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Does 'Liquid Geography' Facilitate Cooperation or Competition? A Study of Sub-Clusters, Knowledge Exchange, and Innovation in the Wine Industry

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Does ‘liquid geography’ facilitate cooperation or competition? A study of sub-clusters, knowledge exchange, and innovation in the wine industry

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Abstract

The relationships between cooperation and competition are a central element of geographically defined clusters. This article advances an understanding of the cooperation–competition nexus by examining how firms in three regional wine clusters in Australia engage in knowledge exchanges about climate change. The findings suggest that, in the main, firms across all three regions appear to be predominantly engaging in these specific knowledge exchanges within their own narrow sub-clusters. This so-called ‘liquid geography’ is suggestive of a somewhat competitive lock-out posture. However, firms in ‘elite’ sub-clusters appear to be cooperating more via external knowledge exchanges, albeit perhaps with self-interest in mind. The results also suggest that only with respect to adaptive climate change innovations (as opposed to mitigative innovations) do implementation rates differ. This appears to be advantaging firms in elite sub-clusters over all other firms in the regions. Implications are discussed along with future research directions.

Keywords: Climate change, collaboration, competition, cluster, geographic clusters, knowledge, knowledge exchange, innovation, wine

1. Introduction

Firms in geographically defined clusters are thought to benefit from being embedded in localised networks, which are believed to facilitate the diffusion of knowledge and enhance collective learning (Maskell and Malmberg, 1999; Capello and Faggian, 2005; Mitchell et al., 2010). Here, as inter-firm networks develop, they are strengthened through social linkages, cooperation, and trust, all of which facilitate the transfer of knowledge (Keeble and Wilkinson, 1999; Mitchell et al., 2010). This knowledge transfer benefits firms in the cluster, particularly in the area of innovation (Porter, 1990, 2000). However, there remains a tension between cooperation and competition amongst firms within clusters (Polenske, 2004). In fact, according to Cooke (1998), the *central* element of clusters lies in the relationships between cooperation and competition. Hence, under what conditions do firms either engage in or refrain from cooperating with their peers in a geographical cluster?

In the study of the cooperation—competition nexus in clusters, various theories have emerged. You and Wilkinson (1994) suggest that cooperation in clusters is based on horizontal similarities, while Porter (2000) and Sammarra and Biggiero (2001) argue that this cooperation is based also on vertical complementarities. Ottati (2002) indicates that cooperation in clusters is a result of institutional 'intermediaries', which play a central role in supporting, policing, and spreading intra-cluster cooperation. On the other hand, while firms in clusters may cooperate, they remain in competition. This is because their overriding imperative remains that of being competitive and innovative so as to meet the challenges posed by other firms. As Porter (2000, 24) notes, in clusters, a 'similarity of basic circumstances (e.g. labour costs, utility costs), combined with the presence of multiple rivals, forces firms to seek creative ways in which to distinguish themselves'. In other words, they drive competition.

While having improved our understanding of cooperation and competition in clusters, the contributions of prior research are limited in two ways. First, in addition to the theoretical treatments noted above, there is a considerable body of empirical research that examines, for example, cooperation of firms in clusters. This cooperative role includes a wide variety of activities, ranging from lending money (Dei Ottati, 1994), to equipment rental (Lorenzoni and Baden-Fuller, 1995), to the purchase of raw materials (Molina-Morales, 1999). However, not all studies of clusters look at the question of cooperation and competition with respect to knowledge exchange between firms. Yet, given the criticality of knowledge to both individual firms and clusters (Grant, 1996; Maskell, 2001), this is an important area of study. For example, Silva (2005) finds that the fear of a loss of competitiveness can make firms in clusters apprehensive to cooperate through the exchange of knowledge with their peers, while Sammarra and Biggiero (2008) find that clustered firms readily cooperate through the exchange of technological, market, and managerial knowledge. What remains understudied is whether knowledge exchange is confined to certain groups or coalitions of firms within clusters (i.e. competitive lock-out within a cluster), or is widespread across all firms in a cluster (i.e. cooperation within a cluster) (cf. Giuliani, 2007).

Second, do certain issues, challenges, or problems facing a cluster lead to a higher degree of cooperation or competition amongst firms? According to Ansoff (1980), all firms face challenges or business problems that are likely to have a critical impact on their ability to meet their objectives, a condition that holds for firms operating within clusters. Of interest then are which problem domains stimulate the cooperative exchange of knowledge and which ones see firms in clusters withholding or restricting the exchange of knowledge. While R&D continues to be a key challenge or business problem addressed in the literature on knowledge exchange and clusters (e.g. Dumont and Meeusen, 2000; Fritsch and Franke, 2004; Funk, 2014), other problem domains have received far less attention.

In this study of the wine industry, climate change is treated as a central problem domain. This is because the global wine industry appears to be under considerable threat from climate change (Jones et al., 2005; Hannah et al., 2013), and recent scientific evidence suggests changes in climatic conditions by the middle of the century could significantly undermine wine production in places such as Bordeaux, Tuscany, Australia, California, Chile, and South Africa (Hannah et al., 2013).Climate change, therefore, might be expected to be a 'common' challenge amongst wine clusters the world over, one that would motivate wine producers to help one another. Alternatively, as consumers increasingly seek out products from firms that demonstrate sensitivities to the natural environment (Corsi et al., 2013; Delmas and Grant, 2014), innovative wine firms are establishing environmental credentials to gain a competitive advantage and to differentiate themselves from their competitors (cf. Russo, 2003; Atkin et al., 2012). Hence, studying climate change in the wine industry offers a good opportunity to empirically investigate cooperation and competition in clusters.

This paper makes two key contributions. First, it shifts attention to a very specific problem domain: climate change. In this sense, the study advances a more specific understanding of *when* cooperation—or competition—might prevail among clustered firms. In this sense, the study advances a more specific understanding of *when* cooperation—or competition—might prevail with clustered firms. Second, the wine industry has been characterized by so-called 'liquid geography' (Costley, 2012). That is, in wine clusters there are sub-clusters that are seeking to identify themselves as distinctive relative to other sub-clusters in the region. Hence, cooperation and competition might take place at comparatively finer spatial levels within a cluster. This study utilizes data from three key regional wine clusters in Australia, and it appears to be one of the first studies to empirically explore sub-clusters from a knowledge exchange perspective. In addition, it advances understanding of whether or not a cooperative—competitive posture advantages ‘elite’ groups of firms within clusters over other firms within the same geographic boundaries.

2. Theoretical background

2.1. Cooperation and competition in clusters.

Clusters are defined as ‘a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities’ (Porter 2000, 16). Within this geographically bound distinctive, a defining characteristic of clusters is their mix of cooperation and competition (You and Wilkinson, 1994; Cooke, 1998). Hence, there are two aspects to consider. First, there are several means by which cooperation in clusters can be explained. These include Marshallian thought, the ‘Californian School’, modern cluster theory, and GREMI explanations.

Marshallian thought, or standard agglomeration theory, suggests that external economies benefit from the ‘commons’, such that firms that cluster benefit from infrastructure, other services, and knowledge (Marshall, 1920; Porter, 1990; Krugman, 1995). Hence, cooperation may assist the prospect of success of individual firms within clusters through ‘common’ resources. The Californian School suggests that transaction costs increase when the disintegration of productive systems occurs (Scott and Storper, 1986; Scott, 1988; Storper, 1989), clustering of firms therefore being the result of the attempt to minimize transactions costs. As a consequence, firms in clusters are seen to have an incentive to cooperate in situations in which the minimization of transaction costs outweighs other production cost differentials. Alternatively, modern cluster theory emphasizes the trust that develops between actors in clusters (Brusco, 1982; Piore and Sabel, 1984; Mitchell et al., 2010). This trust creates cooperative networks that benefit from repeated interactions and the reciprocal exchange of information and knowledge, which in turn are dependent on geographic proximity (Belussi, 1996). Lastly, the GREMI (*Groupement Européen des Milieux Innovateurs*) group of regional economists argue that clustering enables collective learning processes (Aydalot and Keeble, 1988; Camagni, 1995), which operate 'through skilled labour mobility within the local labour market, customer—supplier technical and organizational interchange, imitation processes…and informal 'cafeteria' effects' (Camagni, 1991, 130). The GREMI argument, therefore, is that cooperation leads to an innovative milieu in the cluster that benefits individual firms.

Though the various theories of clusters and agglomeration economies emphasize the importance of cooperation among firms, competition between firms—the second aspect of the behaviour of clustered firms—is also addressed in their thought. The Marshallian perspectives and the Californian School, in particular, being grounded in neo-classical economic theory, are consistent with views of local economies as a collection of atomistic businesses in competition with each other through price/cost signals. However, theories of cooperation in clusters recognize the benefits of competition. For example, You and Wilkinson (1994) suggest that the competitive aspects of clusters help firms to effectively specialize, as well as helping them to remain flexible to meet market challenges. Porter (1990, 2008) and Martinez-del-Rio and Céspedes-Lorente (2014) note that local *competitive* relations prompt rivalry and increased motivation among a cluster's firms. As one firm within the cluster acts entrepreneurially, the firms in the cluster are compelled to follow and to strive to outperform other firms within their cluster. Thus, while cooperation exists in both vertical and horizontal forms (You and Wilkinson, 1994; Porter, 2000; Sammarra and Biggiero, 2001), an overriding imperative will be one of competition and innovation so as to meet the challenges of other firms in the cluster—and the wider market

(Porter, 2000; Martinez-del-Rio and Céspedes-Lorente, 2014). In essence, the paradox of clusters rests in the trade-off between the benefits of cooperation and the potential loss of competitive advantage.

2.2. Climate change and wine.

Wine grapes are successfully grown in a very narrow climate range and consequently are highly sensitive to changing climatic conditions (Keller, 2010). For example, as little as a one-degree Celsius increase in average temperature can dramatically affect what varieties can best be ripened where, and can potentially affect yield, quality and, ultimately, economic viability (Jones et al., 2005; Keller, 2010). Because of climate change's direct (temperature, precipitation, CO_2 concentration, etc.) and indirect consequences (resource management, energy efficiency, sustainability in production, consumer acceptance, etc.), all facets of wine production are likely to be affected by it (Keller, 2010).

Reports in some parts of the world already claim the wine industry is under stress as a result of climate change (e.g., Fenner, 2009). For example, a major global study has found that in the world's top wine-producing clusters, temperatures have risen in the last 55 years by an average of 1.26°C, and are expected to rise by an average of 2.04°C by 2050 (Jones et al., 2005). Similarly, Hannah et al. (2013) demonstrate that by 2050, due to climate change, viable wine production in Bordeaux and Tuscany could be reduced by 85 percent, in Australia by 74 percent, in California by 70 percent, in South Africa by 55 percent, and in Chile by 40 percent. Thus, the survival of many wine-growing regions around the world could be under threat due to climate change.

To respond to climate change, firms in the wine industry can generally take two approaches: mitigative and adaptive actions (Galbreath, 2011). Mitigative actions are those actions designed to reduce greenhouse gas (GHG) emissions and manage the carbon footprint.

Examples include the reduced use of agrichemicals, the use of new packaging (e.g. lightweight glass bottles), use of alternative energy sources (e.g. solar), and the reduction of refrigeration loads (e.g. overnight chilling). Adaptive actions are those actions designed to adapt to climate change or take advantage of the opportunities it presents. Examples include growing hotter climate varieties, minimizing the use of water, and adjusting canopy management techniques (e.g. increased shading to control for heat stress). The evidence suggests that wine firms are engaging in both types of actions (Galbreath, 2011; Nicholas and Durham, 2012), demonstrating that climate change innovations are an important strategic consideration for producers of wine.

2.3. 'Liquid geography' and the wine industry.

Wine producers and scholars of the wine industry use the term *terroir* to refer to the special characteristics of a place that impart unique qualities to the wine produced (Beverland, 2005). The term originates in the *Appellation d'Origine Contrôlée* (AOC) system in France, and systems similar to the AOC have been adopted by wine-producing regions all over the world. Based upon the geographic location of grape production, these systems are to a large extent, predicated on the notion of terroir. Although the concept of terroir is variously interpreted, its link to geography is widely recognized (Vaudour, 2002).

According to Vaudour (2002), terroir includes the physical environment of geography, including climate, typology, and soil; the identity of geography, including its history; the distinctiveness of geography, including unique cultural features; and the branding of geography, including the marketing of a specific place. These four aspects of terroir overlap to define a wine-producing region by its geography. Research demonstrates the value and importance of geography to wine. For example, in the Willamette Valley in the State of Oregon in the United States, Cross et al. (2011) find that certain geographically-bound and defined vineyards sold for a considerable premium relative to others. The authors argue the findings confirm the critical importance of place, and that geography is perhaps the best way to define terroir. The authors argue the findings confirm the critical importance of place, and that geography is perhaps the best way to define terroir. However, a unique and somewhat overlooked feature of the study of Cross et al. (2011) is their use of *sub-clusters*, a concept that is beginning to gain importance in the study of the wine industry.

Sub-clusters are clear distinctions of 'place' that are become increasingly significant in the wine industry. They include finer geographic designations within a given wine cluster and are referred to by Costley (2012) as 'liquid geography'. For example, California, the largest wine cluster in the United States (Porter and Bond, 2008), has 107 identified sub-clusters, the Napa Valley and Sonoma Valley being amongst the most well-known. According to Costley (2012, 67), 'Industry is recognizing that…sub-regional geographical indicators…are powerful marketing tools, prompting [these sub-clusters] to look for innovative ways to set themselves apart from their counterparts'. This is not only confirmed by the findings of Cross et al. (2011), but is also a feature of the research of Beverland (2005) and Gokcekus and Finnegan (2014).

Beverland (2005) finds that the efforts of producers to protect the status of the sub-clusters within which they operate are marked, for example using authenticity programmes—that are legally enforceable—which permit members to use the sub-cluster name on their labels, or sourcing grapes from within the sub-cluster only. Further, Beverland (2005) finds that a key means of building brand authenticity is by using *place* as a referent, which helps sub-clusters to craft a sincere brand story and to create a means of differentiation with which to compete. In their study, Gokcekus and Finnegan (2014) find that some sub-clusters within Oregon's Willamette Valley have 'split' with other sub-clusters in order to distance themselves from firms with lesser skill as wine producers. Their evidence suggests that this increased sub-cluster identity has led to an increase in both quality and price for these select sub-clusters. Hence, 'liquid geography'

(Costley, 2012), or sub-clusters, appears to be a distinct spatial dimension that is likely to impact on the cooperation—competition nexus in wine clusters (cf. Beebe et al., 2013).

3. Hypotheses

3.1. Climate change and knowledge exchange in wine clusters.

The scientific evidence points to the increasing impact of climate change on wine clusters around the world (Hannah et al., 2013), while actions taken in response to climate change, such as reductions of greenhouse gas (GHG) emissions, appear to benefit wine producers in the marketplace (Galbreath, 2011; Atkin *et al.*, 2012). Thus, climate change poses a 'common' challenge for wine clusters while at the same time advantaging individual firms that take strategic initiatives to respond to it (Atkin et al., 2012; Corsi et al., 2013; Delmas and Grant, 2014). According to theories of economic geography, clusters would be advantageously positioned to respond to an issue such as climate change, mainly due to a geographic proximity that expedites the exchange of knowledge. Such proximity would be particularly conducive to innovation in response to climate change, given that firms require new knowledge to innovate in this area (Slawinski and Bansal, 2012). More specifically, clusters develop strong collective identities, which give rise to a community consciousness that creates an environment for the diffusion and sharing of knowledge about factors affecting focal firms (Scott, 1988; Porac and Thomas, 1995; Martinez-del-Rio and Céspedes-Lorente, 2014). Such diffusion and sharing of knowledge creates an innovative milieu and shared recipes within the cluster (Spender, 1989; Keeble and Wilkinson, 1999), benefiting firm members. However, the movement of knowledge about climate change in and around a wine cluster could be somewhat restricted, for a few main reasons.

First, as wine sub-clusters increasingly seek to create a means of distinction (Gokcekus and Finnegan, 2014), one way these can be achieved is through response to environmental issues such as climate change (Galbreath, 2011). Responding to the natural environment is predicated upon issue identification (Bansal, 2003), which, within clusters, comes through the acquisition of knowledge about the issue (Haugh and Talwar, 2010). Hence, as firms in a given wine sub-cluster attempt to differentiate themselves from other sub-clusters (e.g. through demonstrating sensitivity and response to climate change), the expectation is that they more *readily* exchange knowledge about climate change with members within their own sub-cluster than with members in other sub-clusters.

Second, as sub-clusters develop cohesion and an identity that is distinct in a given wine cluster (Costley, 2012; Schmitt, 2013; Gokcekus and Finnegan, 2014), their members recognize that the decision to engage in knowledge exchanges with others is affected by an awareness of a particular source as a valuable reserve of relevant knowledge (Borgatti and Cross, 2003). As individuals are likely to engage in knowledge exchanges with those whose areas of expertise are known best to them, knowledge exchange is dependent upon individuals' knowing 'who knows what' (Moreland et al., 1996). Evidence suggests that knowing 'who knows what' is bound by geographic proximity (Uzzi, 1996, 1999); therefore, given their proximity, the expectation is that as member firms within a given sub-cluster become aware of each other, develop trust, and gain a sense of relationship, they are more likely to engage in knowledge exchanges *within* their sub-cluster than they are outside of their sub-cluster—that is, with firms who, while remaining within geographic proximity, are likely more distant in terms of *cognitive* proximity (Boschma, 2005). This is because firms can compete on the basis of very specific grape-growing and wine production processes and techniques, where idiosyncratic knowledge can be guarded in an attempt to protect sub-clusters' images and reputations (Costley, 2012; Schmitt, 2013; Gokcekus and Finnegan, 2014).

Therefore, the extent to which cooperation is demonstrated through knowledge exchanges about climate change needs to be considered at the level of the sub-cluster as well as the cluster. While there is evidence to suggest that there are knowledge exchanges between wineries (Nicholas and Durham, 2012), what is not clear is the extent to which this knowledge exchange is relatively open or closed (for exceptions, see Giuliani, 2007; Caple et al., 2010). That is, while the arguments put forth do not discount the possibility of flows of knowledge *between* sub-clusters, the expectation is that competition will be more the norm and that exchanges of knowledge about climate change will be more widespread *within* sub-clusters than between them (i.e. less cooperation and more competition across sub-clusters). Hence:

H1: In the main, knowledge exchange about climate change in wine regions is more prevalent within wine sub-clusters than between them.

Following Cross et al. (2011) and Gokcekus and Finnegan (2014), this paper also recognizes that some sub-clusters have a stronger sense of identity and a better reputation than others. For example, in California, the Napa Valley is considered the preeminent sub-cluster, which has the strongest international reputation (Cuellar and Claps, 2013). The establishment of such premier sub-cluster status is a result of a number of factors. First, history is important. For instance, Champagne is one of the most recognized sub-clusters in the wine world. Having invented and being home to the product of the same name (Guy, 2002), the Champagne sub-cluster in France has a long and rich history that has helped it gain world renown. It has an identity that is virtually unparalleled in the industry (Guy, 2002). Natural endowments are also important. In the Hawke's Bay area of New Zealand's eastern North Island, which covers 800 hectares, their sub-cluster is strictly determined by a tightly specified soil type that has been laid down by the old Ngaruroro River (Costley, 2012). This sub-regional identity enriches the story of wine businesses operating in the sub-cluster, and this story is important in taking the product to market. Similarly, some researchers have argued that sub-clusters have unique natural endowments that are difficult for other sub-clusters to replicate. In Australia, examples include Bordeaux blend wines in Margaret River's sand and gravel over clay, and its maritime climate (Easingwood, 2006). Finally, an analysis of the published empirical evidence demonstrates that some sub-clusters clearly command higher prices for their wines than others (Beverland; 2005; Orrego et al., 2012; Gokcekus and Finnegan, 2014).

Following the literature on economic geography and institutional theory (DiMaggio and Powell, 1983; Pouder and St. John, 1996; Rolfe, 2004), it is expected that more well-established and reputable sub-clusters will engage in more intense levels of knowledge exchange. While Hypothesis 1 predicts more internal knowledge exchanges about climate change than external ones *overall*, because elite sub-clusters have considerable reputations to protect they are likely to have more incentive than other sub-clusters to seek out knowledge from outside their own clique—given knowledge is fundamental to competitive advantage (Grant, 1996). Further, as elite sub-clusters can be considered at the forefront of technology, firms within them would particularly be expected to benchmark themselves against other firms (DiMaggio and Powell, 1983). In this sense, cooperation through knowledge exchange with other firms becomes a gateway to access insight into 'best performers' in various sub-clusters, regardless of whether or not they are in an 'elite' sub-cluster. Accordingly, it seems logical that firms within elite sub-clusters perceive themselves to be at the forefront of wine production (cf. Gokcekus and Finnegan, 2014).

As those considered to be at the forefront of their industry, elite sub-clusters are likely to seek to maintain and extend their competitive advantages. To do this, they have a strong incentive to cooperate with other sub-clusters in their region—those outside of their sub-cluster—by engaging in knowledge exchanges about climate change. Therefore:

H2: The intensity of external knowledge exchange about climate change is greater in elite sub-clusters than in other sub-clusters.

Sub-clusters, knowledge exchange, and innovation

Most wine firms face limitations as to what can be produced and, therefore, to remain competitive, they must continually search for differentiation. Responding to climate change and the natural environment is emerging as a means to differentiate (Galbreath, 2011; Atkin et al., 2012). However, as knowledge underpins innovation and competitive advantage (Cohen and Levinthal, 1990; Grant, 1996), those firms that have greater access to knowledge about climate change are likely to demonstrate higher levels of innovation around it. An argument is put forth that this is impacted by sub-cluster membership.

As sub-clusters increasingly seek to differentiate themselves from other sub-clusters (Costley, 2012; Schmitt, 2013; Gokcekus and Finnegan, 2014), elite collectives can emerge (Abrahmson and Rosenkopf, 1997). These elite sub-clusters are likely to develop strong social, cognitive, and relational proximities that help to support firms within their own narrowly defined geography. These multiple proximities facilitate and protect the sub-cluster identity and advantages (Beverland, 2005), and set it apart from other sub-clusters (Gokcekus and Finnegan, 2014). In this scenario, incentive to gain access to knowledge is higher in elite sub-clusters (Hypothesis 2) while the need to innovate is more compelling.

Following Rolfe (2004), widespread knowledge exchange can advantage an elite sub-cluster's innovation capacity. Because elite sub-clusters perceive that firms within them, as a group, are more successful than firms in other sub-clusters within the region, this leads to imitation. As noted by DiMaggio and Powell (1983, 152), when 'Organizations…model themselves after similar organizations in their field that they perceive to be more legitimate or successful [imitation follows]'. In this sense, because firms in elite sub-clusters are expected to be on the leading edge of knowledge creation and exchange about climate change, they are likewise expected to lead innovation performance. More specifically, because the expectation is that firms in elite sub-clusters cooperate more, not only with each other, but with other firms within the region, they will demonstrate higher innovation levels as they acquire more knowledge. However, in the context of climate change innovations, not all innovations may be equal.

Galbreath (2011) demonstrates that in the wine industry, there are both mitigative and adaptive climate change innovations. Mitigative innovations are predominately related to the management of the carbon footprint, through reductions in GHG emissions and carbon sinks. Given growing public attention to climate change and the effect of human-induced GHG emissions on changing climatic conditions (IPCC, 2007, 2014), evidence suggests that the implementation of mitigative innovations can be a form of legitimacy, which bolsters the overall image and reputation of all firms in a cluster (Martinez-del-Río and Céspedes-Lorente, 2014). Alternatively, a reputation for negative environmental impacts can damage a cluster's image and reputation and those of its member firms (Bansal and Roth, 2000). The expectation, therefore, is that whether or not a firm is in an elite sub-cluster in the wine industry there is a proclivity to ensure a positive response to climate change through mitigative innovations in order to benefit the industry as a whole. This is particularly the case in Australia where market and institutional pressures to demonstrate environmental credentials, in the form of mitigative response, are relatively high (WFA, 2007). According to Martinez-del-Río and Céspedes-Lorente (2014, 134), 'Consequently, there is an objective common interest in geographical clusters to avoid free-riding and to develop not only firm-level but also cluster-level environmental responsiveness'. This results in firms within both elite and non-elite sub-clusters seeking to establish legitimacy and to avoid the consequences of noncompliance (Roxas and Coetzer, 2012). Therefore, as knowledge is exchanged about climate change in and around clusters, this is expected to have a 'cooperative' or more uniform effect in that firms in elite or non-elite sub-clusters will give relatively equal attention to mitigative innovations.

Adaptive innovations, on the other hand, are innovations that seek to adjust to the impacts (current and potential) of climate change or to take advantage of opportunities. Adaptive innovations tend to be risky, because in many cases their implementation requires an inter-temporal orientation that accounts for long-term horizons in which payoffs may be unknown or unquantified, or require investments under a good deal of uncertainty (Slawinski and Bansal, 2012; Galbreath, 2014). Innovations offer firms the opportunity to differentiate if they are proactive and willing to take risks (Galbreath and Oczkowski, 2013), and because firms in elite sub-clusters seek to differentiate themselves from other sub-clusters within the region (Costley, 2012; Schmitt, 2013; Gokcekus and Finnegan, 2014), they are more likely to continually pursue and invest in new opportunities to differentiate themselves in the market, and to create greater distance between themselves and those firms in other sub-clusters. Adaptations to climate change are a means to do this, and leveraging knowledge about climate change exchanged both within the sub-cluster and outside of the sub-cluster can advantage this process. Therefore:

H3: Firms in elite sub-clusters demonstrate higher implementation rates of adaptive climate change innovations than firms in non-elite sub-clusters.

4. Methods

4.1. Sample and data collection.

Conducted in 2012, this study was part of a national survey of the Australian wine industry and the climate change issue. The wine-producing states included in the survey were South Australia, Victoria, and Western Australia. These states were included because they account for around 75 percent of Australia's wine production, and include a good mix of red and white wine producers, of premium and bulk wine producers, and comprise a range of firm sizes. Geographic representation of the regions/sub-clusters under study is displayed in Figure 1. Participants for the survey were drawn from the annual *Australian and New Zealand Wine Industry Directory* (Winetitles, 2012). In South Australia, all 666 producers were surveyed; all 737 producers in Victoria were surveyed; and in Western Australia, all 389 producers were surveyed. Surveys were sent to the CEOs/managing directors of each firm (who were instructed to pass on the survey to a more qualified respondent if necessary given the objectives of the study) and after accounting for undeliverables and surveys that had large amounts of missing data, the effective response rates were 34 percent (207 firms), 34 percent (242 firms), and 30 percent (108 firms) for South Australia, Victoria, and Western Australia, respectively.

[Insert Figure 1 here]

To capture the variables of interest, the survey was designed to measure knowledge exchange about climate change, by sub-cluster, in each state. The sub-clusters in each state were identified using government classifications, available through national peak industry bodies such as the Winemakers' Federation of Australia (Table 1). The survey also contained questions about absorptive capacity and climate change innovations. Control variables were collected from both the survey and secondary sources. All surveys were coded, enabling each firm to be identified by location, including its sub-cluster location.

[Insert Table 1 here]

To test for non-response bias, early versus late respondents were compared on all variables used in the study. Independent samples *t*-tests revealed no significant differences between any of the variables. Thus, nonresponse bias does not appear to be a problem.

4.2. Measures.

Knowledge exchange. To measure knowledge exchange about climate change, different versions of the survey were created to account for the different sub-clusters by state (see Appendix). In any given state version, an initial paragraph explained the implications of climate change to wine production. Respondents were then instructed to consider any knowledge their business held about climate change and had exchanged with firms within their sub-cluster and with firms in other sub-clusters in the state (appropriate sub-clusters were listed for each state, as shown in Table 1). Descriptions of how knowledge could be exchanged were very specific, e.g. formal or informal conversations, email correspondence, site visits, exchanges at educational forums or symposia. In this way, an attempt was made to control for a bias that could be weighted more towards internal versus external knowledge exchanges in the region. A four-point Likert scale was used to gauge the intensity of levels of exchange, which ranged from 'no knowledge exchange' about climate change (1 on the Likert scale) to 'very high knowledge exchange' about climate change (4 on the Likert scale).

To statistically compare differences and to determine levels of cooperation versus competition, proxy measures were calculated in which any level of exchange (2 to 4 on the Likert scale) by each firm internal and external to the sub-cluster was counted as a 1, 0 otherwise (i.e. a firm was assigned a 1 if they had indicated any level of knowledge exchange with firms either in the same sub-cluster or with firms in other sub-clusters in the region). Here, the extent to which firms are cooperating or competing is determined by the intensity of knowledge exchanged with firms within the sub-cluster relative to exchanges with firms outside of the sub-cluster. If there was more knowledge exchanged within than outside of the sub-clusters, this was considered to be a proxy of competitive lock-out (i.e., competition). This level of analysis is used to examine Hypothesis 1. To test Hypothesis 2, an assumption was made that there would likely be some level of external knowledge exchanges for a given sub-cluster. In the case of elite sub-clusters (see measurement below), given the prediction that they would demonstrate relatively more *external* knowledge exchanges than other sub-clusters in the region, these were used as a proxy of cooperation. Regarding Hypothesis 3, given the nature of the Likert scale to measure implementation of climate change innovations, there was a particular interest in those firms selecting a 6 ('implementing now') or 7 ('implemented'); in other words, 'active implementers'. However, to maximize the sample size for this test, all other selections (1 to 5) on the Likert scale were treated as a 0. Means where then calculated on the basis of this protocol.

Elite sub-clusters. Wine quality is one of the most important factors determining the prestige and reputation of a wine producer, as well as of regions and sub-clusters (Cross et al., 2011; Giuliani, 2013). Hence, to determine elite sub-clusters, this study relied on the James Halliday *Australian Wine Companion* (Halliday, 2013). James Halliday is Australia's most well-known and respected wine critic and writer, and has been rating Australian vintages and wines for several decades. Halliday uses a point system, in which wines rated 94 or higher are considered outstanding or elite, and of the highest quality produced in the country. The 2013 version of the guide (covering the 2012 vintage, the same year the survey was completed) was used, and the proportion of wines rated 94 or higher, by firms in each sub-cluster, was examined. Based on the proportions, Barossa Valley (South Australia), Port Phillip (Victoria), and Margaret River (Western Australia) were considered elite sub-clusters for testing Hypotheses 2 and 3. This supports the findings of other Australian and international wine researchers, who demonstrate that Australia's leading and most reputable and prestigious sub-clusters includes Barossa Valley, Port Phillip, and Margaret River (Jones et al., 2005; Aylward, 2004, 2007).

Climate change innovations. Following the formative construct convention (Bollen and Lennox, 1991), for measurement, an extensive literature review was undertaken to create an index of actions for both mitigative and adaptive innovations. The compiled index was assessed by two experts—one academic and the other scientific—in the area of wine production and climate change. Based on their assessment and with continual reference to the literature, each index was narrowed down to seven actions that best typified mitigative and adaptive innovations (see Appendix). Respondents were asked to rate their implementation rates of each action on a seven-point Likert scale, were 1 = not considering to 7 = implemented (see Appendix). OLS regression analysis revealed that significant collinearity was not present between the actions in the mitigative innovation index (highest VIF of 1.66) or for the actions in the adaptive innovation index (highest VIF of 1.78), providing *prima facia* evidence that the formative indicators were suitable (Diamantopoulus and Winklhofer, 2001).

Lastly, key control variables were accounted for. Because knowledge exchanges in clusters can be impacted by internal capabilities (Cohen and Levinthal, 1990), a firm's *absorptive capacity* was measured. A scale was adapted from the study of Delmas et al. (2011). In the survey, respondents were asked to assess 10 items related to absorptive capacity on a seven-point Likert scale, ranging from 1 = strongly disagree to 7 = strongly agree (see Appendix). After item reduction, confirmatory factor analysis (CFA) indicated a good fit (CFI = 0.93; RMSEA = 0.059), with the loads for all the remaining items being significant ($p < .001$). Cronbach alpha was 0.77, demonstrating sufficient reliability. *Age* was measured in number of years since founding. To control for *size*, the number of cases of wine produced was used, where 1 = 1 to 2,499 cases, 2 = 2,500 to 19,999 cases, 3 = 20,000 to 99,999 cases, 4 = 100,00 to 1,499,99 cases, and 5 = over 1,500,000 cases. Because evidence suggests that export orientated firms can be more innovative in the wine industry (Alyward, 2004), export orientation was measured for each firm where 1 = do not export; 2 = 1 to 25 percent exports; 3 = 26 to 50 percent exports; 4 = 51 to 75 percent exports; and 5 = 76 to 100 percent exports. Data for firm age, size, and export orientation were sourced from company websites and the annual *Australian and New Zealand Wine Industry Directory* for 2012 (Winetitles, 2012).

5. Empirical results

Demographics and control variable statistics are presented in Table 2. With respect to the control variables, a one-way analysis of variance (ANOVA) test suggests that there are no differences in firms' absorptive capacities across the states (F = 0.756, p = 0.519). As for firm age, there are statistically significant differences (F = 3.196, p = 0.230), firms in South Australia, on average, being the oldest. There are also differences in firm size (as measured by case production). An ANOVA test is statistically significant (F = 14.659, p = 0.000), and indicates that South Australian firms are the largest. Lastly, an ANOVA tests reveals that there are statistically significant differences in export orientation as well (F = 23.857, p = 0.000), with South Australian firms exporting more product than other states. These differences should be considered in light of the tests of the Hypotheses.

[Insert Table 2 here]

As for Hypothesis 1, that knowledge exchanges about climate change would be more prevalent within wine sub-clusters than between them, for each sub-cluster in each State the mean exchange of firms within the sub-cluster (intra-exchange) was examined relative to the mean of exchange with firms external to the sub-cluster (inter-exchange). To test statistical significance, one-way ANOVA tests were conducted. As for South Australia, with one sub-cluster exception (Southern Flinders Ranges, F = 1.200, p = 0.366), all other sub-clusters are statistically significant (Barossa Valley, F = 23.682, p = 0.000; Clare Valley, F = 11.786, p = 0.000; Fleurieu Peninsula, F = 22.472, p = 0.000; Riverland, F = 3.483, p = 0.013; Limestone Coast, F = 5.509, p = 0.000). The results for the two other states are similar. For Victoria, all sub-clusters are significant (Central Victoria, $F = 19.959$, $p = 0.000$; North East Victoria, $F = 43.251$, $p = 0.000$; Northwest Victoria, $F = 3.347$, $p = 0.010$; Port Phillip, $F = 27.579$, $p = 0.000$; Western Victoria, $F = 10.643$, $p = 0.000$; Gippsland, $F = 5.400$, $p = 0.000$). As for Western Australia, with the exception of three sub-clusters (Peel, $F = 1.000$, $p = 0.495$; Pemberton, $F = 0.896$, $p = 0.526$; Swan Valley, $F = 1.300$, $p = 0.250$), all other sub-clusters are statistically significant (Blackwood Valley, $F = 1.929$, $p = 0.074$; Geographe, $F = 7.044$, $p = 0.000$; Great Southern, $F = 11.001$, $p = 0.000$; Margaret River, $F = 23.431$, $p = 0.000$; Perth Hills, $F = 2.333$, $p = 0.065$).[1] Given that in over 80 percent of the sub-clusters, across three states, knowledge exchange about climate change is much more intense within sub-clusters than outside of them, Hypothesis 1 finds support.[2]

[Insert Table 3 here]

With respect to elite sub-clusters, Hypothesis 2 predicts that elite sub-clusters will engage in external knowledge exchanges more intensely than other sub-clusters. To test the hypothesis, the mean external exchange of knowledge of the elite sub-cluster was compared to the mean external exchange of knowledge of each of the other sub-clusters, by region. For comparative purposes, *t*-tests were used for statistical significance. Table 3 presents the results. As for South Australia, in all cases, the elite sub-cluster Barossa Valley is more actively exchanging knowledge externally than are the non-elite sub-clusters. With respect to Victoria, Port Phillip is found to demonstrate more external knowledge exchange than other sub-clusters; Central Victoria being the only exception ($t = 0.920$, $p = 0.927$). Finally, the findings for Margaret River, Western Australia's elite sub-cluster, suggest that this sub-cluster has more intense external

[1] Note: Manjimup was not calculated as no exchanges were indicated by the one firm surveyed.

[2] To save space, means and standard deviations are not presented. The statistics are available from the author.

knowledge exchanges than all other sub-clusters in the region. Overall, the findings offer support for Hypothesis 2.

Lastly, Hypothesis 3 posits that firms in elite sub-clusters will demonstrate higher implementation rates of adaptive climate change innovations than firms in non-elite sub-clusters. First, the elite sub-clusters across all three states were examined relative to the mean of all non-elite sub-clusters on the implementation rates of mitigative innovations (Table 4). Using *t*-tests, the results suggest that there are no differences in mitigative innovations: in South Australia, there is no difference (t = 1.547, p = 0.124); in Victoria, there is no difference (t = 1.599, p = 0.120); and in Western Australia, there is no difference (t = 0.166, p = 0.869). Second, adaptive innovations were examined. Using *t*-tests, the results suggest that there are statistically significant differences in the implementation rates of adaptive innovations in elite sub-clusters versus non-elite sub-clusters across each state. South Australia demonstrates a difference (t = 2.910, p = 0.012) as does Victoria (t = 3.407, p = 0.001) and Western Australia (t = 2.303, p = 0.023). The findings, therefore, suggest support for Hypothesis 3.

[Insert Table 4 here]

6. Conclusions

Firms within clusters are expected to both cooperate and compete. One way that cooperation and competition can be observed is through the extent to which knowledge is exchanged in the cluster. Given the criticality of knowledge to competitiveness, on one hand, firms can be hesitant to exchange knowledge for fear of losing competitive advantage. On the other hand, the exchange of knowledge can create mutual advantages between firms in clusters. Of importance to both scholars and those in industry is understanding when cooperation and competition might affect knowledge exchange, and if there are implications for innovation.

By relying upon data from 557 firms across three major wine-producing clusters in Australia, this study examined the question by exploring a specific problem domain—climate change—and by seeking to understand how cooperation and competition might be at work in distinctive, narrowly-defined geographic sub-clusters (or so-called 'liquid geography'). Does 'liquid geography' facilitate cooperation or competition? It depends. When asked to what extent firms exchange knowledge about climate change with other firms within their regional cluster, the results suggest that, in the main, they exchange more knowledge with firms within their own sub-cluster than they do those with those outside of their sub-cluster, suggestive of a more protective or competitive posture across the cluster.[3] However, geographically bound firms within the larger cluster that have distinct and considerable reputations to protect, and that are seen as being leading innovators, do more readily exchange knowledge about climate change externally than do firms in non-elite sub-clusters. This suggests greater openness to cooperation, although perhaps with self-interest in mind. The results therefore suggest that rather than a few firms dominating knowledge exchanges because of, for example, superior absorptive capacities, when climate change is considered, groups of firms readily exchange knowledge *within* their own unique sub-clusters, while a distinct group of *elite* firms appear to more regularly span a broader set of firms across the cluster. In this sense, some firms exhibit a restrictedness in the knowledge they exchange about climate change, and others exhibit relative openness to engage in knowledge

[3] Note that physical distance does not appear to be an issue with respect to knowledge exchanges in the sample. For example, firms in Western Australia's Swan Valley reported exchanges with firms in Margaret River (also in Western Australia), these two sub-clusters separated by over 250 kilometres. This suggests that 'built-in' bias towards exchanges with firms only within one's own sub-cluster, due to geographic closeness, is unlikely.

exchange about climate change, each depending on one's 'position' in the cluster. Importantly, this does not appear to depend on the level of development of firms' adsorptive capacities, unlike the findings of Giuliani and Bell (2005), who study only a *single* sub-cluster within a large wine-producing region. Hence, cooperation and competition in clusters exists with respect to the exchange of knowledge, and these appear to depend on the problem domain of study (in this case, climate change) and the spatial level of analysis.

As for the implications for innovation, again, these depend. There is evidence to suggest that knowledge spillovers do benefit the innovation capacity of firms in clusters (Jaffe et al., 1993; Bell, 2005). Further, there is clear evidence that knowledge exchange about climate change in a cluster increases firms' implementation rates of climate change innovations (Galbreath and Oczkowski, 2013). Such positive externalities benefit the whole area (Turner, 2010). However, when do firms in clusters benefit and when do they not benefit with respect to innovation? This study suggests that knowledge exchanges about climate change, whether they are contained within individual sub-clusters or are 'external' in elite sub-clusters, are likely to influence *mitigative* innovations equally. This is likely due to the fact that regardless of sub-cluster membership, there are institutional and consumer pressures upon firms to recognize their common interest in gaining regional legitimacy for how the cluster treats the natural environment and, particularly, how it manages its carbon footprint (Martinez-del-Río and Céspedes-Lorente, 2014). Alternatively, the wine industry has seen a dramatic increase in competition in recent years, which has left firms scrambling to put in place strategies that will help them differentiate themselves from their rivals (Giuliani, 2007; Hussain et al., 2007). This too, may be spatially related.

According to Funk (2014), geographic proximity may be more or less advantageous depending on the degree of proximity. Given that customer power is high and rivalry is very intense in the global wine industry, firms in sub-clusters that have the most at risk (e.g. those with the most recognized reputations or highest innovation levels), are more likely to 'band' together to maintain and further their advantages, rather than diluting them by giving away too much knowledge to firms in 'non-elite' sub-clusters. This study demonstrates that elite sub-clusters do, in fact, have higher implementation rates of adaptive innovations, which are more likely to differentiate them and for which a broad range of knowledge acquisition is likely to be critical (cf. Slawinski and Bansal, 2012). This suggests that finer spatial elements of clusters likely exist, where degrees of geographic proximity can advantage some; others, however, may be disadvantaged by the nexus between cooperation versus competition (Funk, 2014).

In conclusion, while there is considerable understanding of knowledge exchange in clusters, relatively less is known about the conditions under which firms might cooperate or compete on the basis of knowledge exchange. With R&D perhaps being one of the most studied problem domains, this study's point of departure was to examine climate change because of its significance to the wine industry. Further, drawing on the wine literature, we examined so-called 'liquid geography', or spatially defined sub-clusters within larger geographically bound wine-producing regions. The findings suggest that, generally, firms exchange knowledge about climate change within their own sub-cluster (a form of competition or competitor lock-out within the broader cluster), although this is tempered by elite sub-clusters, who engage in more intense external exchanges (a form of cooperation within the broader cluster). This indicates different levels of both cooperation and competition, depending on position in the cluster. It is also found that differences between elite sub-clusters and non-elite sub-clusters exist only with respect to adaptive innovations, suggesting that elite sub-clusters may have greater motivation to differentiate in order to protect or enhance their unique advantages relative to other sub-clusters in a region.

The findings suggest further research is needed to better understand when firms in clusters cooperate—or compete. There are several future research areas to explore, including problem domains such access to talent (i.e. human resources). For example, a key feature of the literature on clusters includes the transfer of knowledge via employee mobility. However, a recent report in the *Wall Street Journal* documents that over 2005 to 2009, some of Silicon Valley's biggest employers (including Adobe Systems, Apple, Google, and Intel) conspired to avoid hiring each other's employees (Catan and Kendall, 2010). In this case, researchers could explore the extent to which such anti-competitive behaviour impacts innovation, particularly in smaller, entrepreneurial firms in a cluster who could be locked-out from gaining access to new talent (and new knowledge and ideas). Future research could also examine the role of cooperation versus competition with respect to specific social issues, such as worker health and safety, obesity, or recycling (Galbreath, 2009). Further, apart from the wine industry's finer spatially-defined sub-clusters, are there certain 'close' or 'elite' groups of firms in other types of industrial clusters who have a greater proclivity to cooperate or compete on a specific problem domain? Additionally, to what extents do these varying proclivities affect innovation levels? In this sense, the role of knowledge exchange is expanded beyond the much-studied issue of R&D and, following Funk (2014), the degree and role of proximity within clusters is more carefully explored.

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Appendix

Variable measurement

*Knowledge exchange**

Please best estimate *how much knowledge* your business has exchanged with other wine businesses in Western Australia about the *climate change issue* (note that knowledge exchange can take place through formal or informal conversations, email correspondence, phone calls, site visits, exchanges at educational forums or industry symposia, etc.).

	No knowledge exchange	Very little knowledge exchange	Moderate knowledge exchange	Very high knowledge exchange
With wine businesses in the Blackwood Valley	1	2	3	4
With wine businesses in Geographe	1	2	3	4
With wine businesses in the Great Southern	1	2	3	4
With wine businesses in Manjimup	1	2	3	4
With wine businesses in Margaret River	1	2	3	4
With wine businesses in Peel	1	2	3	4
With wine businesses in Pemberton	1	2	3	4
With wine businesses in the Perth Hills	1	2	3	4
With wine businesses in the Swan Valley	1	2	3	4

*This is the version for Western Australia. Other versions of the survey are identical excepting the use of different states and sub-clusters.

Mitigative innovations[a]

1. Use of alternative energy sources (e.g. 'green' power, solar, wind) in the overall production of wine.
2. Use of alternative packaging to bottle wine (e.g. use of lightweight glass bottles, plastic PET bottles, recycled bottles).
3. Reduction of refrigeration loads (e.g. night-time air cooling, timing of loads).
4. Energy efficient technology in buildings (e.g. variable speed devices, computer-controlled lighting; use of thermal efficient materials).
5. Minimizing the use of agrichemicals (e.g. petiole analysis, optical weed spray controllers).
6. Alternative fuel use (e.g. biodiesel, ethanol) to power tractors, utility vehicles, machinery, etc.
7. Carbon sinks/sequestering (e.g. reduced tillage, use of compost, planting of shrubs, hedgerows, or trees).

Adaptive innovations[a]

1. Sales of hotter climate varieties.
2. Water–saving techniques in the winery (e.g. water treatment and reuse).
3. Canopy management techniques that address potential increases in temperature (e.g. sprawl trellis systems, leaf-canopy shading, inter-row swards).
4. Establishing vineyards in locations predicted to be less vulnerable to climate risks.
5. Application of vineyard orientations that address potential temperature increases (e.g. east—west row orientation, vineyards planted at angles).
6. Water–saving techniques in the vineyard (deficit irrigation techniques, partial root zone drying).
7. Growing grape varieties that are better suited to hot temperatures.

[a]. 7-point scale were 1 = not applicable, 2 = not considering, 3 = future consideration, 4 = assessing suitability, 5 = planning to implement, 6 = implementing now, and 7 = implemented.

Absorptive capacity[a]

1. Our business experiences difficulties in implementing changes required to meet market demands (reverse coded).
2. Our business quickly recognizes the usefulness of new external knowledge to existing knowledge.
3. Our business regularly reconsiders technologies and adapts them accordant to new knowledge.
4. Practical experiences are rarely shared in the business (reverse coded).[b]
5. We regularly interact with other firms in the region to acquire new knowledge.
6. Newly acquired knowledge is documented and stored for future reference.
7. Our business regularly considers the impact of changing market demands in terms of new products and/or modifications of existing ones.
8. We have difficulty in grasping opportunities for our business from new external knowledge (reverse coded).
9. We constantly consider how to better exploit knowledge.
10. Staff periodically meet to discuss the consequences of market trends to the business.[b]

[a]. 7-point scale ranging from 1 = strongly disagree to 7 = strongly agree.
[b]. Item eliminated based on refinement procedure.

Firm age

Calculated as the year of founding subtracted from the year 2012.

Firm size

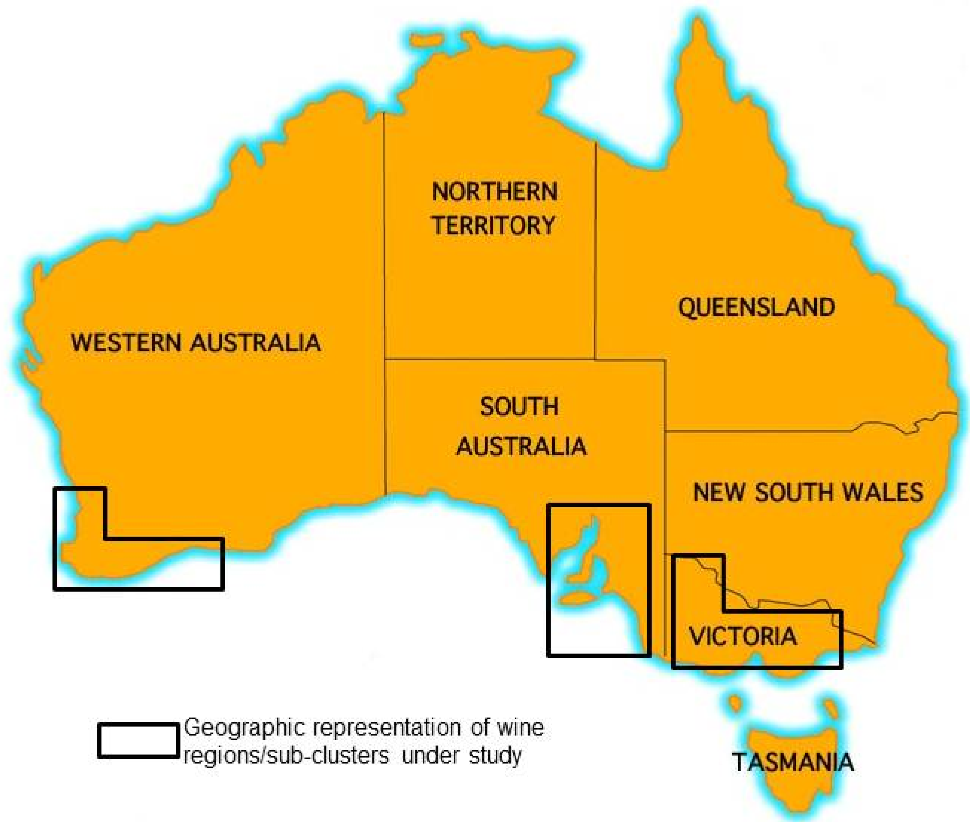
The number of cases of wine produced, where 1 = 1 to 2,499 cases; 2 = 2,500 to 19,999 cases; 3 = 20,000 to 99,999 cases; 4 = 100,000 to 1,499,99 cases; and 5 = over 1,500,000 cases.

Export orientation

Percentage of export sales where 1 = do not export; 2 = 1 to 25 percent exports; 3 = 26 to 50 percent exports; 4 = 51 to 75 percent exports; and 5 = 76 to 100 percent exports.

Figures

Figure 1. Geographic representation by state



Tables

Table 1. Sub-clusters by state

Sub-clusters by state		
South Australia	Victoria	Western Australia
Barossa Valley	Central Victoria	Blackwood Valley
Clare Valley	Gippsland	Geographe
Fleurieu Peninsula	North East Victoria	Great Southern
Riverland	North West Victoria	Manjimup
Limestone Coast	Port Phillip	Margaret River
Southern Flinders Ranges	Western Victoria	Peel
		Pemberton
		Perth Hills
		Swan Valley

Table 2. Demographics and control variables by state

South Australia (n = 207)									
Absorptive capacity		Age of winery		Firm size		Export orientation		Firms by sub-cluster	
Mean	s.d.	Mean	s.d.	Cases	(%)	Cases exported	(%)	Sub-cluster	(%)
4.98	1.01	29.31	38.52	> 1,500,000	1.3	76-100%	7.9	Barossa Valley	43.2
				100,000-1,499,999	6.3	51-75%	10.5	Clare Valley	12.6
				20,000-99,999	19.6	26-50%	25.7	Fleurieu Peninsula	30.1
				2,500-19,999	39.9	1-25%	42.1	Riverland	2.9
				< 999-2,499	32.9	Do not export	13.8	Limestone Coast	9.7
				Total	100		100	Southern Flinders Ranges	1.4
									100

Victoria (n = 242)									
Absorptive capacity		Age of winery		Firm size		Export orientation		Firms by sub-cluster	
Mean	s.d.	Mean	s.d.	Cases	(%)	Cases exported	(%)	Sub-cluster	(%)
4.85	0.91	25.91	29.89	> 1,500,000	1.0	76-100%	2.2	Central Victoria	24.2
				100,000-1,499,999	2.0	51-75%	1.1	Gippsland	4.2
				20,000-99,999	6.9	26-50%	15.6	NE Victoria	17.5
				2,500-19,999	28.7	1-25%	45.3	NW Victoria	4.2
				< 999-2,499	61.4	Do not export	35.8	Port Phillip	39.2
				Total	100		100	Western Victoria	10.8
									100

Western Australia (n = 108)									
Absorptive capacity		Age of winery		Firm size		Export orientation		Firms by sub-cluster	
Mean	s.d.	Mean	s.d.	Cases	(%)	Cases exported	(%)	Sub-cluster	(%)
4.89	1.02	21.46	15.94	> 1,500,000	0.0	76-100%	2.6	Blackwood Valley	6.5
				100,000-1,499,999	1.2	51-75%	1.3	Geographe	13.9
				20,000-99,999	12.3	26-50%	15.8	Great Southern	13.0
				2,500-19,999	50.6	1-25%	39.5	Manjimup	0.9
				< 999-2,499	35.8	Do not export	40.8	Margaret River	40.7
				Total	100		100	Peel	1.9
								Pemberton	6.5
								Perth Hills	2.8
								Swan Valley	13.9
									100

Table 3. Elite sub-cluster comparisons (external knowledge exchange)

Intensity of external knowledge exchange (elite sub-cluster comparisons) by mean (s.d.)

Elite sub-cluster South Australia (Barossa Valley vs. others)							
Barossa Valley	Clare Valley	Fleurieu Peninsula	Riverland	Limestone Coast	Southern Flinders Ranges	*t* -test	significance
0.451 (0.492)	0.325 (0.492)					4.008	0.000*
		0.345 (0.493)				3.904	0.000*
			0.270 (0.446)			7.032	0.000*
				0.250 (0.435)		7.532	0.000*
					0.150 (0.354)	10.669	0.000*

* statistically significant

Intensity of external knowledge exchange (elite sub-cluster comparisons) by mean (s.d.)

Elite sub-cluster Victoria (Port Phillip vs. others)							
Port Phillip	Central Victoria	Gippsland	NE Victoria	NW Victoria	Western Victoria	*t* -test	significance
0.430 (0.496)	0.430 (0.405)					0.920	0.927
		0.140 (0.350)				7.341	0.000*
			0.350 (0.479)			1.685	0.093*
				0.160 (0.370)		6.678	0.000*
					0.250 (0.434)	4.212	0.000*

* statistically significant

Intensity of external knowledge exchange (elite sub-cluster comparisons) by mean (s.d.)

Elite sub-cluster Western Australia (Margaret River vs. others)										
Margaret River	Blackwood Valley	Geographe	Great Southern	Manjimup	Peel	Pemberton	Perth Hills	Swan Valley	*t* -test	significance
0.411 (0.499)	0.170 (0.376)								6.503	0.000*
		0.290 (0.456)							4.150	0.000*
			0.350 (0.478)						3.219	0.001*
				0.150 (0.358)					6.928	0.000*
					0.070 (0.248)				9.197	0.000*
						0.200 (0.399)			5.904	0.000*
							0.070 (0.264)		8.908	0.000*
								0.140 (0.349)	7.149	0.000*

* statistically significant

Table 4. Elite sub-cluster comparisons (climate change innovations)

Climate change innovations (South Australia)					
Innovation type	n	Mean	s.d.	*t* -test	significance
Mitigative innovations					
Elite sub-cluster (Barossa Valley)	89	2.638	1.670	1.547	0.124
Non-elite sub-clusters	117	2.295	1.580		
Adaptive innovations					
Elite sub-cluster (Barossa Valley)	89	3.970	1.300	2.910	0.012*
Non-elite sub-clusters	117	2.874	0.920		

* statistically significant

Climate change innovations (Victoria)					
Innovation type	n	Mean	s.d.	*t* -test	significance
Mitigative innovations					
Elite sub-cluster (Port Phillip)	93	2.322	1.711	1.599	0.120
Non-elite sub-clusters	149	1.988	1.588		
Adaptive innovations					
Elite sub-cluster (Port Phillip)	93	2.676	1.971	3.407	0.001*
Non-elite sub-clusters	149	1.842	1.568		

* statistically significant

Climate change innovations (Western Australia)					
Innovation type	n	Mean	s.d.	*t* -test	significance
Mitigative innovations					
Elite sub-cluster (Margaret River)	44	2.768	1.900	0.166	0.869
Non-elite sub-clusters	64	2.711	1.510		
Adaptive innovations					
Elite sub-cluster (Margaret River)	44	3.039	1.615	2.303	0.023*
Non-elite sub-clusters	64	2.301	1.613		

* statistically significant