# Bordeaux 2016 Abstract Submission

**Title**
The Cost of Quality and Monetary Benefits of Adoption of Precision Viticulture Technologies

**I want to submit an abstract for:**
Conference Presentation

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**Keywords**
Precision Viticulture, wine, quality, fruit, price, adoption

**Research Question**
What is the cost of (grape) fruit quality and optimal point of adoption of Precision Viticulture technologies for different sized producers?

**Methods**
It employed the creation of two levelised cost of vineyard production models able to directly compare alternative management practices in the vineyard.

**Results**
The results of this experiment examined levelised cost per tonne under uniform and differential management for all sizes of producers.

**Abstract**
Research into Precision Viticulture has grown substantially since the late 1990’s. Investigators have endeavoured to prove the merits of site specific management, targeted decision making, and efficient use of inputs and resources to gain max profitability from a vineyard. A few projects (Bramley et al. 2005, Cortell et al. 2005, Lamb et al. 2001, Lamb et al. 2002, Proffitt and Pearse 2004, Proffitt and Bramley 2010, Scollary et al. 2008, Trought et al. 2011) have attempted to gauge differences between selective and conventional harvesting practices. The shortcomings of these past projects lie in the methodology associated with economic analysis. In particular, they were limited by the use of theoretical price differentials for fruit quality; and, if further economic analysis was undertaken, only operating costs were included.
Another limiting factor of prior studies is a lack of accurate quality descriptions and parameters. Fruit quality is paramount to final wine quality (Jackson 2008). However, no research has been able to appropriately define quality (of fruit or wine) based on some measurable parameter (Iland et al. 2011, Jackson and Lombard 1993, Jackson 2008). Surrogate measures for objective identification of fruit quality have involved the use of different berry chemistry parameters such as pH, total soluble solids, and titratable acidity (Trought et al. 2011). However, many would argue that simple berry chemistry indices are not indicative of quality and only serve to fulfil a base requirement for harvest (Iland et al. 2011).

So far, adoption of PV technologies has been limited (Arnó et al. 2009) even though Scholefield and Robinson (1999) advocated the potential to “improve production systems by looking over the fence at what other industries are doing.” It is known that early adopters of technology tend to benefit from adoption (Anderson et al. 1977); however a number of factors could be contributing to this lack of adoption. Lamb et al. (2008) cited cost in addition to a lack of knowledge at the consultant level as contributing factors. However, as farmers overall tend to be slightly risk averse (Abadi Ghadim et al. 2005, Bardsley and Harris 1987, Binswanger 1980, Bond and Wonder 1980, Pringle 2012), proximity to and communication with an adopter is also a factor (Kutter et al. 2011). Abadi and Pannell (1999) noted that a farmer is more likely to adopt a new technology if he or she is near to and frequently contacts an adopter. It has been shown that a knowledge gap, and perhaps a level of mistrust, exists between farmers and researchers (Cook and Bramley 1998, Lamb et al. 2008). Lindner (1987) showed that a producer’s conclusion to adopt or reject an innovation is determined by his/her “self-interest” and perceived benefits. This concept of innovation can be extended to PV as a range of technologies.

Another cited reason for this slow adoption rate is a lack of corresponding agronomic research into the benefits or otherwise of Precision Viticulture. Agronomic analysis of Precision Agriculture has been explored more comprehensively than Precision Viticulture. Most of the prominent analysis of PA has centred on cost-benefit and gross margin analysis. However, no study included full cost analysis incorporating both operating and hidden capital costs. Brennen et al. (2007) discussed the importance of including total costs (capital, overheads, and operating) to fully evaluate benefits of PA in an economic analysis.

Levelised cost analysis addresses these deficits. By providing a framework structure that breaks down cost into subunits based on producer size (including dynamics of economies of scale), a unique view of cost-drivers in terms of levelised cost per tonne can be viewed. Additionally, full cost analysis of PV equipment, data acquisition, ground truthing, and implementation is crucial to complete analysis of response functions as determined through PV and vigour interactions. By meticulously “unpacking” cost, the final levelised cost per tonne of fruit production and cost of PV adoption is an objective measure that is attributable to specific items and actions in the production system. This provides a rigour in estimation not demonstrated in earlier research.

Another benefit of this approach is the ability to nominally (dollars/tonne) address “quality” of fruit. As fruit quality is a much debated parameter in the wine industry (Ililand et al. 2011), the ability to assess fruit quality with a measurable unit (dollars/tonne) is necessary. While many have attempted to measure it, no objective scale has been derived to assess fruit quality. There is a large degree of conjecture in the literature with regard to fruit and wine quality and the roles of intrinsic and extrinsic factors on quality and price. Many econometricians have used hedonic regression to show that intrinsic characteristics (sensory and volatile properties of the wine) did not significantly affect price or quality (Lecocq and Visser 2006, Nerlove 1995, Schamel and Anderson 2001, Schamel and Anderson 2003). Others have argued that intrinsic characteristics drive overall quality and price (Cardebat and Figuet 2006, Combris et al. 1997, Combris et al. 2003, Lesschaeve 2007). Still others have acknowledged the short comings of hedonic analysis and recommended a move away from it (Miller et al. 2007, Palma et al. 2013).

Principles of production economics dictate that fundamental to the price of a commodity is a combination of the total cost of production, including operating and capital expenses, and a profit margin for the producer. Consequently, any difference between a price estimate derived from cost of production and the fruit price
received by the grower (observed) can be labelled as “quality premium.” Understanding how quality, as a subjective measure, may be monetised, will help define fruit quality and thus guide the contribution that PV can make to fruit quality.

Past econometric modelling has demonstrated positive benefits of Precision Viticulture at a limited scale, but lacks the fundamental grounding of a full cost analysis. These models have had limited success in demonstrating significant benefits from adoption of PA (Anselin 2002, Florax et al. 2002). However, farmers are more likely to adopt PA technologies after witnessing successful trials and examples (Abadi and Pannell 1999). Analysis derived from econometric models also benefits from ex-post (based on observed results) information such as growing season weather (Anselin et al. 2004, Brennen et al 2007, Bullock and Bullock 2000). This knowledge is unrealistic and does not adequately portray the ex-ante (based on forecasts) decision-making situation. This research is the first of its kind in viticulture to attribute key management practices that determine quality of fruit and the costs associated with doing so.

This research aims to look at fruit quality as determined by cost, and define a Precision Viticulture adoption function that outlines optimal point of PV adoption for grape growers. A levelised approach has been undertaken that includes all costs, including capital costs, associated with fruit production. It is important to include every step from site establishment through harvest to understand all inherent costs incurred to produce one tonne of fruit. Cost is the fundamental component of the fruit pricing matrix which is normally derived from the addition of cost per unit plus (usually) 20% profit margin.

\[
P = \frac{C_{total}}{Yield} + \pi
\]

where

\[
P = \text{fruit price}
\]
\[
C = \text{total cost}
\]
\[
\pi = \text{profit margin}
\]

Any discrepancy between observed price and modelled price can be described as “quality.”

It found that capital and overheads expenses decreased with increasing producer size and that operating expenses remained almost unchanged. Harvesting method was the only activity that changed operating expenses ($/tonne) across all producer sizes. For very small producers it is not economically viable to own or rent a mechanical harvester. For small to very large producers, it is more economically efficient to own rather than rent a mechanical harvester. However, it is acknowledged that often a price premium is paid for manually harvested fruit, hence some small producers, depending on overall size and desired fruit price, may incur the extra cost of manual harvesting to achieve a greater fruit price, as the difference between the two is $125/tonne.

A PV adoption model found that full PV adoption is encouraged for small to very large producers, and not encouraged for very small producers. It should be noted that at the time this thesis was written, yield monitor technology for manually harvesting methods was not commercially available. Therefore, only producers owning a yield monitor are able to gain benefits from the third step of PV adoption (imagery + soil sensing + yield monitoring). As soil sensing is an operation performed only once and requires no capital purchases not incurred through imagery acquisition, all producers (small to very large) saw a measurable increase in benefits from Step 1 to Step 2. Small to very large producers saw ROI from 1-23% (decrease in levelised cost per tonne). It is therefore highly encouraged to adopt imagery and soil sensing technologies and use the data together to make more informed management decisions. Benefits of PV adoption directly increase with size until the large producer category (361-1430 ha) is reached. There is no change in PV benefits between large and very large (