An exploratory study of clusters, knowledge exchange, and the climate change issue

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ABSTRACT: *This paper discusses an exploratory study of the climate change issue in the Tasmanian wine cluster. Following cluster theory, we predict knowledge exchange about climate change is widespread in clusters and, further, that it is more widespread within sub-clusters than between them. Finally, we posit that component knowledge about climate change is exchanged more readily than architectural knowledge. Using network analysis and a quantitative approach, all three hypotheses, surprisingly, are rejected. A discussion of the findings and their implications is presented along with future research directions*.

Keywords: Australia, climate change, clusters, knowledge, knowledge exchange, wine

Climate change is leading to business volatility, risk and disruption (Hoffman & Forbes 2011). As a result, the expectations of stakeholders and investors are increasing. They want to know how companies are future-proofing themselves against climate change, whilst maximizing any opportunities it may present. This seems to be especially so for wine production, which is perhaps one of the most sensitive industries to climatic conditions: as little as a one degree increase in average temperature can dramatically affect which varieties can best be ripened where (Keller 2010). Given that wine production takes place mainly in particular territorial clusters (Porter and Sölvell 2010) and clusters have been described as systems of learning and innovation (Porter 1998, 2000), are there insights that can be derived from wine clusters' responses to climate change that helps us to better understand the flow of knowledge between firms, and, therefore, how better to facilitate learning on climate change adaptation more widely?

The idea of the cluster has generated considerable interest among strategy scholars, corporate managers and economic development agencies. However, the concept is still an emerging one. To answer our research question, this paper aims to address two key gaps in the literature. First, Tallman, Jenkins, Henry and Pinch (2004) posit that two types of knowledge exchange exist in clusters: component and architectural. Component knowledge is that which is generally technical, subject to discovery by firms and therefore transferable. Architectural knowledge is tacit, path dependent and therefore more subject to mobility barriers between firms. Unfortunately, too little research has studied the types of knowledge exchanged in clusters (Tallman et al. 2004). This study aims to fill this gap by studying the types of knowledge exchanged in the Tasmanian wine cluster about the climate change issue.

Second, studies of clusters, while focused on issues such as gatekeepers, network centrality, and structural holes, have not fully explored the extent to which 'sub-clusters' within a cluster network differ with respect to knowledge spillovers. More specifically, in the case of wine clusters, there are sub-sets of agglomerated firms that make up cluster-specific regions. For example, in the Californian wine cluster, distinct sub-clusters face unique sets of climatic and production conditions (Porter & Bond 2008). This is an important point, because wine is associated with 'place', or what the French call *terroir* (Seguin & de Cortazar 2005). As sub-clusters seek to build and protect their unique 'place-based' brand identities, little is known about the extent to which they engage in cooperating or exchanging knowledge with other sub-clusters (in the event that doing so does not undermine their competitive advantages). Identifying sub-clusters could be important for this study, because Australian wine producers are being increasingly required to demonstrate their protection and stewardship of the natural environment, including their response to climate change. To fill this gap, the Tasmanian wine cluster and its seven place-based sub-clusters will be explored, adding a new dimension to the previous treatment of clusters as single entities that mutually benefit their members (Harrison 1992).

HYPOTHESES

Wine production is potentially more directly impacted by climate change than almost any business sector. Response to climate change, therefore, may be a key to the long-term survival and sustainability of wine clusters. In the Australian context, there is evidence to suggest that wine clusters have demonstrated an ability to innovate and adapt to changing external challenges (Aylward 2007a, 2007b). This ability to innovate is thought to be driven predominantly by cluster dynamics such as quick access to new knowledge, knowledge spillovers and a centralized research and development program. However, given climate change's documented disruption of wine production (Webb et al. 2010), firms in the Australian wine cluster could be expected to be benefiting from knowledge spillovers about production practices and techniques that respond to climate change (this is in addition to spillovers about the more traditional wine-making practices focused on improving wine quality and the commercial activities of distribution and marketing).

Following cluster theory, clusters would be in an advantageous position in responding in anticipation of climate change because of their enhanced and frequent interactions resulting in acquiring, sharing, diffusing, and creating knowledge (Jaffe, Trajtenberg & Henderson 1993). Within a cluster, such knowledge is widely distributed and freely shared, because the majority of firms in a cluster are more likely to have common norms and values, which, among other things, prevent cheating and opportunistic behaviour (Harrison 1992). Therefore, we argue that accounting for any sub-cluster effects, knowledge spillovers on climate change are free-flowing:

> *Hypothesis 1: Factoring in sub-cluster effects, knowledge exchange on climate change is generally pervasive in wine clusters.*

Following Hypothesis 1, there are two aspects that require further examination: the type of knowledge exchanged and the importance of terroir or specific place. The first aspect is related to the *type* of knowledge exchanged in clusters. Tallman et al. (2004) propose that cluster knowledge can be broadly classified as component and architectural. Component knowledge is knowledge that is specific and related to identifiable parts of an organizational system. Examples include simple engineering knowledge based upon specific scientific principles. In the case of wine, component knowledge could be knowledge about growing grapes or making wine. Component knowledge is generally subject to discovery, relatively transparent and relatively mobile among firms with similar architectural knowledge. Architectural knowledge, in contrast, is tacit, relates more specifically to an understanding of a whole system as opposed to an identifiable part, is path dependent, nontransparent and causally ambiguous, and is embedded within a firm. Examples might include organizational or managerial routines that distinguish one firm's capabilities or core competencies from another (Teece, Pisano & Shuen 1997).

Evidence suggests that, globally, component knowledge in the wine industry has become substantially diffused (Giuliani 2007a). In the case of the Australian wine industry, component knowledge is spread throughout Australian wine clusters (Aylward 2007a, 2007b). National wine peak bodies are promoting and educating members about the technical aspects of responding to climate change and research demonstrates that to date many firms' responses are, in fact, technical in nature (Galbreath 2011;

Webb et al. 2010). Hence, one might argue that the ability of Australian wine clusters to address climate change will be heavily influenced by component knowledge. On the other hand, little evidence demonstrates that architectural knowledge is as freely flowing in or between clusters. This might be due to the fact that any architectural knowledge about climate change would be highly embedded and subject to causal ambiguity, such that it is difficult to describe or exchange. Therefore:

> *Hypotheses 2: Component knowledge on climate change is more readily exchanged than architectural knowledge in wine clusters.*

The second aspect is the idea of 'place', or as described by the French, terroir. This refers to a vine's whole natural environment, the combination of climate, topology, geology and soil, all of which bear on its growth and the characteristics of its grapes and wine (Seguin & de Cortazar 2005). Terroir, then, describes the unique geography of a wine's origin. It is not a property of the wine itself; rather, good wine *reflects* the terroir of its origin (Wilson 1998). Of importance is the fact that a wine's defined origin conveys a meaningful message to buyers and consumers. Given this place-based identity, there is the possibility that firms within a unique location could seek to protect their place-based brand identities, and could therefore be hesitant to cooperate or exchange knowledge with other firms outside of what we might call the 'sub-cluster'—so that they do not undermine their own competitive advantages. We posit that this could be the case in Australia and in wine clusters in general.

In Australia, there has been a recent backlash against the standardised branding approach of Australian wines, controlled by a national peak body, and greater emphasis on the unique wine clusters within the country is being sought. For example, Australia's First Families of Wine, a collective of 12 wine firms worth over AUD$1.2 billion in annual sales, recently broke away from the peak national body's standardized marketing and branding campaigns, to campaigns based on the unique characteristics of the origins of their members. Similarly, in late 2011in Western Australia, the Wine Industry Association of Western Australia revealed its new brand, which also focuses on the uniqueness and origins of its wines. Clear distinctions are being drawn by Australian wine clusters based on the issue of terroir; these distinctions could influence clusters' responses to the climate change issue.

As mentioned, response to the natural environment (including climate change) is viewed as important to the Australian wine industry's sustainability. For example, some of Australia's largest wine markets are calling for environmentally responsible production practices, such as those that demonstrate response to climate change and reductions in greenhouse gas emissions (Russell & Battaglene 2005, 2007). Further, one of Australia's key national competitors, New Zealand, already has 95 percent of its vineyard capacity under a national sustainable winegrowing program, which is significantly lifting their profile in key markets such as the UK (Cooper 2012). Given the growing importance of 'place-based' identities and the potential for competitive advantage gained through stewardship of the natural environment, we speculate that these two factors will affect knowledge exchange about climate change in the Australian wine cluster.

Cluster theory implies that, for example, only those semiconductor firms located in Silicon Valley in northern California would benefit from the unique resources of the semiconductor cluster. However, in wine clusters, as noted, there are sub-clusters that are increasingly identified with place. Given the concept of terroir, we argue that wine sub-clusters develop a sort of protectionism or 'territoriality' (cf. Camagni 2002; Crevoisier 2004) to maintain their given that some consumer markets are increasingly concerned about how wine producers are responding to climate change. While such territoriality could withhold valuable knowledge and resources from the larger cluster network, it would be expected to benefit the sub-cluster. Hence:

> *H3: Knowledge exchange on climate change is more widespread within wine sub-clusters than between wine sub-clusters.*

METHODS

This study focused on the Tasmanian wine cluster. Tasmania was chosen because one of the researchers was in the process of planning a national study on climate change in the Australian wine industry, and the size of the wine cluster in Tasmania made it a good location for an initial small-scale study.

Sample and data collection

The entire population of Tasmanian wine producers was sourced from the Winetitles database, a directory of the Australian and New Zealand wine firms (Winetitles 2010). In all, 97 firms were included. To collect

data, a purpose-designed questionnaire was created. Out of 97 firms surveyed, 38 replied, resulting in a response rate of nearly 40 percent, which is outstanding in the Australian wine industry (Sellitto 2006). However, two firms were eliminated because they were located outside of the seven officially identified sub-clusters, resulting in 36 firms used for analysis. To supplement the main data, we collected demographic information on each company through information contained in the Winetitles database. Key demographics are presented in Table 1.

Measurement of variables

We conceptualized knowledge exchange as a two-way flow, in which knowledge can be exchanged from one firm in a sub-cluster to another firm in that sub-cluster (or other sub-clusters) and vice versa (Sammarra & Biggiero 2008). To measure knowledge exchange, a procedure was developed that varies from a typical network analysis study. Rather than create a roster listing all 97 firms, we listed a roster of the seven sub-clusters within Tasmania. Respondents were then asked to assess knowledge exchange levels (on a four-point Likert scale from 'no exchange' to 'very high exchange') with firms in each of the *sub-clusters*, but not with any specific firm. We mapped these responses onto a knowledge matrix, recording knowledge exchanges with firms in other sub-clusters. The values of cells in the matrix range from cell $ij = 0$, indicating that a firm in sub-cluster i exchanged no knowledge on the climate change issue with firms in sub-cluster j, to '3', indicating that a firm in sub-cluster i exchanged a very high amount of knowledge about the climate change issue with firms in sub-cluster j.

Types of knowledge were developed from the literature and, then, four experts on knowledge exchange and clusters who reside in the United Kingdom and the United States were consulted and a consensus on knowledge type and categorization was formed. Consequently, knowledge types consisted of component (technical, industry and market) and architectural (organizational, marketing and strategy) knowledge (see Appendix).

The respondents were asked to consider knowledge exchanges about the climate change issue, rating how much they had exchanged on each knowledge type (see the above description of the ratings scale). Factor analysis revealed two factors with eigen values greater than one, explaining 83 percent of

the variance. Varimax rotation demonstrated that technical, industry and market knowledge loaded on factor one (α = .88), which was labeled component knowledge. Organizational, marketing and strategy knowledge loaded on factor two (α = .87), which was labeled architectural knowledge.

RESULTS

To test the general pervasiveness of knowledge exchange on climate change (Hypothesis 1), we calculated the proportion of firms, by sub-cluster, reporting any level of knowledge exchange to the total number of sub-clusters in the sample (n=7).[1] The averaged proportion of knowledge exchanged across the sample is .31. The *intensity* of knowledge exchange appears to be mixed. More specifically, respondents were asked to rate the intensity of knowledge exchanges from 0 ('no exchange') to 3 ('very high exchange'). Taking into account knowledge exchanges across all sub-clusters, for those not exchanging any knowledge (0), the averaged proportion is .69. For very little exchange (1), the averaged proportion is .15. For moderate exchange (2), the averaged proportion is .11. For very high exchange (3), the averaged proportion is .05. The results suggest that, when examined across all sub-clusters, less than half of the sample is exchanging knowledge relating to climate change. The findings therefore suggest a lack of support for Hypothesis 1.

Hypothesis two predicted that wine clusters would more readily exchange component knowledge than architectural knowledge. The mean for component knowledge exchange is .82 (S.D. = .71), while for architectural knowledge exchange the mean is .75 (S.D. = .76). To assess differences, *t*-tests were used. The results indicate that there is no significant difference in the type of knowledge being exchanged in the overall sample (p = .48). Therefore, Hypothesis 2 is not supported.

To test if certain sub-clusters are exchanging more knowledge than other sub-clusters (hypothesis three), we first classified each responding firm by its corresponding sub-cluster, including their knowledge exchange ratings. We then calculated the proportion of exchange across each sub-cluster, using this value

[1] To calculate proportions, we created a 36 x 7 matrix that contained each individual firm and the seven sub-clusters. For any given firm, if there was evidence of any level of exchange, either within the sub-cluster or to other sub-clusters, this was counted as a 1. Counts were then divided by the total number of firms within the sub-cluster, which gave us a proportion of exchanges. We repeated this process for each sub-cluster to derive an average proportion of the sub-cluster exchanges, which was then used to calculate an overall averaged proportion for the whole sample. The process was repeated again for each intensity level of knowledge exchange.

to create a matrix for analysis in ORA, Carnegie Mellon's social network analysis software. Figure 1 demonstrates the results of the network analysis. As can be seen, the network analysis graphically reveals knowledge exchanges of businesses in each sub-cluster, and whether these exchanges are internal or external to the sub-cluster. However, to statistically compare sub-clusters, we examined the proportion of exchange within the sub-cluster (intra-exchange) relative to the proportion of exchange with the other sub-clusters (inter-exchange) across each sub-cluster. Analysis of variance (ANOVA) tests were conducted to detect statistical differences in the proportions. In all cases, no statistically significant differences were found (Coal River Valley, $p = .62$, Derwent Valley, $p = .68$, East Coast, $p = .28$, Huon/Channel, $p = .49$, Pipers River, $p = .68$, Tamar Valley, $p = .37$; NB: North West was not calculated as no exchanges were recorded). The findings suggest that companies are not exchanging more knowledge about climate change within their sub-cluster than with other sub-clusters; therefore, Hypothesis 3 is rejected.

DISCUSSION

This is the first study, to our knowledge, that has explored empirically clusters and the climate change issue. Although exploratory, that not one of the hypotheses was confirmed is somewhat surprising. This is particularly the case given that wine production is among the most vulnerable industries to climate change (Galbreath 2011). The results therefore bear upon previous research on knowledge exchange and learning in clusters.

More specifically, although knowledge exchange in clusters has reached almost axiom status in the literature, there is some evidence to suggest that membership in a cluster does not necessarily lead to knowledge sharing or knowledge-based collaboration (Hassink & Wood 1998). In our case, one plausible explanation for the lack of widespread knowledge exchange about the climate change issue, contrary to the prediction of Hypothesis 1, might be clusters' shared mental models and strong collective identities (Porac & Thomas 1995; Saxenian 1994). In the case of shared mental models, firms operating in the various Tasmanian wine sub-clusters might have a similar perspective that sees climate change as a low risk or lesser priority than other challenges to their firm and industry. As for collective identities, Tasmania is a cool climate region; therefore, a community consciousness (Scott 1988) could exist that has

created not necessarily scepticism about climate change (cf. Hoffman & Forbes 2011; Nordberg 2010), but rather a subdued or cautious approach.[2] This is supported by respondent quotes, taken from the questionnaires. For example, one respondent said: 'Very hard for us to say climate change appears to be occurring', while another stated 'You missed the option of the climate cooling over the next decade or more as suggested by several solar scientists!' Lastly, another respondent claimed, '…we may never have to think about changing things in [Tasmania] to counteract global climate change. Alternatively, it may impact us on a more positive perspective…'.

As for the type of knowledge exchanged on the climate change issue, Hypothesis 2 predicted that Australian wine clusters predominantly rely on component knowledge for success, because such knowledge would be more readily exchanged than architectural knowledge. However, the results suggest there is no difference between component and architectural knowledge exchanges on climate change. This might be due to personal, or relational, proximities of the sub-clusters, rather than geographic proximities. Personal, or relational, proximity describes the extent to which relations between actors are personally embedded (Knoben & Oerlermans 2006), meaning they involve trust based on friendship or kinship, and encompass emotional bonds and relationship-based commitment (Boschma 2005). Personal proximity is important to the acquisition of component knowledge as well as to learning and complex problem solving, which both require architectural knowledge exchange (Burt 1992; Hutchins 1991). Another possible explanation for the lack of difference in types of knowledge exchanged might also be due to actors viewing knowledge—even tactic, firm-specific knowledge—about climate change as a 'common' good (cf. Nag & Giola 2012). Here, because climate change is expected to impact firms collectively, architectural knowledge might flow more freely because, according to Crossan, Lane and White (1999), collective knowledge and learning processes stem from idiosyncratic, individual ideas.

[2] However, we note that a 'cool' climate region does not in any way preclude such a region from experiencing the effects of climate change. While there could potentially be some protection from *severe* increases in temperature, cool climate wine regions are nonetheless susceptible to climate change impacts such as rising temperatures, less rainfall, extreme weather events, higher humidity and unpredictable frosts.

Lastly, no differences were found in the knowledge exchanged about climate change within sub-clusters in comparison to exchanges with other sub-clusters, contrary to our prediction in Hypothesis 3. This finding suggests that knowledge about climate change might not necessarily be perceived as a source of competitive advantage. More specifically, we predicted that as wine sub-clusters seek to build, promote and protect unique place-based identities, response to climate change could be viewed as an advantage to a given sub-cluster, and, as a consequence, this could hinder knowledge exchanges with other sub-clusters. Our assumption here does not appear to be correct. This might be due to the nature of climate change knowledge. For example, while McDermott, Corredoira and Kruse (2007) argue that the exchange of knowledge in wine clusters is limited, due to contextualized knowledge and terrior, the application of knowledge about climate change in the wine industry might be more universally applicable. That is, given the reliance of wine upon climatic conditions and the natural environment, regardless of location, knowledge on climate change applied to any one sub-cluster could be equally applicable to other sub-clusters. Therefore, in 'craft-based' communities such as the wine industry, where mutuality and trust are likely to exist (Amin & Roberts 2008), some types of knowledge would be expected to flow more freely between sub-clusters than others.

CONCLUSION

This study aimed to explore whether cluster theories on knowledge exchange help to explain responses to climate change in the wine industry. The results can inform and direct future research. First, from a knowledge-based perspective, the facilitation of learning based on technology and innovation is thought to be the key advantage of cluster membership (Maskell 2001; Porter 1998, 2000), yet the actual type of learning flows that take place within clusters have received limited attention. In the case of climate change, it has largely been described as a cultural and sociopolitical—even moral and religious—issue (Galbreath 2009; Hoffman & Forbes 2011; Nordberg 2010; Okereke, Wittneben & Bowen 2012). The results of this study suggest *nonmarket* (Baron 1995) learning might be a feature of clusters that requires further research, with a closer examination of the motives and benefits of knowledge exchanges that are

nonmarket in nature. Of interest could be studying whether clusters are inordinately successful with nonmarket strategies, as compared to isolated or non-clustered firms.

Second, knowledge exchanges in clusters are dependent upon the type of knowledge (Tallman et al. 2004). That our study found no significant difference in exchange between the two main types of cluster knowledge raised questions for the study of component and architectural knowledge. Architectural knowledge is thought to be less readily transferred in clusters because it is a closely protected source of competitive advantage (Amit & Schoemaker 1993; Barney 1991). Yet, under conditions of relational proximity and member trust, there might be forms of architectural knowledge that can be more readily exchanged and have benefit beyond a focal firm (e.g. political strategies) (Boschma 2005; Knoben & Oerlermans 2006). Similarly, if firms have sufficiently developed absorptive capacity (Cohen & Levinthal 1990), they might more readily assemble, transfer and exploit 'private' architectural knowledge so that flows of this type exist within the cluster. Hence, further research is needed to explore the interactions between component and architectural knowledge, cluster member trust and relational proximity, market and nonmarket learning, and the absorptive capacity of cluster firms.

Third, although not specific to wine, it is an industry that comprises unique *sub-clusters* within regions due to variations in climates, soils, varietals and clones (McDermott et al. 2007), where significant differences can exist within a few kilometers (Deloire et al. 2009). Therefore, success is often grounded in highly context-specific and localized knowledge and practices. However, we found no differences between the knowledge exchanged about climate change between firms in a given sub-cluster and that exchanged between firms in other sub-clusters. One implication of the finding relates to territorial learning, spatial proximity and knowledge exchange in clusters. The prevailing view in cluster theory is that territorial learning depends upon spatial proximity (Amin & Cohendet 2004). In the case of wine, while terrior can be substantially different across sub-clusters, and learning therefore is highly context specific, when faced with uncertainty, firms seek to develop their skills and capabilities by gaining knowledge from outside of the local community of practice (cf. Deakin & Michie 1997; Williamson 1996). In the case of climate change, there are many uncertainties and unknown risks (Winn, Kirchgeorg,

Griffiths, Linnenlueke & Günther 2011). This could, in part, explain the nature of the knowledge exchange across the sub-clusters in our sample, despite differences in spatial proximity (Figure 1). Hence, future cluster research could more carefully explore the relationships between territorial learning, spatial proximity, and the type and content of knowledge. Particular attention could be given to what type of learning (e.g., market or nonmarket learning) most underlies knowledge exchanges and the parameters for these exchanges under various levels of uncertainty.

This study has limitations. First, this was an exploratory study and the sample size is relatively small. However, our study is similar in size to previous studies on wine clusters (e.g. Giuliani 2007a, 2007b; Giuliani & Bell 2005), which generally include smaller samples due to the nature of the industry. Second, data on the main variables of interest were collected through a single source. This has the potential to introduce common method bias. Yet, a Harman's *ex post* single factor test (Podsakoff & Organ 1986) revealed the absence of a single general factor accounting for most of the observed covariance in the variables, indicating that common method bias was likely minimal. Third, our interest was in exploring sub-cluster effects, while foregoing the collection of individual firm ties; therefore, we did not examine network structure, network density and network type (e.g. bridging, linking, bonding), which might have potential influence on the findings. Lastly, our study was isolated to a certain location, therefore generalizability is limited. There is evidence to suggest that climate change is affecting other wine clusters in Australia more significantly than Tasmania (Webb et al. 2010). Hence, studies of other wine clusters in Australia—or in other parts of the world—might produce results that differ from those of this study.

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APPENDIX

Knowledge type items used in the survey

1. *Technical knowledge*: insight on technologies, technical enhancements, vineyard and/or winery techniques that can be applied to address climate change.

2. *Industry knowledge*: know-how gained from peak industry bodies, specialist sources, or employees/peers about addressing industry requirements or government policies on climate change.

3. *Market knowledge*: how to market to 'green' wine consumers, how to enter markets sensitive to environmental credentials, how competitors are responding to climate change.

4. *Organisational knowledge*: how your company has coordinated and supervised organisational resources and processes so that climate change impacts are addressed efficiently and effectively.

5. *Marketing knowledge*: how your company addresses customer preferences, marketing and branding, and new product development as these relate to any climate change requirements.

6. *Strategy knowledge*: insight on your company's strategy, planned competitive moves, long-term business plans, and ability to manage change that relates to climate change.

TABLES

Table 1. Demographics

	Number of Respondents
Sub-cluster	
Coal River Valley	7
Derwent Valley	3
East Coast	6
Huon/Channel	4
North West	3
Pipers River	2
Tamar Valley	11
Other	2
Type of business:	
Grape grower	11
Wine producer	2
Vertically-integrated	23
Ownership:	
Domestic	36
Foreign	2
Number of employees	
Less than 5	29
5-9	3
10-19	3
30 or more	3
Annual revenue	
Less than $1M	31
$1M-$5M	5
$6M-$10M	1
More than $10M	1

FIGURES

Figure 1. Network analysis (agent to location)
Note: thickness of lines represents level of knowledge exchange (very little, moderate, very high)