affect the outcome realised in those states. The inference problem of the winery with regards to the grower’s efforts, and the grower’s inference problem with regards to the winery’s efforts, therefore relates to the potential of mitigating or enhancing the wine quality outcome in an unobserved manner in certain states-of-nature. What are examples of such exogenous shocks? A shock that can affect the outcome of the wine-quality-contributing efforts of a given grower could be a certain disease in the vineyards. After harvest, the grower could thus supply grapes of lower quality, blaming the pest. However, the winery may contract with other growers from the same region, and thus find out that the grower in question could have enhanced certain grape (and thus wine) qualities by additional effort, following the disease incident. Similarly, the winery may be exposed to an external shock on its quality-contributing efforts that could, for example, originate from an input supplier or from the retailer end. A quality shock due to a defective cork may be an example for the former. Due to extreme weather conditions in a given region (or simply due to a lack of storage care under regular conditions), the wine retailer may affect the wine quality through its storage quality efforts, such that a certain wine quality variation that impedes the winery’s marketing efforts maybe outside of the control of the winery. A winery may therefore suggest vis-à-vis its grower that it suffered a quality shock that was outside of its control, originating from the retail level. However, if the grower would supply the same grapes to multiple wineries (or use some other monitoring device), she may be able to control to what extent the wine’s final quality (and thus market success) at the retail level is due to the winery’s processing and/or marketing effort, as well as due to the winery’s unobserved efforts that may enhance a given quality shock which originated from the retailer end.

4.1. Quality outcome from effort allocation

Considering both sources of randomness, the wine quality outcome from effort allocation becomes

\[ q = \Phi_{w} + \Phi_{w} \varepsilon_{w} + \varepsilon_{k}, \]  

where \( \Phi \) denotes a matrix of productivities. It is the objective of both grower and winery to specify a joint performance indicator that relies on this outcome, \( q \). To achieve this, the relationship between efforts and quality outcome could be modelled more explicitly. This has two advantages. First, it allows us to transform grape and wine quality attributes into monetary values via grape grower and winery characteristics (see discussion below). Secondly, this enables us to take production, processing and marketing realities into account. We generally observe that a combination of inputs (production, processing, marketing) is responsible in
determining a given quality attribute. For example, the residual sugar level (Brix) in grapes is influenced by irrigation, weeding and pruning (e.g. Jones and Ough, 1985). Assuming that \( \Phi \tilde{w} = y \) and \( y = [y_a^T, y_e^T] \), we have

\[
\begin{bmatrix}
\Phi_{aa} \tilde{w}_a + \Phi_{ae} \tilde{w}_e \\
\Phi_{ea} \tilde{w}_a + \Phi_{ee} \tilde{w}_e
\end{bmatrix} =
\begin{bmatrix}
y_a \\
y_e
\end{bmatrix},
\]

(3)

In this way, Equation (3) tells us how grower and winery efforts translate into quality attributes of the wine. As an example, consider \( \Phi_{aa} \tilde{w}_a \), which tells us how a grower’s effort affects quality attributes that he delivers to the final product. Also, \( \Phi_{ae} \tilde{w}_a \) reveals that the way in which grower efforts affect the winery’s quality contribution is not necessarily symmetric to the way by which winery efforts affect the grower’s quality contributions. The extent to which wineries can affect the final bottle quality by making ‘bad’ wine out of ‘good’ grapes may differ from the extent to which grape growers can affect the processing efforts of the winery, and thus final bottle quality. Consider that the grower can impact the processing abilities of the winery by affecting the fermentation qualities of the wine. The fermentation process can be impeded by an undesired use of certain pesticides and fertiliser (Wade et al., 2004; Downey et al., 2006; Lund and Bohlmann, 2006). Further, the final bottle quality may be impeded by grape grower efforts in terms of credence attributes (Darby and Karni, 1973; Emons, 1997), even if the fermentation quality is not affected: grape supply contracts in Australia, for example, contain a chemical use clause due to potential chemical residues resulting from chemical applications to the grapes (Fraser, 2005).

Further, to obtain a monetary compensation scheme, let vector \( z_a \) denote grower characteristics that are observable by the winery, including characteristics such as location of the vineyard, grape varieties planted or production methods used. Winery characteristics that can be observed by growers are denoted as \( z_e \), and are assumed to include the type of processing technology employed (e.g. type of oak barrels), the size of vintage and the brand name. These attributes, denoted by \( z^T = [z_a^T, z_e^T] \), are a reflection of the contract terms to which both parties have committed to. They also form the basis for the monetary valuation of wine attributes by consumers and marketers at the retail level, as these attributes are frequently visible on the wine bottle or elsewhere in the marketplace. We could thus allude to hedonic studies, which have derived implicit prices for wine qualities and labelling attributes (e.g. Oczkowski, 1994; Nerlove, 1995; Steiner, 2004). Perhaps most intriguing in the context of the following model is the hedonic study by Golan and Shalit (1993), which derives a producer pricing schedule for grape growers based on the monetary valuation of wine attributes by consumers and marketers at the retail level.
Table 1. Notation and structure of performance measure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( w )</td>
<td>Effort (variable inputs)</td>
</tr>
<tr>
<td>( \tilde{w} = w + \varepsilon_w )</td>
<td>Observable effort (with observational noise), ( E(\varepsilon_w) = 0 )</td>
</tr>
<tr>
<td>( q = \Phi \tilde{w} + \varepsilon_k )</td>
<td>Production function (with external shocks), ( E(\varepsilon_k) = 0 )</td>
</tr>
<tr>
<td>( \Phi )</td>
<td>Productivities</td>
</tr>
<tr>
<td>( z )</td>
<td>Contract provisions (e.g. grape variety, type of oak barrel)</td>
</tr>
<tr>
<td>( s = Qw )</td>
<td>Information outcome of monitoring activity</td>
</tr>
<tr>
<td>( V )</td>
<td>Weights on monitored variables</td>
</tr>
<tr>
<td>( z^T[VQw] )</td>
<td>Conversion of monitoring grades into dollars</td>
</tr>
<tr>
<td>( \tilde{v}(s) = Vs )</td>
<td>( \Rightarrow ) performance indicator ( \mu = z^T[\Phi(w + \varepsilon_w) + \varepsilon_k + VQw] )</td>
</tr>
<tr>
<td>( w : (N \times 1) )</td>
<td>( \varepsilon_w : (N \times 1) ), ( \varepsilon_k : (M \times 1) )</td>
</tr>
<tr>
<td>( q : (M \times 1) )</td>
<td>( \Rightarrow \Phi : (M \times N) )</td>
</tr>
<tr>
<td>( v : (M \times 1) )</td>
<td>( \Rightarrow V : (M \times S) )</td>
</tr>
<tr>
<td>( s : (S \times 1) )</td>
<td>( \Rightarrow Q : (S \times N) )</td>
</tr>
</tbody>
</table>

4.2. Performance indicator with monitoring

Not only are winery fieldmen assumed to monitor grape growers, but it is also assumed that winery monitoring is observed, such that growers infer winery processing and marketing efforts from winery reports, trade publications and other industry participants. The resulting ‘monitoring scorecards’ (grades) are weighted by a contractually determined matrix \( V \), which reflects the relative importance that a given effort is perceived to have for the final outcome from contracting. Further, it is assumed that matrix \( Q \) converts efforts \( w \) into grades, such that each effort which has been monitored receives a single grade (diagonal matrix), or several efforts are used to determine a single grade. Therefore, it is assumed that \( \tilde{v}(s) = VQw \), and in order to convert these grades into monetary terms, the assumption is that \( z^T[VQw] \). The total performance indicator is thus

\[
\mu = z^T[\Phi(w + \varepsilon_w) + \varepsilon_k + VQw].
\] (4)

To summarise the notation and model structure so far, see Table 1.

4.3. Model timeline

The timeline of the model is as following. When the contract is signed, the winery puts forward a sharing rule to the grower. As part of this sharing rule, both parties agree \textit{ex ante} that certain weights will be placed on the informational outcome from monitoring activities. The contract also specifies \textit{ex ante} that grape growers are compensated based on retail prices of the forthcoming
bottles from the current vintage. After the contract is signed, and given the information from monitoring, we obtain \( \tilde{v}(s) \). After both grower and winery have committed their efforts, and wine is produced, we observe to which contract terms \( z \) they have adhered to. This is a reflection of their production function that transformed efforts with observation noise \( \varepsilon_w \), and in the presence of random shocks \( \varepsilon_k \). Assuming that the contract provisions \( z \) have market value and are ultimately responsible for the price of the bottle of wine, revenue is generated that can be shared through a performance indicator as in Equation (4).

The underlying cost-of-effort function (‘disutility’) is assumed convex and monotonically increasing, since the cost-of-effort matrices \( K_1 \) and \( K_2 \) are assumed symmetric positive semidefinite and considered in monetary terms:

Assumption 1.

\[
C'(w) > 0, \quad C''(w) \geq 0 \quad \forall w \in \mathbb{R}^N, \text{ where}
\]

\[
C'_w (w) = \frac{\partial C(w)}{\partial w} \quad \text{and} \quad C''_{ww} (w) = \frac{\partial^2 C(w)}{\partial w \partial w^T}.
\]

Hence, \( C_1(a) = 1/2 a^T K_1 a \) defines the grower’s quadratic cost of effort, and \( C_2(e) = 1/2 e^T K_2 e \) denotes the winery’s quadratic cost of effort (see Holmström and Milgrom (1991, 1994) and Slade (1996) for quadratic cost functions in the context of multitasking). Therefore, \( C(w) = 1/2 w^T K_3 w \), where

\[
K_3 = \begin{bmatrix}
K_1 & K_{a,e} \\
K_{a,e}^T & K_2
\end{bmatrix}.
\] (5)

Since the cost-of-effort matrices \( K_1 \) and \( K_2 \) are assumed symmetric positive semidefinite, efforts can be represented as substitutes in the grower’s and winery’s cost-of-effort function, respectively. In those cases, it is assumed that if the incentive intensity is increased on one effort, this will cause substitution away from other types of efforts.

Given the outcome from monitoring and the outcome from grape and wine production as in Equation (4), it is assumed that the optimal second-best incentive scheme, \( \tilde{l} \), takes the following linear form

\[
\tilde{l} = \alpha (z^T [(\Phi(w + \varepsilon_w) + \varepsilon_k) + V Q w]) + \beta, \quad (6)
\]

where \( \alpha \) denotes the commission rate on the dollar outcome (there exists no sharing contract that implements first-best under double moral hazard, even with risk-neutral agents; the contract will be second-best as long as we assume that the budget-balancing constraint is satisfied; see Holmström (1982) and Bhattacharyya and Lafontaine (1995) for proof).
The size of $\alpha$ reflects thus how strongly powered the incentives are for the grower such that in a high-powered incentive contract, the agent’s total returns will be relatively sensitive to the contracting outcome. If $\alpha = 0$, the grower ceases to be an independent supplier, whereas with $\alpha = 1$, the grower would become full residual claimant. The scalar $\beta$ denotes a fixed *ex ante* base payment upon which grower and winery agree when signing the contract. We could also let $\beta$ take negative values, which would allow for the possibility that the grower borrows capital from the winery. For example, in Australia, we observe that wineries desire specific grape varieties from grape growers in the production of certain wines (Scales *et al.*, 1995), a practice that could be implemented by wineries lending capital to growers. In New Zealand, we have evidence that wineries provide capital to growers for converting vineyards (Boyd *et al.*, 2000).

The sharing rule could be modified, such that another parameter is determined *ex ante* to the allocation of grower and winery effort. Instead of leaving the relative weights allocated to production, processing and marketing outcome versus monitoring outcome in the performance indicator unspecified, both parties could agree *ex ante* on a base split that is variable: the quality outcome could, for example, be linked with the performance of the consumer price index (CPI), resulting in a flexible sharing rule over $\lambda$:

$$E[\mu^*] = z^T[\lambda \Phi + (1 - \lambda)VQ]w = z^T M^* w.$$  \hfill (7)

Indeed, linking wine bottle contracts to the CPI is practised in the Australian wine industry (Scales *et al.*, 1995; Fraser, 2002). However, since this modification does not change the key results in which we are interested, we will proceed as in Equation (6).

Given Equation (6), the winery’s problem is to allocate the surplus such that expected profits are maximised, subject to the constraints that the winery and the grower comply with the efforts specified in the contract, and subject to the condition that the reservation utility for the grower is assured. While the resulting contract is assumed to be efficient, it leaves the surplus allocation unspecified since retail prices are unobserved *ex ante*: the winery only chooses $\alpha$ and agrees with the grower on the weights that shall be placed on the monitoring outcome.

### 4.4. Setting up incentive compatibility conditions

Assuming a risk-averse grower, we are interested in the variance of the payment scheme (6), as this serves to derive the risk premium. Further, through the covariance matrix, we can analyse random complementarities between tasks. Random complementarities arise when the random allocation of efforts to one quality task increases the marginal expected benefit of allocating efforts to another task, for example, as a result of a random positive demand shock (e.g. Slade, 1996). Consider that, in a stochastic environment, the covariation of uncertainty across contract provisions implies that the
grower is exposed to greater compensation risk. Given the greater sensitivity of the grower to a given incentive (to reallocate efforts) in this environment, we would expect that incentive contracts are used which are of lower power (e.g. Holmström and Milgrom, 1991). Therefore, the optimal share parameter should be decreasing in random complementarities, where risks are correlated across tasks.

From Equation (6), we obtain

\[
\text{Var}(\mu(a,e,z)) = E(z^T (\Phi \varepsilon_w + \varepsilon_k)(\Phi \varepsilon_w + \varepsilon_k)^T z)
\]

\[
= z^T \left( \Phi \sum_{ww} \Phi^T + \Phi \sum_{we} \sum_{zw} \Phi^T + \sum_{zz} \right) z, \quad \left( \sum_{ij} = \varepsilon_i \varepsilon_j^T \right)
\]

\[
= z \sum z \quad (8)
\]

where

\[
\sum = \begin{bmatrix}
\sum_{a,a} & \sum_{a,e} \\
\sum_{a,e}^T & \sum_{e,e}
\end{bmatrix}
\]

Given the above sharing rule as in Equation (6), the grower profits are given by

\[
\Pi_a = \alpha \mu - \frac{1}{2} a^T K_1 a + \beta. \quad (9)
\]

From the moment generating function for the multivariate normal, \( \varepsilon \sim N(0,\Sigma) \), we obtain the CARA expected utility of profits as,

\[
E[u(\Pi_a)] = -\exp \left\{ -r \left( \alpha \mu + \beta - \frac{1}{2} a^T K_1 a \right) + \frac{1}{2} r^2 \alpha^2 z^T \Sigma z \right\}, \quad (10)
\]

where \( r \) denotes the constant absolute risk aversion coefficient, \( r = -U''/U' \), \( r > 0 \).

Noting that,

\[
E[\mu] = z^T (\Phi + V Q) w
\]

\[
= z^T M w = z^T a a + z^T a e + z^T e a + z^T e e, \quad (11)
\]

It follows that the certainty equivalent (CE) for the grower is

\[
\text{CE} = \alpha(z^T M w) + \beta - \frac{1}{2} a^T K_1 a - \frac{1}{2} r \alpha^2 z^T \Sigma z. \quad (12)
\]

The CE utility is thus given by the expected compensation minus the private cost of efforts minus the risk premium. As long as the CE utility satisfies the grower’s reservation level, he will accept the contract. However, since it is assumed that contracting takes place in an environment of randomness in \( \text{ex post} \) observed retail prices, the associated information asymmetries require that incentive
compatibility constraints are met. In setting up the incentive compatibility conditions, it is assumed that the grower chooses his own efforts $a$ such that the winery’s expected profits are maximised. This optimisation problem of the grower excludes the effort choice of the winery, $e$, but includes the variance–covariances since we assume a CARA model of grower choice:

$$a \in \arg \max \left\{ \alpha z^T M w + \beta - \frac{1}{2} a^T K_1 a - \frac{1}{2} r \alpha^2 z^T \Sigma z \right\}. \quad (13)$$

The necessary first-order conditions for Equation (13) are thus,

$$\alpha(z_a^T M_{aa} + z_e^T M_{ea}) - a^T K_1 \leq 0, \quad (14a)$$

$$a \geq 0, \quad (14b)$$

$$a[\alpha(z_a^T M_{aa} + z_e^T M_{ea}) - a^T K_1] = 0 \quad (14c)$$

Assuming that an interior solution exists, we can solve Equation (14a) as a system of equalities for $a$, such that

$$\hat{a}(e) = aK_1^{-1}(M_{aa}^T z_a + M_{ea}^T z_e). \quad (15)$$

Since Equation (15) reveals the level of grower effort that maximises the grower’s certain equivalent income in Equation (12), it gives us the incentive compatibility condition that needs to be satisfied to achieve a feasible contract.

### 4.5. Setting up the winery’s unconstrained maximisation problem

In the following step, we substitute the grower’s effort choice function (15) into the grower’s CE income function (12) to obtain the indirect certainty utility of the grower.

Denoting

$$E[\mu] = \delta_a[\mu(a)] + \delta_e[\mu(e)],$$

we can write the indirect CE as,

$$\widehat{CE}(\alpha, a) = \beta + a \delta_a[\mu(a)] + \alpha \delta_e[\mu(e)] - \frac{1}{2} a^T K_1 a - \frac{1}{2} r \text{Var}(\alpha \mu \alpha). \quad (16)$$

Together with the participation constraint,

$$\beta + \alpha \delta_a[\mu(a)] + \alpha \delta_e[\mu(e)] - \frac{1}{2} a^T K_1 a - \frac{1}{2} r \text{Var}(\alpha \mu \alpha) \geq U(\overline{v}), \quad (17)$$

in which $U(\overline{v})$ is the default utility level of the grower and $(\overline{v})$ is its certain monetary equivalent. As long as the CE utility is greater than the default utility of the grower, the grower’s performance incentives are not affected, and $\beta$ serves only as a redistribution (surplus transfer) between winery and
grower without affecting the agent’s performance incentives (Holmström and Milgrom, 1994). From Equation (17), an inequality constraint is implied on the winery’s choice for the fixed base payment $b$:

$$
\beta \geq \bar{\nu} - \alpha \delta_a[\mu(a)] - \alpha \delta_e[\mu(e)] + \frac{1}{2} a^T K_1 a + \frac{1}{2} r \text{Var}(\alpha \mu a).
$$

(18)

Thus, to induce the grower’s voluntary participation, we impose a participation constraint, which, together with the incentive constraint, is necessary to deliver an incentive feasible contract.

For convenience, let

$$
\tilde{K}_1 = \begin{bmatrix} K_1^{-1} & 0 \\ 0 & 0 \end{bmatrix}, \quad \tilde{K}_2 = \begin{bmatrix} 0 & 0 \\ 0 & K_2^{-1} \end{bmatrix},
$$

such that $\tilde{K}_1 + \tilde{K}_2 = K_3^{-1}$.

Considering the grower’s optimal effort level from Equation (15), we obtain

$$
E(\mu(\hat{a})) = \alpha (z_a^T M_{aa} K_1^{-1} M_{aa} z_a + z_e^T M_{ae} K_1^{-1} M_{ee} z_e)
$$

(19a)

$$
+ z_a^T M_{aa} K_1^{-1} M_{aa} z_a + z_e^T M_{ee} K_1^{-1} M_{ee} z_e)
$$

(19b)

$$
= \alpha z^T M \tilde{K}_1 M^T z
$$

(19c)

Given the winery’s profit function as

$$
\Pi = (1 - \alpha) \mu - \frac{1}{2} e^T K_2 e - \beta,
$$

(20)

the expected profit criterion becomes

$$
E(\Pi_e) = (1 - \alpha) E[\mu] - \bar{\nu} + \alpha \delta_a[\mu(a)] + \alpha \delta_e[\mu(e)] - \frac{1}{2} a^T K_1 a
$$

$$
- \frac{1}{2} r \text{Var}(\alpha \mu a).
$$

(21)

From Equation (21) we know that the participation constraint is binding since $E(\Pi_e)$ is strictly decreasing in $\beta$. Together with a strictly positive reservation utility of the grower $\bar{\nu}$, we know that grapes and wine are produced.

In order to obtain the winery’s unconstrained maximisation problem, max$_{a,e}$ $E(\Pi_e)$, we substitute the right-hand side of Equation (15) for $a$ in Equation (21), and the right-hand side of Equation (18) as equality for $\beta$ into Equation (21). The optimal level of winery efforts is thus given by

$$
\frac{\partial E\Pi_e}{\partial e} = (1 - \alpha + \alpha \delta_e)(z_a^T M_{ae} + z_e^T M_{ee}) - e^T K_2
$$

(22)
This yields
\[ \hat{e}(a) = (1 - \alpha + \alpha \delta_e)K_2^{-1}(M_{ae}z_a + M_{ee}z_e). \] (23)

Therefore, Equation (19c) becomes
\[ E[\mu(\hat{e})] = (1 - \alpha + \alpha \delta_e)z^T\bar{M}K_2M^Tz, \] (24)

which yields unconstrained profits of the winery,
\[ \max_{a,e} \hat{E}(\Pi_L) = z^T \left[ \left( 1 - \alpha + \alpha \delta_a - \frac{1}{2} \alpha \right) a\bar{K}_1 + \left( 1 - \alpha + \alpha \delta_e - \frac{1}{2} (1 - \alpha + \alpha \delta_e) \right) (1 - \alpha + \alpha \delta_e) \bar{K}_2 \right] M^T - \frac{1}{2} \alpha \Sigma \] (25)

\[ = z^T \left[ M \left( -\alpha - \frac{3}{2} \delta_a \right) \bar{K}_1 + \frac{1}{2} \left( 1 + \alpha^2 + \alpha^2 \delta_e^2 - 2a - 2 \alpha^2 \delta_e + 2 \alpha \delta_e \right) \bar{K}_2 \right] M^T - \frac{1}{2} \alpha \Sigma \] (26)

To find the optimal level of winery efforts, we use the following equation:
\[ \frac{\partial \hat{E}(\Pi_L)}{\partial \alpha} = z^T \left[ M \left\{ \left( 1 - 3\alpha + 2\alpha \delta_a \right) \bar{K}_1 + \left( \alpha + \alpha \delta_e^2 + 1 - 2 \alpha \delta_e + \delta_e \right) \bar{K}_2 \right\} M^T - \alpha \Sigma \right] z = 0 \] (27)

Therefore,
\[ \alpha^* = \frac{1}{1 + r \left( z^T \Sigma z / \left( z^T M \bar{K}_1^{-1} M^T z \right) \right)} \] (28)

Several comparative static results can be obtained by considering the ‘optimal share parameter’ \( \alpha^* \) and by varying the assumptions with regard to the degree of effort contractibility, the grower’s risk aversion and the grower’s disutility of effort.

**Proposition 1.** As long as the grower is risk-averse and observational error in measuring quality and randomness on the supply and demand side is present, the optimal contract involves strict sharing.

**Proof**

if \( \varepsilon_w, \varepsilon_k, r > 0 \Rightarrow \{ \alpha : 0 < \alpha < 1 \} \)

Q.E.D.
Proposition 2. Increasing risk aversion of the grower is associated with a higher Pareto optimal share that goes to the winery (and vice versa).

Proof

$r \to \infty; \quad \alpha^* \to 0.$

$r \to 0; \quad \alpha^* \to 1.$

Q.E.D.

In a single-moral hazard setting, and with both risk-neutral principal and agents, we would not expect strict sharing (i.e. the optimal contract cannot have $\alpha = 0$ or $\alpha = 1$), since the agent who provides the only unobservable input would be the single residual claimant. However, Bhattacharyya and Lafontaine (1995) show that this result changes in the context of double-moral hazard to a strict sharing arrangement. Therefore, Proposition 1 is consistent with previous model evidence of strict sharing in the presence of double-sided moral hazard, when both parties are risk-neutral and only a single task is performed (Bhattacharyya and Lafontaine, 1995; Corollary 1). Since the model in this paper accounts for a risk-averse agent in the context of multi-tasking, Proposition 1 suggests that, under the above model conditions, strict sharing, and thus partial residual claimancy, can extend to a double-moral hazard setting when the agent is risk-averse and performs multiple tasks. Therefore, the prediction of strict sharing also distinguishes the above model from the Holmström and Milgrom (1991) model.

To motivate Proposition 1 further, consider that strict sharing is not only consistent with previous incentive theories of franchising (e.g. Rubin, 1978; Mathewson and Winter, 1985), but also with empirical evidence from franchising (Kaufmann and Lafontaine, 1994). In those franchise contracts, ex post rents can serve as a coordination device, because the ex post rents that are left downstream by the franchisor create franchisee incentives (Kaufmann and Lafontaine, 1994). This rationale that ex post rents in a strict sharing contract serve to motivate agents lends support to the use of strict sharing as a meaningful coordination device in the context of bottle price contracts, as they are observed in Australia, New Zealand, California and France.

The prediction from Proposition 2 regarding the relationship between the grower’s risk aversion and the allocation of the Pareto optimal share to the grower is comparable to the prediction from standard linear compensation contracts in the absence of multi-tasking and bilateral moral hazard: the agent’s commission rate is predicted to be a decreasing function of risk aversion and goes to zero when risk aversion goes to infinity (Holmström and Milgrom, 1987). What is novel compared with the standard linear contract with one task, and compared with predictions from Holmström and Milgrom’s (1991) risk-neutral multitask model, is the prediction of what this relationship
between risk aversion and partial residual claimancy means for cooperation in a bottle price contract, i.e. to what extent the model can provide us with further insights into the extent of higher levels of cooperation between winery and grape grower. Consider that Holmström and Milgrom (1991) put forward their analysis of multi-tasking in a one-sided moral hazard setting as a ‘rudimentary theory of ownership’ (p. 26), which takes the variance of measurement error and thus measurement costs as an important determinant of integration. Thus, as long as observational errors in measuring quality are present in the above multi-task setting (Proposition 1), we would not only anticipate higher levels of cooperation compared with the absence of multi-tasking and measurement errors, but in the context of a risk-averse grower (Proposition 1) expect that, with increasing grower’s risk aversion, the increasing efficiency of the winery of bearing risks is likely associated with higher levels of cooperation (towards ownership and thus integration), such that closer coordination is associated with a lower Pareto optimal share that goes to the grower.

Considering empirical evidence from California, we observe that larger grape growers – which are likely to be less risk-averse compared with smaller growers – are more likely to supply lower quality grapes to wineries than smaller producers (Goodhue et al., 2004). Compared with smaller growers, these grape growers are observed to contract with wineries over price incentives rather than production practices: evidence from California suggests that winegrape acres have a significant positive effect on the inclusion of price incentives in the grape contracts (Goodhue et al., 2004). Since the use of production practices – which effectively amounts to a higher degree of coordination between grower and winery (compared with contracting over price incentives) – is more frequently associated with growers supplying higher quality grapes, Propositions 1 and 2 seem to fit the observation that wineries are more likely to coordinate closely (towards integrating grape growing into the winery) with smaller and likely more risk-averse growers (while possibly receiving a greater Pareto share, although we have no published evidence from industry or other studies of a higher Pareto share going to the winery).

**Proposition 3.** As the magnitude of the grower’s disutility of effort increases, the Pareto optimal share which goes to the grower decreases.

**Proof**

\[ \|K_1\| \to \infty; \quad \alpha^* \to 0 \]

Q.E.D.

**Proposition 4.** With increasing observational error in measuring quality, the Pareto optimal share which goes to the grower decreases.
Proof

$$\text{as } e_w \to \infty; \quad \alpha^* \to 0 \quad (\Sigma \to \infty \text{ in Equation } (28))$$

Q.E.D.

From Propositions 3 and 4, we anticipate that as a grower’s disutility of effort increases (for example, by expanding into the production of higher quality grapes), and as the role of quality measurement error and thus the difficulty (cost) of monitoring performance increases, a greater Pareto share goes to the winery. The prediction that more extensive grower monitoring costs are associated with a reduced partial residual claim going to the grower, i.e. that partial residual claimancy substitutes for monitoring in the above context of multi-tasking and bilateral moral hazard, has interesting parallels to related contracting studies. We have empirical evidence from share contracts in franchising that residual claimancy can save on monitoring costs (Arruñada et al., 2005). Similarly, in a model of one principal contracting with two agents, where each agent performs an outside and an inside activity, residual claimancy of agricultural producers (in the sense of contracts being linearly conditioned on each grower’s revenue) is predicted to substitute for performance measurement (Hueth and Melkonyan, 2004). Furthermore, Hueth et al. (1999) predict that a substitution relationship between residual claimancy and monitoring could be expected to hold stronger in some agricultural organisational forms rather than in others.¹

But what does evidence from the wine industry suggest with respect to the above? Evidence from Australia and California suggests that the use of production practice provisions (indirect monitoring) and a high direct monitoring intensity is predominant in high-quality grape regions (Scales et al., 1995; Goodhue et al., 2004; Fraser, 2005). The more extensive use of production practice provisions in grape supply contracts of high-quality regions is likely a reflection of the difficulty (costs) of identifying and measuring the key grape characteristics that determine grape and thus wine quality in those regions (Scales et al., 1995). This suggests that the winery uses these provisions as an indirect monitoring mechanism in an attempt to address the incentive problems created by multi-tasking, when grower efforts between quality tasks differ in measurability at harvest time.

Further, in those cases where wineries contract with high-quality grape growers, we anticipate that these wineries, which likely face greater quality measurement costs (multitasking problems) and thus higher processing quality risks, would receive a higher Pareto share under bottle price contracts.

¹ ‘... a processor might let growers earn some portion of their payment through... revenue sharing with the processing firm. Presumably, growers would feel greater connection with the organization and would be more inclined to produce high-quality output. It is noteworthy that agricultural marketing cooperatives – organizations that do use this form of residual claimancy – have a notoriously difficult time monitoring the quality of their members’ production.’ (Hueth et al., 1999: 384).
This increasing Pareto share could thus be expected to be associated with an increasing internalisation of contracting externalities associated with multi-tasking. Considering the above model framework (Propositions 2–4), we would expect that wineries aim to internalise those externalities of incentive design by closer cooperation (towards integration) between grape production and their own processing operation. Such evidence of wineries integrating high-quality grape growing into their own operation comes from Australia (Scales et al., 1995) and Spain (Olmos, 2008).

We also observe that production practices in high-quality regions encompass the use of winery and wine-specific grape varieties (Scales et al., 1995), such that wineries supply growers with new vines on the condition that they have a right to buy the vintages from those vines for a certain number of years (Boyd et al., 2000). Thus, we have further evidence that closer coordination between wineries and growers occurs in cases where quality measurement cost and growers’ disutility of efforts are high, and multi-tasking problems are likely to be more significant.

**Proposition 5.** With increasing uncertainty of measuring effort contribution, it becomes more efficient to allocate a greater Pareto optimal share to the less risk-averse party.

**Proof**

When $\varepsilon_w, \varepsilon_k \gg 0$, $r \rightarrow \infty$; $\alpha^* \rightarrow 0$.

Q.E.D.

Proposition 5 is supported by empirical evidence in the sense that closer coordination (towards integration of grape growing into the processing operation) is observed in high-quality regions where bottle-price indexing is observed (Scales et al., 1995; Boyd et al., 2000), and where the uncertainty of measuring bilateral efforts is likely higher compared with low-quality regions. These observations support Proposition 5, since in those wine-producing regions, in which (i) effort allocation inference problems and (ii) quality shocks due to states of nature and related moral hazard issues are most likely prevalent (i.e. high-quality wine regions where both the likelihood and the magnitude of states of nature and their quality implications is expected to be most significant), it is likely more efficient to allocate the winery a greater Pareto share through closer coordination (towards integration). Furthermore, in those instances ((i) and (ii)), it is also likely more efficient to allocate the winery as the less risk-averse party a larger Pareto share, since it likely can bear these risks with regard to the measurability of effort contribution more efficiently than the grower.
5. Conclusions

This paper explores internal organisational design problems of firms in the wine industry, as they relate to moral hazard, multi-tasking and residual claimancy. The paper uses a quasi-case-study approach to analyse contract specifications and their relationships with performance measurement and control in the wine industry of certain regions. Stylised facts are employed from previous industry studies to explore the applicability of the theory to the wine industry in regions where we have documented evidence for residual claimancy in supply contracts.

To explore predictions from a particular agency relationship between a grape grower and a winery over the supply of grapes for wine production, a multi-tasking model is first developed which encompasses residual claimancy through bottle-price indexing (revenue sharing) and double-sided moral hazard, while allowing for asymmetric quality contributions of the contracting parties.

The model’s comparative static results are employed to provide insights into what factors determine the Pareto optimal shares of the contracting parties. The model predicts that as long as there are observation errors in measuring efforts, and as long as the grape grower is risk averse, the Pareto optimal rate lies strictly between 0 and 1; hence, partial residual claimancy is supported. Thus, strict sharing (partial residual claimancy) finds support in a bilateral moral hazard setting when the agent is risk-averse and faces multiple tasks. Further, the model predicts that with increasing magnitude of the grower’s disutility of effort, and with increasing difficulty of monitoring performance, a greater Pareto share goes to the winery under partial residual claimancy. At the same time, the model predicts that when partial residual claimancy is used, closer coordination (towards integration of grape growing into the processing operation) is to be observed in high-quality regions where the uncertainty of measuring bilateral efforts is likely higher compared with low-quality regions.

Although no formal tests are presented, several model predictions fit with empirical evidence in those wine industries where we have documented evidence that residual claimancy is used, namely in Australia, France, New Zealand and California. Nevertheless, some model predictions may also be applicable to other markets than to the above wine markets, for two reasons. First, when considering Hueth et al.’s (1999) argument that the proprietary nature of contracts implies limited empirical research (and thus evidence) on contracts, the actual use of residual claimancy in global wine markets may be more widespread than the published academic literature suggests. Secondly, we have evidence for multi-tasking and the use of residual claimancy in the sugar beet sector as well as in the market for fresh tomatoes (Hueth and Ligon, 1999; Hueth and Melkonyan, 2002), and we have evidence that residual claimancy is used in the asparagus, the broccoli, the carrot, the onion, the orange, the potato, the squash and the peaches sector of California (Hueth et al., 1999; Wolf et al., 2001; Hueth and Melkonyan, 2004).
The model has made a number of convenient assumptions and has thereby left aside important issues that warrant further analysis. Given the static nature of the model, it ignores *ex post* contract renegotiation and an analysis of its consequences (e.g. Tirole, 1999). The model implies equality in bargaining power between grape grower and winery in implementing contracts. Although the paper has presented empirical evidence which suggests that the balance of bargaining power is not consistently skewed towards the winery, ongoing industry consolidation at the processor level in increasingly global wine markets, as well as grape supply–demand disequilibria (e.g. Fraser, 2005), could change this balance of bargaining power.

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