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AN EXPLORATORY STUDY OF CLUSTERS, KNOWLEDGE EXCHANGE, AND THE CLIMATE CHANGE ISSUE

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ABSTRACT: This study explores the climate change issue in the Tasmanian wine cluster. Following cluster theory, we predict knowledge exchange on climate change is widespread in the overall cluster, while component knowledge on climate change is exchanged more readily than architectural knowledge. We also predict knowledge exchange on climate change is more widespread within sub-clusters than between them. Using network analysis and a quantitative approach, all three hypotheses 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). Response to these is therefore a growing expectation of stakeholders and investors, who want to know how companies are future-proofing themselves against climate change, whilst maximizing any opportunities presented. This seems to be especially the case for wine production. Wine production is perhaps one of the most sensitive sectors to climatic conditions, where 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 is categorized as a cluster (Porter & Sölvell 2010) and clusters have significant economic importance in the global economy (Porter 1998, 2000), are there insights that can be derived revealing how clusters respond to climate change, particularly from a knowledge-based perspective?

The idea of the cluster has generated considerable interest among strategy scholars, corporate managers and economic development agencies. However, 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 is more subject to mobility barriers between firms. Unfortunately, little research has actually studied the types of knowledge exchanged in clusters (Tallman et al. 2004). As a relevant subject for research (Brenner 2007), this study aims to fill this gap by studying types of knowledge exchanged on the climate change issue in the Tasmanian wine cluster.

Second, studies of clusters, while focused on issues such as network centrality and gatekeepers, 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

California wine cluster, there are distinct sub-clusters that face unique sets of climatic and production conditions (Porter & Bond 2008). This is an important distinction 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 as to the extent to which they engage in cooperating or exchanging knowledge with other sub-clusters, in the event that they do not undermine their own competitive advantages. This could be an important distinction in the context of this study, as key Australian wine markets are increasingly requiring the demonstration of protection and stewardship of the natural environmental and response to climate change. This study aims to fill this gap by exploring the Tasmanian wine cluster and its seven place-based sub-clusters. This will help overcome the treatment of clusters as a single entity, where firms are assumed to enjoy mutually the benefits of cluster membership (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 long-term survival and sustainability of wine clusters. In the Australian context, the setting of this study, 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 largely to be driven by cluster dynamics such as quick access to new knowledge, knowledge spillovers and a centralized research and development program. However, given the documented disruption of climate change on wine production (Webb et al. 2010), the expectation is that firms in the Australian wine cluster would also potentially be enjoying the advantage of knowledge spillovers around production practices and techniques that respond to climate change, in addition to the more traditional wine-making practices focused on quality and distribution and marketing aspects.

Following cluster theory, clusters would be in an advantageous position to learn about climate change because of their geographic proximity and spatial dependence (Jaffe, Trajtenberg & Henderson 1993). Here, frequent interactions results in knowledge acquisition, as well as sharing, diffusing and creating it. Knowledge is pervasively distributed and freely shared because firms in a cluster are likely to share knowledge given common norms and values preventing cheating and opportunistic behavior (Harrison 1992). Therefore:

Hypothesis 1: Knowledge exchange on climate change is widespread in wine clusters.

While knowledge exchange on the climate change issue is predicted to be pervasive, there are two aspects that require further examination. 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 to specific scientific principles. In the case of wine, this 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 differs in that it 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 sector has become substantially diffused (Giuliani, 2007a). In the case of the Australian wine sector, component knowledge has openly permeated Australian wine clusters (Aylward 2007a, 2007b). Further, evidence also exists to show that national wine peak bodies are promoting and educating members on the technical aspects of response to climate change and research demonstrates that much of the response to date is 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. This might be due to the fact that any architectural knowledge on 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. Terroir refers to a vine's whole natural environment, the combination of climate, topology, geology and soil that 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 origin could seek to protect their place-based brand identities, and therefore they might be hesitant in cooperating or exchanging knowledge with other firms outside of, what we 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 a potential phenomenon of wine clusters.

In Australia, recently, there has been a backlash against the historic standardized branding approach of Australian wines, controlled by a national peak body, to one that places far more emphasis on the unique wine clusters within the country. 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 standardized marketing and branding campaigns, to one based on the unique characteristics of origin of their members. Similarly, in Western Australia, the Wine Industry Association of Western Australia in late 2011 launched an entirely revamped branding campaign, which focuses on the uniqueness and origin of its wines. Essentially, battle lines are being drawn in Australian wine clusters on the issue of terroir, which might spillover to the climate change issue.

Specifically, response to the natural environment (including climate change) is increasingly seen as critical to the Australian wine sector's sustainability. For example, some of Australia's largest wine markets place strong emphasis on 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 facets have implications for knowledge exchange on 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, or terroir. Given the concept of terroir, we argue that wine sub-clusters develop a sort of protectionism or 'territoriality' (cf. Camagni 2002; Crevoisier 2004) to ensure that their ability to compete in a market that is increasingly concerned about climate change is secured. While the effects on the larger cluster network could be a withholding of valuable knowledge and resources that undermines overall cluster effectiveness and innovativeness, 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 sector at the time, and given the relatively small size of the wine cluster, Tasmania served as a good location for an initial small-scale study.

Sample and data collection

The entire population of Tasmanian wine firms 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 survey 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 sector (Sellitto 2006). However, two firms were eliminated because they were located outside of the seven officially identified sub-clusters within Tasmania, 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.

Insert Table 1 about here

Measurement of variables

We conceptualized knowledge exchange as a two-way flow, where knowledge can be exchanged from one firm in a sub-cluster to another firm in the 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 instead 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 on the climate change issue with firms in sub-cluster j.

For the type of knowledge exchanged, types were developed from the literature and then we consulted with and gained consensus on type and categorization (i.e. component vs. architectural) from four experts on knowledge exchange and clusters who reside both in the United Kingdom and the United States. Knowledge therefore consist of component (technical, industry and market) and architectural (organizational, marketing and strategy) knowledge (Appendix).

For measurement, respondents were asked to consider knowledge exchanges on the climate change issue. They then rated how much they had exchanged on each knowledge type, where 0 = no exchange, 1 = very little exchange, 2 = moderate exchange and 3 = very high exchange. 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 how widespread knowledge is being exchanged on the climate change issue in wine clusters, we calculated the proportion of firms, by sub-cluster, reporting any level of knowledge exchange on the climate change issue to the total number of sub-clusters in the sample (n=7).[1] The averaged proportion of knowledge exchange across the sample is .31. With respect to *intensity* of knowledge exchange, this appears to be somewhat 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 on the climate change issue. The findings therefore suggest a lack of support for hypothesis one.

Hypothesis two predicted that component knowledge would be more readily exchanged than architectural knowledge in wine clusters. The results indicate that 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

[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.

significant difference in the type of knowledge being exchanged in the overall sample (*p* = .48). Therefore, hypothesis two is not supported.

Insert Figure 1 about here

To test if more knowledge is being exchanged within sub-clusters as opposed to 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 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 the 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, note: North West was not calculated as no exchanges were recorded). The findings suggest that companies are not exchanging more knowledge on climate change internal to the sub-cluster relative to other sub-clusters; therefore, Hypothesis 3 is rejected.

DISCUSSION

Although this study is exploratory, that not one of our hypotheses was confirmed is somewhat surprising. This is particularly the case given that wine production is among the most vulnerable sectors to climate change (Galbreath 2011). The results are therefore suggestive for 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 evidence to suggest 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 on the climate change issue, as predicted in hypothesis 1, might be due to shared mental models and high collective identities of clusters (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 low priority challenge. As for collective identities, Tasmania is identified as a cool climate region; therefore, a community consciousness (Scott 1988) could exist that has created an environment not necessarily of skepticism (cf. Hoffman & Forbes 2011; Nordberg 2010), but rather one that embraces a more subdued or cautious approach to climate change.[2] This is supported by respondent quotes taken directly from the surveys. 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 had this say, '…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, we predicted, in hypothesis 2, that due to the high reliance on component knowledge to the success of Australian

[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.

wine clusters, it would more readily be exchanged than architectural knowledge. However, the results suggest that there is no difference between component and architectural knowledge exchanges on climate change. We posit that 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 necessitate 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 across the collective, architectural knowledge might flow more freely because, according to Crossan, Lane and White (1999), collective knowledge and learning processes stem from idiosyncratic, individual ideas.

Lastly, no differences were found in knowledge exchanged on climate change within sub-clusters relative to exchanges with other sub-clusters, contrary to our prediction in hypothesis 3. This finding suggests that knowledge on 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, the expectation is that response to climate change could be viewed as an advantage to a given sub-cluster; therefore, this could hinder knowledge exchange on climate change with other sub-clusters. Our assumption here does not appear to be correct. This might be due to the nature of knowledge about climate change. 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 use of knowledge on climate change to wine might be more universally applicable. That is, given the strong reliance of wine to climatic conditions and the natural environment, regardless of location, knowledge applied on climate change to any one sub-cluster could have relative applicability to other sub-clusters; therefore, in cases of 'craft-based' communities, such as the wine sector, 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 some key gaps in cluster research. The results have implications and offer avenues for 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 has received limited attention. In the case of climate change, in addition to a market issue, it has been described as a cultural and sociopolitical—and 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 successfully 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 has implications 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, there might be forms of architectural knowledge that could have benefit beyond a focal firm (e.g. political strategies) that, under conditions of relational proximity and member trust, might be more readily exchanged (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 such that flows of this type exist within the cluster. Hence, further research is needed to explore interactions between component and architectural knowledge, cluster member trust and relational proximity, market and nonmarket learning and the level of development of absorptive capacity of cluster firms.

Third, although not specific to the wine sector, it is a sector 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 practices of knowing. However, we found no differences in knowledge exchanged on climate change within firms in a given sub-cluster relative to firms in other sub-clusters. One implication of the finding relates to territorial learning, spatial proximity and knowledge exchange in clusters. A dominant logic exists in cluster theory that territorial learning is dependent 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 will attempt to develop their skills and capabilities by relying on knowledge gained 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 knowledge exchange across sub-clusters in our sample, despite differences in spatial proximity (Figure 1). Hence, future cluster research could more carefully explore relationships between territorial learning, spatial proximity and the type and content of knowledge, with a particular emphasis on understanding the parameters for knowledge exchanges under various degrees of uncertainty and the level of learning required.

This study has limitations. First, this was an exploratory study and therefore 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 sector. 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. Lastly, our study was isolated to a certain location, therefore generalizeability 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 found in this study.

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APPENDIX

Knowledge types

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

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

3. *Market knowledge* (e.g. 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* (e.g. how your company has coordinated and supervised organisational resources and processes so that climate change impacts are addressed efficiently and effectively)

5. *Marketing knowledge* (e.g. how your company specifically addresses customer preferences, marketing and branding, and new product development as they relate to any climate change requirements)

6. *Strategy knowledge* (e.g. insight on your company's strategy, planned competitive moves, long-term business plans, and ability to manage change as related 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 (map of Tasmania with specified sub-clusters)