Paper to be presented at
the DRUID16 20th Anniversary Conference
Copenhagen, June 13-15, 2016
Knowledge, clusters, firm performance and Resilience

Martin Mathews
University of Westminster
Strategy and Marketing
m.mathews1@westminster.ac.uk

Stephan Ludwig
University of Westminster
Strategy and Marketing
S.Ludwig@westminster.ac.uk

Peter Stokes
University of Chester
Management
p.stokes@chester.ac.uk

Abstract
This study investigates the role of knowledge in clusters and its relationship to firm resilience. Two knowledge properties are considered: stocks and spillovers. Using the NeoDiane dataset on the French bar-turning industry, the authors investigate whether cluster firms make greater use of knowledge and in turn are more resilient to external economic shocks. The findings, obtained using a structural equation model (SEM), suggest that knowledge features are significantly more prevalent in firms within the cluster. Furthermore, cluster firms were significantly better able to recover net profit margins after the economic crisis. Finally the positive cluster membership effects on resilience are stronger for small firms.

On Knowledge, Clusters, Firm performance and Resilience

Abstract

This study investigates the role of knowledge in clusters and its relationship to firm resilience. Two knowledge properties are considered: stocks and spillovers. Using the NeoDiane dataset on the French bar-turning industry, the authors investigate whether cluster firms make greater use of knowledge than remote, dispersed firms and in turn are more resilient to external economic shocks. The findings, obtained using a structural equation model (SEM), suggest that knowledge features are significantly more prevalent in firms within the cluster. Furthermore, when compared to remote firms, cluster firms were significantly better in recovering net profit margins after the 2009 economic crisis. Finally, the positive cluster membership effects on resilience are stronger for small firms.

Key words: knowledge stocks, knowledge spillovers, cluster, networks, resilience

Martin Mathews

University of Westminster Business School

m.mathews1@westminster.ac.uk

Stephan Ludwig

University of Westminster Business School

Peter Stokes

Chester University

Introduction

Clusters continue to present scholars with a conundrum. Cluster theory and the resource based view suggest that clusters can be considered embedded networks characterised by tacit knowledge stocks and spillovers (Grant, 1996, Kogut and Zander, 1992, Spender, 1996, Pinch, Henry, Jenkins and Tallman, 2003) leading to enhanced performance of cluster firms, as well as improved resilience to external shocks. Yet empirical evidence that cluster firms outperform remote firms is inconclusive (eg. Spencer, Vinodrai, Gertler and Wolfe, 2010, Knoben, Arikan, van Oort and Raspe, 2016). For example, Sorensen and Audia, (2000) find that increased local competition negatively influences firm performance. Conversely, Molina-Morales and Marinez-Fernandez, (2003) and Bell, (2005) show a positive relation between clustering and performance.

Tacit knowledge in clusters can be separated into two components; stocks; the existing knowledge capital of an organization and spillovers (Pinch et al., 2003, Knoben et al., 2016), which are conditioned by the firm's social capital; its ability to access resources in one's network of relations (Bourdieu, 1986, Guilliani and Bell, 2005, Knoben et al., 2016). The majority of research suggests cluster firms benefit from superior knowledge, network flexibility (Poldony and Page, 1998), and cooperative behaviour (Harrison, 1992). However, due to fear of leaking proprietary knowledge inside "hotspots" (Knoben, et al., 2016, Maskell and Malmberg, 2002, Pouder and Saint John, 1996), cluster firms may not trust their neighbours and eschew interactions, controversially resulting in clusters characteristically exhibiting lower levels of knowledge exchanges and spillovers (Staber, 1998).

In addition to the ambiguity surrounding the performance of clustered firms, there is a paucity of insights into what type of firm may benefit from its presence in a cluster. Clusters are considered fertile ground for smaller firms, entrepreneurs and start-ups (Schmitz and Nadvi, 1999) but also saturated, mature markets where newcomers struggle for a foothold (Staber, 1998, Sorensen and Audia, 2000). Knoben et al.'s (2016) recent work presents a more nuanced examination of the performance benefits for different types of firms. In their multi-industry study, they find that the relation between agglomeration and performance is not straight forward but rather depends on various firm-level, industry and agglomeration variables.

Recently scholars have turned their attention to the notion of cluster or regional resilience (Martin 2012), but most research has been conducted at the meso or regional level of analysis and very little investigation at the micro level of whether and how cluster firms may be more resilient than remote firms (Martin, et al., 2013).

Therefore there is a clear need to develop further insights into the knowledge properties of clusters, firm performance and the implications of firm size to improve our understanding of agglomeration effects (Gilbert, McDougall and Audretsch, 2008). Accordingly, this study contributes to existing research on clusters in three respects.

First, we draw on Pinch et al., (2003) and Knoben et al., (2016), to propose and empirically validate a parsimonious model of knowledge in clusters comprised of knowledge stocks and knowledge spillovers. Given the debate around cluster firms' relative ability to use knowledge stocks and spillovers, when compared to their outside competitors (Knoben, et al., 2016, Maskell and Malmberg, 2002, Staber, 1998) and the lack of empirical investigations, we contribute to current research by demonstrating the centrality of knowledge in clusters.

Secondly, we contribute to recent research (Martin, 2012, Christopherson, Michie and Tyler, 2010) by examining cluster firm resilience to economic shocks. Cluster theory suggests that firms inside clusters are more resilient but this has been rarely examined. Previous research on the resilience and clusters in economic geography has concentrated on meso-level and system (network) levels of analysis (eg, Bonnet, 2010, Suire and Vincent, 2015, Martin, Sunley and Taylor, 2015) rather than studying individual firm resilience. The nascent research on firm-level resilience, posits a negative influence of cluster interdependencies during economic recessions (Martin et al., 2013). A rigorous empirical test of this notion, studying the effect of cluster membership on firm performance before and after the 2009 recession, contributes to existing conceptualizations.

Third, cluster dynamics seem to impact different firms in different ways (Knoben et al., 2016, Rigby and Brown, 2015). In cluster research, despite being inextricably linked, the implications of cluster membership and firms' size on performance are consistently studied in isolation. We contribute to prior research on cluster performance and resilience by assessing how firm size and cluster membership jointly relate to resilience to external economic shocks.

In the next section we review research which positions knowledge at the centre of cluster dynamics. We then move onto an examination of our cluster model based on knowledge stocks and knowledge spillovers. We formulate hypotheses aimed at assessing the degree to which such knowledge properties are distinctive to cluster firms, and how they may aid them to be more resilient to external economic shocks and the relative benefits of cluster membership for small and medium sized firms. We then test these hypotheses empirically on bar-turning firms[1] (or screw cutting firms, code NAF 2562a) in operation in France between 2007 and 2013. Data were extracted from the NeoDiane financial dataset. The use of net profit variations spanning the 2009 economic crisis as the dependent variable of interest differentiates this study from the majority of prior research on the performance of firms in clusters. In addition, we investigate how these relationships vary with the size of the company.

We contribute to cluster theory by empirically demonstrating that cluster firms exhibit significantly different levels of knowledge stocks and network relations when compared with remote firms in the same industry. We demonstrate that cluster firms can be considered as knowledge nodes in knowledge networks. Finally we examine the implications and outcomes of this different behaviour in terms of cluster firms' resilience to external shocks and demonstrate that micro-firms in clusters (fewer than 10 employees) seem to be more resilient than other firms in this industry.

Part I : Clusters, Knowledge and Performance

Knowledge flows across organisational boundaries in all industries. The intensity and effects of such spillovers are intensified by spatial proximity (Whittington, Owen-Smith and Powell, 2009, Maskell and Malmberg, 1999). Geographic proximity (accompanied by other forms of proximity) facilitates knowledge sharing, interactive learning and consequently, innovation (Boschma and Ter Wal, 2007).

The role of knowledge in cluster dynamics is well summarized by Pinch et al., (2003, 375);

---

[1] *Décolletage* in French.

'Superior ways of designing, manufacturing and assembling products can be facilitated by tacit forms of knowledge that are embedded in a local context and which are therefore difficult to transfer elsewhere'.

We should not suppose that all districts firms connect, inter-act and exchange knowledge to the same levels. Many district firms simply do not interact with their neighbours (Boschma and Ter Wal, 2007). All district firms do not have equal access to knowledge flows or indeed have equal levels of absorptive capacity (Giuliani and Bell, 2005). Knowledge is not diffused evenly throughout district. Firms have different roles in the creation, acquisition and distribution of knowledge; some are gatekeepers, some propagators, while others remain cognitively isolated. Knowledge is not 'in the air' but flows between cluster firms with varying levels of absorptive capacities; it is a relational asset (Bathelt and Gluckner, 2005, Giuliani and Bell, 2005, Huggins and Thompson, 2013).

Possible sources of competitive advantage for clustered firms lie in their production of, access to, and integration of, knowledge (Tallman et al., 2004), however not all empirical studies point to high levels of knowledge flows between cluster firms, or even whether they source and develop their knowledge locally (see Henry and Pinch, 2001, Nadvi and Halder, 2005, Staber, 2007).

In our cluster model below, building on Pinch et al., (2003) and Knoben et al., (2016), we divide cluster knowledge into stocks, the levels of knowledge possessed by the cluster workforce and spillovers, represented by interactions with other firms and conditioned by the firm's social capital

Both the resource based view and cluster literature concur that knowledge is a critical resource in the construction of a sustainable competitive advantage (Malmberg and Maskell, 2002, 2006, Kogut and Zander, 1992, Grant, 1996). According to cluster theory it is the knowledge rich environment of a cluster which provides a fertile soil for firm performance. In addition to learning through interactions with other local companies, cluster firms have the opportunity to learn through monitoring their neighbours and participating in 'local buzz' (Bathelt, Malmberg and Maskell, 2004, Bathelt and Gluckner, 2005). Similar firms, run by managers with similar educations and backgrounds, pick up on successful experiments and copy them rapidly, sometimes adding idiosyncratic variations. Spatial agglomeration makes interactions and spillovers easier and cheaper, leading to local problem solving and innovation. In the cluster fishbowl, successful strategies are copied and reproduced in a

Darwinian ecosystem of variation, retention and reproduction, (Malmberg and Maskell, 2002, 2006).

Having described a parsimonious model of clusters as knowledge-based networks (see figure 1 below), we shall now turn our attention to the idea of the resilience of firms in clusters. Cluster and industrial district literature proposes a wide range of possible performance indicators, but resilience of individual firms in a cluster has not yet been explored extensively with the exception of Martin et al., (2013) who found little advantage accruing to cluster firms during economic downturns.

Resilience has become a popular research theme in economic geography in recent years, but as with many 'fashionable' ideas it carries its load of approximations and misconceptions. We adopt Martin's (2012, 4) definition of resilience as; 'the ability of a local socio-economic system to recover from shock or disruption'.

Authors have dealt with various issues related to the spatial implications for dealing with external shocks such as the relationship between the resilience of regions and capitalism (Martin, Sunley and Tyler, 2015), or attempted to investigate which factors underscore regional resilience (Christopherson, Michie and Tyler, 2010). Others have examined the resilience of clusters as regional eco-systems (Bonnet, 2010, Suire and Vicente, 2014), or the relationship between resilience and local culture (Huggins and Thompson, 2015), but to our knowledge very few authors have investigated the resilience of individual firms that comprise a cluster when compared with non-clustered firms.

We next develop specific hypotheses about (1) the relative knowledge advantages of cluster firms as opposed to remote firms and (2) the effect of cluster membership on firm resilience.

Cluster firms and knowledge stocks

Tacit knowledge, by definition, resides in the minds of skilled workers who represent the repository of the cluster's knowledge. Agglomeration not only generates knowledge but also creates an attractive market for specialised workers; a key externality for cluster firms (Krugman, 1991, de Vaan, Boschma and Frenken, 2013). Clusters tend to attract operators with better skills because they can reduce their risk. If they lose their job or their firm goes bankrupt, they have the choice of other similar jobs in the same industry in the same region (Ali and Peerlings, 2011). Related research on regional performance demonstrates that workers are more productive where there are high concentrations of employees in the same

sectors and regions. Boschma and Wetterings (2005) found that software firms needed less fulltime employment to develop new products when there were more same-skilled employees present in the region, i.e. concentrations of employees in the same sector lead to higher employee productivity. In a broader study in France, Duranton, Martin, Mayer and Mayneris, (2010) replicated these results showing an increase of productivity of about 5% per worker across several industries. Therefore we would expect a cluster workforce to be more productive than workers from remote firms due to higher levels of industry knowledge (Spencer, Vinodrai, Gertler and Wolfe, 2010). Hence we hypothesize

H$_1$: Employees of firms located inside clusters are more productive than employees in remotes.

Cluster firms and knowledge spillovers

Few firms possess all the resources necessary to achieve organisational goals internally and must therefore access these resources from suppliers, clients and competitors in order to innovate and compete successfully. Firms can choose to manage their knowledge imperatives internally or though links with external partners (Arikan, 2009). Smaller firms, typical of industrial clusters (Pannicia, 1999) and lacking internal resources, will need to combine their knowledge with that of other firms in order to solve problems and innovate.

Clusters provide a larger number of possible local partners to interact with and learn from compared with remote firms. Knowledge exchanges are more effective between firms in clusters because of the cognitive proximity between actors, norms of network reciprocity and trusting relationships which in effect reduce transactions costs (Boschma, 2003, Huggins and Thompson, 2014, Mathews and Stokes, 2013). Common institutions and mind-sets developed in the cluster over time make knowledge more easily transferable through the cluster, thus facilitating coordination and collaboration (Bell, 2005, Malmberg and Maskell, 2002, Pouder and St John, 1996). The exchange and combination of resources (including knowledge) through social and business networks is suggested to be a function of geographic proximity. Lechner and Dowling, (2003) found that cluster firms tend to partner with nearby firms. However Grabner and Ibert (2014) cast doubt on the primacy of proximity as facilitator, claiming that 'hybrid virtual communities' can similarly facilitate interactions without the necessity of geographic proximity. Cluster literature overwhelmingly suggests the primacy of geographic proximity to facilitate inter-firm collaboration (Malmberg and Maskell, 2002), therefore we hypothesize:

H₂: Firms located inside clusters interact with other firms more than remotes.

Furthermore, over time each cluster firm builds up the network links that correspond to their particular knowledge needs, creating closer and closer ties to a portfolio of 'compatible' local firms. In many respects we can talk of the firm's social capital (Caragliu and Nijkamp, 2015), being the capacity to access resources in one's network of relations (Bourdieu, 1986). A more experienced firm learns not only where critical information lies in its network (or the network of friends and colleagues), but also, perhaps more importantly, it will have acquired over time sufficient 'credit slips' (or favours, Coleman, 1990) to be able to access this information. There is a feedback loop between accessing new knowledge and increasing one's stock of knowledge. A firm's employees must possess sufficient preliminary knowledge in order to be capable of absorbing new, related knowledge (Rigby and Brown, 2015). Social capital is an integral element of knowledge spillovers because it is a direct result of a history of intense interactions typical of those found in clusters (Mathews and Stokes, 2013, Caragliu and Nijkamp, 2015). Accordingly,

H₃: Firms located inside clusters have a longer history of interactions with other firms than remotes.

Part II : Cluster membership's effect on firm resilience

Resilience has become a popular research theme in economic geography in recent years, but as with many 'fashionable' ideas it carries its load of approximations and misconceptions. We adopt Martin's (2012, 4) definition of resilience as; 'the ability of a local socio-economic system to recover from shock or disruption'. The notion of resilience is appealing in that 'it attempts to capture the endogenous mechanisms of adaptability' (Crespo, Suire and Vicente, 2014, 200). Central to this theme is the place and analysis of local (and extended) knowledge networks; i.e. cluster membership (Suire and Vicente, 2014, Saxenian 1990).

While the empirical evidence that cluster membership contributes to the resilience of firms is scant, related research on overall firm performance is mixed. Conceptualizing performance as the ability to innovate, Molina-Morales and Martinez-Fernandez, (2003) and Bell, (2005) show a positive effects of cluster membership. Studying the performance of regions, Bonnet (2010) and Suire and Vicente (2014) find that the resilience of a territory is mainly a function of the cooperative links between firms due to geographical proximity in the

context of regional eco-systems. On the other hand, several studies indicate cluster firms are less resilient. For example, Sorensen and Audia, (2000) find that increased local competition in clusters negatively influences firm survival. As the clusters grew, firms were increasingly competing for local resources, leaving smaller firms more vulnerable. Comparing urban areas with industrial districts in Italy, Giacinto et al. (2014) suggest that the productivity of industrial districts tends to be less resilient to major external economic shocks. Given that overall empirical results are inconclusive, our conceptualization of cluster firms' use of flexible networks links, knowledge stocks and spillovers and the proven pivotal role of these elements in sustainability of firm performance (Harrison 1992), leads us to therefore posit:

H4: Firms located inside clusters are more resilient to external economic shocks than remotes.

The inherent inseparability of firm characteristic and cluster membership in any form of agglomeration almost dictates an investigation of the joint effect. Accordingly, recent research has begun to examine the differential effects of firm heterogeneity in clusters on their ability to perform. For example, Rigby and Brown (2015) find that smaller and younger firms in particular benefit from agglomeration. Knobe et al. (2016) show that there is a non-linear interaction between firm level variables and performance. Specifically, their results show that size, internal knowledge stocks and face to face contacts vary across firms and significantly influence firm-level productivity. To the best of our knowledge, neither the effect of firm size, nor its interaction with firm location (i.e. inside or outside a cluster) on resilience has been studied. While larger firms are commonly assumed to be more resilient, previous conceptualizations suggest that the resilience capabilities of small firms in particular could be reinforced through cluster membership (Rigby and Brown 2015). Considering cluster membership and firm size characteristics jointly, we therefore hypothesize:

H5: There is an interaction between cluster membership and firm size, such that small firms inside clusters are more resilient than small firms outside the cluster.

(figure 1 here)

Empirical Results

Study 1: Cluster firms as knowledge nodes and implications for resilience

Setting

In order to test our hypotheses we obtained observational data on a total of 420 bar-turning firms in France extracted from the publically available NeoDiane database of financial results of French firms (NAF code 2562a[2]). NeoDiane also tracks firms's financial results (e.g. net profit) as well as operational elements such as number of employees, age of the managing directors etc., over time. The dataset is updated yearly (2005-2013), based on declarations made by firms to their local chamber of commerce. There are 305 small medium enterprises (SMEs) that operate in the bar turning industry in France. NeoDiane supplies information on the performance of 249 of these SMEs. 52 firm observations were excluded from our analysis due to incomplete data over the study period (e.g. profit statements, data concerning the number of employees, the degree of subcontracting and duration of being in the job of managing director). Furthermore, we excluded 15 firms that were not in operation before the financial crisis. This resulted in a dataset of 197 firms, 85 (43%) inside the cluster (i.e. located in the Upper Savoy département and 112 (57%) outside the cluster (please see table 2 below).

Although industrial districts vary widely in terms of output and indeed structure, and notwithstanding the importance of admitting firm heterogeneity in terms of internal capacities inside a cluster (Ter Wal and Boschma, 2011), we can assume a degree of firm homogeneity in this industry when examining a population of firms within a single economic system. This enables us to analyse the effects on firm performance of belonging or not belonging to an industrial district or cluster (Molina-Morales and Martinez-Fernandez, 2003).

This industry makes for an excellent data set for the following reasons. All of the firms are subcontractors; very few (if any) make their own products. Thus we can exclude elements of firm and performance heterogeneity in terms of product innovation and brand differentiation. Bar-turners are highly skilled technicians who make batches of complex components to order for a large range of downstream industries. They do not carry out any research and development, the innovation (difficult to see, but existing) is process innovation

---

[2] This 5 level nomenclature was created specifically for this industry (bar-turning)

based on tacit knowledge; often realized through networks and partnerships of cooperating firms. In order to improve margins (added value), firms compete to produce more complex components relying on their tacit knowledge built up over years of activity. Production technologies have remained stable since the introduction of numerically controlled lathes in the 1970s and all entrepreneurs use similar machines. The Arve valley is an example of an industrial cluster (based on a detailed regional knowledge of one particular industry) compared with a technology cluster (based on cross-cutting technology and driven by start-ups and spin-offs), as detailed by St John and Pouder, (2006). Firm structure is therefore very similar which allows us to strip out organizational layers and puts the actions of the owner/manager at the center of our analysis.

Measurement Development

We operationalize the dependent variable, resilience to external economic shocks, using the end of the year net profit reported at a yearly basis by each firm in the NeoDiane database. We measure the resilience of each firm by the percentage change in net profit from before to after the economic crisis in 2009. We focus on net profit due to its centrality in strategy research and its previous utilization as a proxy for overall firm performance in cluster research (Visser, 1999).

$$Resilience_i = \frac{[Net\ Profit_{i,t}/Sales_{i,t} - Net\ Profit_{i,t-1}/Sales_{i,t-1}]}{[Net\ Profit_{i,t-1}/Sales_{i,t-1}]} \qquad (1)$$

Where Resilience represents the change in net profit sales ratio for firm i, derived by the average net profit, sales ratio after the crisis t (2010-2013) and the average net profit sales ration prior to the crisis t-1 (2007 and 2008). The greater the net profit sales ratio after the crisis relative to before the crisis in 2009, the greater the resilience of the firm. The resulting dependent variable is a percentage limited to values between -100% loss to 100% gain.

The explanatory variables for resilience are cluster membership and firm size. Cluster membership is derived by the postcode of the firms address. Where all firms with a postcode beginning with 74 (Savoy department) are located in the Arve Valley industrial cluster (which is in fact highly concentrated in an Alpine valley around the town of Cluses). We computed a dummy variable that was 1 if a firm is located within the cluster and 0 if the firm operates outside the cluster. Firm size was similarly obtained from the NeoDiane database. We took the average amount of employees per firm as an indication for firm size if they had

recorded their number of employees for at least 4 years (in the 7 year observation period). In order to assess whether clusters display higher levels of knowledge stocks and spillovers we analyzed the following variables; added value per employee, the age of the company and the level of subcontracting.

Firstly, added value per employee is a reflection of the stock of a firm's knowledge (Rigby and Brown 2015). Given the standard technology employed in the sector (computer controlled machine lathes) higher productivity is a reflection of higher levels of tacit knowledge. Secondly, in a craft industry such as bar-turning, the age of a firm is a good proxy for history of interactions. As knowledge is gained over time when workers solve production problems, either with co-workers or external partners (Boschma and Wetterings, 2005, Boschma and Frenken, 2013, Krugman 1991, Giuliani and Bell, 2005). Thirdly, regarding knowledge spillovers, firms can choose to develop knowledge internally but also with external partners (Arikan 2009). Higher levels of subcontracting signify greater knowledge flows. The degree to which firms subcontract (expressed as a ratio of external purchases over sales) is an indication of their network connectivity and therefore learning opportunities. (Huggins and Thompson 2014, Malmberg and Maskell, 2002, 2006, Pinch et al. 2003). The overview of the operationalization of the variables and the sample are included in table 2. We also supply a comparison overview between firms inside and outside the cluster to show the mean differences (of lack thereof) between the firms. The average resilience is negative, with an average reduction in net profits per sales of .29% outside-, and .05% inside the cluster. The relatively large standard deviation in table 3 indicates however, that although firms tend to do worse following the crisis, a sizable number do not. The correlation table further indicates that multi-collinearity should not be an issue (please see table 3).

[please insert table 1 here]
[please insert table 2 here]

Results

To test the hypotheses we formulated, we employed structural equation modeling using STATA 13 to obtain maximum likelihood estimates of the free parameters in our conceptual framework. Figure 1 displays the model structure corresponding to the hypotheses. Our sample size of 197 in the final model meets the criteria by Tanaka (1987) and Bentler & Chou (1987). The χ^2 statistic indicates a good fit between the theoretical model and the data, χ^2 (5) = 13.41, p = .019. Other indices are also indicative of a good fit: Comparative fit index (CFI) = 0.91; root mean square error of approximation (RMSEA) = 0.086. All measures exceed recommended conventional cutoff values (Bagozzi and Yi 1988; Jöreskog and Sörbom 1989). Hu and Bentler (1999) suggest more stringent cutoff values: 0.95 for CFI and TLI and 0.06 for RMSEA. However, Hu and Chou maintain that decreasing the cutoff value for RMSEA could increase Type I errors, especially given the small sample size. Furthermore, the values of the χ^2/df ratio also indicate a good fit of the data to the hypothesized model (Bagozzi andYi 1988; Hoelter 1983). Inspection of the standardized residuals show that none of these exceeded the absolute value of 2.58, the cutoff value suggested by Jöreskog and Sörbom (1989).

Inspection of the path coefficients allows us to test our hypotheses (please see table 4). Considering the endowment of knowledge stocks and knowledge spillovers we find that, in support of hypothesis 1, there is a significant positive relationship between the employee productivity and cluster membership (standardized path coefficient = 0.245; z value = 3.74; p < 0.05). Therefore firms within clusters characteristically have significantly more productive employees than firms outside the cluster. Regarding hypothesis 2, we find that firms within clusters characteristically network more with external partners (standardized path coefficient = 0.174; z value = 2.60; p < 0.05). Given its role as an indicator for knowledge spillovers (Guiliani and Bell, 2005), the significantly larger amount of subcontracting by firms within clusters demonstrates their potential to access external knowledge sources. Moreover, in line with hypothesis 3, cluster firms also have a longer history of networking than remotes (standardized path coefficient = 0.217; z value = 3.29; p < 0.05). As such, firms within clusters should possess more knowledge thanks to previous interactions (Malmberg and Maskell, 2002). Considering resilience, we find support for hypothesis 4. Clustered firms recover better from external economic shocks in terms of their net profits than remotes (standardized path coefficient = 0.158; z value = 2.27; p < 0.05). Thus, when considering the

change in net profit from before to after the economic crisis in 2009, firms within the cluster were less negatively affected than firms which operate in dispersed locations.

Furthermore, we find weak support ($p < 0.1$) that larger firms are more resilient to economic shocks than small firms (standardized path coefficient = 0.126; z value = 1.81; $p < 0.1$). This is in line with previous findings by Martin et al., (2013). We find that the return on capital equity (ROCE) before the crisis has a positive effect (standardized path coefficient = 0.145; z value = 2.10; $p < 0.05$) on the ability to recover from an external economic shock. Notably this positive effect may, to a large part, also be explained by investment's negative impact on profits. Hence larger investment before the crisis would imply that profits were also potentially lower than usual, resulting in a less drastic change in profits from before to after the crisis.

Study 2: The Combined Effect of Cluster Membership

Setting

In the second part of this study, we examined how the ability to be more resilient is influenced by the location of the firm (inside the geographical cluster or outside) and firm size. Drawing on Schmitz and Nadvi, (1999) we expect micro companies to fare better inside the cluster. Following the approach outlined for study 1 we constructed our proxy for resilience as the change in net profit and sales ratio from before to after the economic crisis in 2009 (please see equation 1). Similarly we continue to use the postcode '74' as an indicator for firms inside the cluster (coded 1) or outside (coded 0). For the purpose of assessing the interaction effect between firm size and location we recoded the firm size into 1 if there were 10 employees or less (micro firms) and 0 if there were 11 or more employees in the firm (please see table 2 for an overview). This created a 2 (location: inside or outside) $\times$ 2 (firm size: micro or small) factorial design.

Results

We conduct a two-way ANOVA for resilience across firm location and size. As predicted in Hypothesis 5, we find a significant interaction effect (6.080, $F_{(1,197)} = 7.67$, $p < 0.05$, $\eta^2 = 0.038$). To further investigate whether it is truly micro firms which tend to be more resilient inside clusters we conducted a post-hoc test to contrast the individual combinations of firm

size and location (Figure 3). Indeed, micro firms inside the cluster were significantly more resilient than micro firms outside the cluster (t= 3.38, p < 0.05). Notably, for medium firms we find no significant difference in resilience depending on where they are located (t = -.0.23, p = 0.816). We discuss the implications in the following section.

Discussion

This study contributes to contemporary research on agglomeration by delineating and empirically validating the centrality of knowledge stocks and spillovers in clusters. Furthermore we extend current research on the performance implications of cluster membership by showing the superior resilience of cluster firms to external economic shocks. Finally, beyond the stand-alone effect of cluster membership and firm size, we underscore the importance of their joint consideration. Specifically, micro firms rebound better if they are situated within a cluster. We extend extant research in three important ways.

First, most research on clusters postulates the centrality of knowledge (Maskell and Malmberg, 2002) such that clustered firms exhibit greater levels of knowledge stocks and spillovers. We offer new insights to the the debate surrounding cluster firms' relative knowledge stocks and spillovers when compared to remotes. Concurrently to Bathelt and Gluckner, (2005), Boschma and Wetterings (2005) and Boschma and Frenken (2013) we confirm that employees in the Arve Valley industrial cluster are more productive than remote firm employees. In an industry with so few possibilities for differentiation, our findings suggest that cluster workers possess more tacit knowledge and higher technical skills than remote workers, making them more productive. These technical skills allow cluster firms to demand higher prices (therefore higher margins) for the fabrication of more sophisticated components.

Furthermore, in line with Harrison (1992) and Arikan (2009) but contrary to Staber, 1998 and Boshma and Ter Wall (2007), we empirically demonstrate that cluster firms characteristically show higher levels of inter-firm interactions. They therefore do not seem to be concerned with losing proprietary knowledge to local competitors, but exchange knowledge and local 'buzz' in order to combine these sources into generating new knowledge (Maskell et al., 2006, Giuliani and Bell, 2005). Apart from appropriating new knowledge, outsourcing allows bar-turners to buy in specialized services and components. This allows cluster firms to concentrate on their core capabilities, thus increasing their knowledge levels in specialized

domains (Prahalad and Hamel, 1990). The feedback loop, specialized workers, higher levels of specialized activities leading to more specialized workers typifies processed based innovation in mature industries (Frenken et al., 2015).

Finally, in line with Caragliu and Nijkamp (2015) we find that cluster firms have a longer history of interactions. They have acquired the knowledge of where certain types of tacit knowledge are located in their networks. If they have behaved correctly in precedent interactions, they may acquire this information through collaboration with other district firms. Higher levels of technical skills and tacit knowledge lie partly in the quality of initial training and education but also in the relational dynamics of the cluster and the notion that knowledge itself is a relational asset (Guiliani and Bell, 2005, Boschma and Ter Wal, 2007).

Secondly, in accordance with Molina-Morales and Martinez-Fernandez, (2003) and Bell, (2005) but in contrast with Sorensen and Audia, 2000) and Giacinto et al. (2014), we note, when considering resilience as an important performance indicator, that cluster firms are less affected by external economic shocks than remotes. Although cluster firms were not immune to the economic downturn in 2009 they were less negatively affected than remote firms and restored their margins more rapidly than remotes. Given the higher levels of knowledge stocks and spillovers typical of cluster dynamics, this resilience may stem from their capacity to demand higher prices for more sophisticated components thanks to their superior levels of tacit knowledge and network links.

Thirdly, in line with Rigby and Brown (2015), we find that micro cluster firms recovered quicker than micro firms outside the cluster. Smaller firms benefit more from being situated in clusters than remotes. This finding also supports Knoben et al., (2016) who found that medium sized firms were at a disadvantage in absorbing knowledge. Following this, we argue that smaller firms are more receptive to external knowledge and are more capable of capturing the knowledge in their immediate environment. Starbuck (1976) coined the term 'environmental munificence', meaning the extent to which the environment can sustain growth. It would seem that clusters can provide the requisite knowledge which helps micro-firms resist adverse economic situations. Our findings indicate that micro firms, having fewer resources internally, rely more on their external environment for the key resource of knowledge.

<u>Limitations</u>

Our results contribute to recent research suggesting that clustering can be interpreted through the lens of knowledge generation, circulation and acquisition. However, several limitations of our study provide worthwhile avenues for future research. First, although our operationalization of knowledge stocks as the added value per employee, knowledge spillovers as the degree of subcontracting and experience of inter-firm interactions are consistent with prior research, additional research should involve uncovering other knowledge indicators that differentiate clustered firms from remotes and in turn entail performance implications.

Second, our modeling approach takes into account the change in net profit, as a key economic performance indicator, from before to after the crisis; however, future research may test the implications of our knowledge characteristics on alternative performance indicators (e.g. sales growth, amount of patents, new product development etc.). Moreover, while the age of a firm represents its experience and capacity to access and acquire knowledge from other firms, more fine-grained measures using comprehensive surveys may improve our understanding of the pivotal role of social capital in clusters.

Third, given our focus on knowledge centrality in clusters, we studied a large scale sample of similar SMEs in the bar-turning industry, because it is a craft industry based largely on exploiting tacit knowledge. However, this particular context also implies that advantages accrued to cluster firms is limited to process innovation, further research may study the knowledge implications in industries where product development is more important. Such research may further enhance the understanding of the importance of knowledge stocks and flows next particularly in terms of product innovations.

Any attempt to capture the complex dynamics of economic agglomeration will always run into limitations as it is extremely difficult to isolate geographic location as an independent variable. A limitation of this study was the incomplete nature of the dataset used. We attempted to capture an entire population of firms in the same industry but for reasons described above we were obliged to reduce the total numbers of firms sampled.

Conclusion

In this paper we contribute to the literature of agglomeration in three ways. Firstly, we elaborate and test a knowledge based model of the cluster. We then investigate whether and under what conditions firms may benefit from agglomeration. Thirdly, we examine which type of firm benefits from agglomeration. In order to examine these questions we chose an industry which demonstrated a very clear cluster/remote dichotomy and one in which many possible sources of firm heterogeneity were absent, thus increasing the relevance and weight of the independent variable; cluster membership.

The particular structure of the bar-turning industry means that firms pursue higher value added manufacturing as a strategy to maintain margins and profits. This strategy relies on the accumulation and exploitation of tacit knowledge which is considered central to cluster dynamics (Malmberg and Maskell, 2002, 2006). Cluster firms in this industry demonstrate the primacy of knowledge as a source of competitive advantage. Cluster workers were more productive, indicating higher levels of technical and tacit knowledge while cluster firms network more and are significantly older than remote firms. The reason that these factors may not feed directly into higher profit levels could be because of the sharing of margins when firms conjointly produce more sophisticated components.

Our findings suggest that cluster firms suffered less from the 2009 recession because they were able to continue to obtain higher value added work from customers thanks to the higher levels of knowledge available to them internally and through their network links. Micro firms (fewer than 10 employees) suffered less than micro remotes because more of their resources are situated externally to the firm but internally to their network; demonstrating that cluster knowledge is a positive externality. This finding raises interesting theoretical questions concerning the boundaries of the firm. Larger and more technologically advanced firms may suffer from knowledge leakage (Knoben et al., 2016) but larger firms (between 10 and 50 employees) seem to have struck the right balance between internal and external resources. In this way we contribute to the recent literature illustrating how agglomeration may have differing effects on different types of firms.

We could consider this industry as special or particular, but our findings suggest that agglomeration may supply advantages to knowledge intensive craft industries rather than to all agglomerated industries. The value of this research lies in its confirmation of knowledge as the central factor in clusters and its importance for firm resilience.

References

Ali, M., and Peerlings, J., (2010), Value Added of Cluster Membership for Micro-Enterprises of the Handloom Sector in Ethiopia, World Development, 39, 363-374

Arikan, A.T., (2009), Interfirm Knowledge Exchanges and the Knowledge Creation Capability of Clusters, Academy of Management Review, 34, 658 - 676

Bathelt, H., Gluckner, J., (2005), Resources in Economic Geography: From Substantive Concepts Towards a Relational Perspective, Environment and Planning A, 37, 1545-1563

Bathelt, H., Malmberg, A., Maskell, P., (2004), Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation, Progress in Human Geography, Vol. 28, 31-56.

Bell, G.G., (2005), Clusters, Networks and Firm Innovativeness, Strategic Management Journal, 26, 287-295

Bagozzi, R.P. and Yi, Y. (1988), "On the evaluation of structural equation models", Journal of the Academy of Marketing Science, Vol. 16, Spring, pp. 74-94

Bonnet, N., (2010), What do innovation networks really do for local development?, 50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden

Boschma, R.A., Weterings, A.B.R., (2005), The Effect of Regional Differences on the Performance of software Firms in the Netherlands, Journal of Economic Geography, 5, 567 – 588

Boschma, R., Frenken, K., (2010), The Spatial Evolution of Innovation Networks: A Proximity Perspective. In R. Boschma, R. Martin (eds) The Handbook of Evolutionary Economic Geography, pp120-135. Cheltenham: Edgar Elgar.

Boschma, R.A., Ter Wal, A.L.J., (2007), Knowledge Networks and Innovative Performance in an Industrial District: The Case of a Footwear District in the South of Italy, Industry and Innovation, 14, 177-199

Boschma, R.A., Wetterings, A.B.R., (2005) The Effect of Regional Differences on the Performance of Software Firms in the Netherlands, Journal of Economic Geography, 5, 567-588

Bourdieu, P., (1986), The Forms of Capital, Richardson, J., (ed), Handbook of Theory and Research for the Sociology of Education, Westport, CT, Greenwood, 241 - 58

Caraglia, A., Nijkamp, P., (2015), Space and Knowledge Spillovers in European Regions: the Impact of Different Forms of Proximity on Spatial Knowledge Diffusion, Journal of Economic Geography, December, 1 -26

Christopherson,S., Michie, J., Tyler, P., (2010), Regional Resilience : Theoretical and Empirical Perspectives, Cambridge Journal of Regions, Economy and Society, 3, 3-10

Coleman, J.S., (1990), Foundations of Social Theory, Belknap Press, Cambridge, Massachusetts.

Crespo, J., Suire, R., Vincente, J., (2015), Network Structural Properties for Cluster Long-run Dynamics: Evidence from Collaborative R&D Networks in the European Mobile Phone Industry, Industrial and Corporate Change, 1 – 22

Duranton, G., Martin, P., Mayer, T., Mayneris, F., (2010), The Economics of Clusters. Lessons from the French Experience, Oxford University Press, Oxford.

Frenken, K., Cafis, E., Stam, E., (2015), Industrial Dynamics and Clusters: A Survey, Regional Studies, 49, 10-27

Di Giacinto, V., Gomellini, M., Micucci, G., Pagnini, M., (2014), Mapping Local Productivity Advantages in Italy: Industrial Districts, Cities or Both? Journal of Economic Geography, 14, 395 - 394

Gilbert, B.A., McDougall, P. P., Audretsch, D.B., (2008), Clusters, Knowledge Spillovers and New Venture Performance: An Empirical Investigation, Journal of Business Venturing, 23, 405-422

Giuliani, E., Bell, M., (2005), The Micro-Determinants of Meso-level Learning and Innovation: Evidence from a Chilean Wine Cluster, Research Policy, 34, 47-68

Grabher, G., Ibert, O., (2014), Distance as Asset? Knowledge Collaboration in Hybrid virtual communities, Journal of Economic Geography, 14, 97-123

Grant, R.M., (1996), Towards a Knowledge Based Theory of the Firm, Strategic Management Journal, 17, 109-122

Harrison, B., (1992), Industrial Districts; Old Wine in New Bottles? Regional Studies, 26, 469 - 483

Henry, H., Pinch, S., (2001) Neo-Marshallian Nodes, Institutional Thickness, and Britain's 'Motor Sport Valley': Thick or Thin?, Environment and Planning A 33 , 7,1169-1183

Hoelter, J.W. (1983), "The analysis of covariance structures: goodness-of-fit indices", Sociological Methods and Research, 11, 325-44.

Hu, L. T., & Bentler, P. M. (1995). Evaluating model fit. In R. H. Hoyle (Ed.), Structural equation modeling: Concepts, issues, and applications (pp. 76-99). Thousand Oaks, CA: Sage.

Huggins, R., Thompson, P., (2014), A Network-Based View of Regional Growth, Journal of Economic Geography, 14, 511 – 54

Jöreskog, K.G. and Sörbom, D. (1989), LISREL® 7: A Guide to the Program and Application, Jöreskog & Sörbom/SPSS Inc., Chicago, IL.

Knoben, J., Arikan, A.T., van Oort, F., Raspe, O., (2016), Agglomeration and Firm Performance: One Firm's Medicine is Another Firm's Poison, Environment and Planning A, 132-153

Kogut, B., Zander, U., (1992), Knowledge of the Firm, Combinative Capabilities and the Replication of Technology, Organization Science, 3, 383- 397

Krugman, P., (1991), Geography and Trade, Cambridge, MIT Press

Christian, L., Dowling, C., (2003), Firm networks: external relationships as sources for the growth and competitiveness of entrepreneurial firms, Entrepreneurship & Regional Development,15, 1-26

Malmberg, A. and Maskell, P., (2002), The Elusive Concept of Localisation Economies: Towards a Knowledge-Based Theory of Spatial Clustering, Environment and Planning, 34, 429-449

Malmberg, A. and Maskell, P., (2006), Localised Learning Revisited, Growth and Change, 37, 1 - 18

Martin, P., Mayer, T., Mayneris, F., (2013), Are Clusters more Resilient in Crisis? Evidence from French Exporters in 2008 – 2009, IRES Discussion Papers; 2013026, 19 pages

Martin, R., (2012), Regional Economic Resilience, Hysteresis and Recessionary Shocks, Journal of Economic Geography, 12, 1 - 32

Martin, R., Sunley, P., Tyler, P., (2015), Local Growth Evolutions: Recession, Resilience and Recovery, Cambridge Journal of Regions, Economy and Society, 8, 141 - 148

Maskell, P., Bathelt, H., and Malmberg, A., (2006), Building Global Knowledge Pipelines: The Role of Temporary Clusters, European Planning Studies, 14, 997 -1013

Mathews, M., Stokes, P., (2013) The Creation of Trust; the Interplay of Rationality, Institutions and Exchange, Entrepreneurship and Regional Development, 25, 845-866

Molina-Morales, F.X., Martinez-Fernandez, M.T., (2003), The impact of Industrial District Affiliation on Firm Value Creation, European Planning Studies, 11, 155-171

Nadvi, K., Halder, G., (2005), Local clusters in global value chains: exploring dynamic linkages between Germany and Pakistan, Entrepreneurship and Regional Development, 17, 339-363

Paniccia, I., (1999), The Performance of IDs. Some Insights from the Italian Case, Human Systems Management, 18, 141-159

Pinch, S., Henry, N., Jenkins, M., Tallman, S., (2003), From 'Industrial Districts' to 'Knowledge Clusters': a Model of Knowledge Dissemination and Competitive Advantage in Industrial Agglomerations, Journal of Economic Geography, 3, 373- 388

Podolny, J., M., Page, K.L., (1998), Network Forms of Organization, Annual Review of Sociology, Vol. 24, 57-76.

Pouder, R., Saint John, C., (1996), Hot Spots and Blind Spots: Geographical Clusters of Firms and Innovation, Academy of Management Review, 21, 1192-1125.

Prahalad, C.K., Hamel, G., (1990), The Core Competence of the Corporation, Harvard Business Review, May – June, 79 - 90

Rigby, D.L., Brown, W.M, (2015), Who Benefits from Agglomeration?, Regional Studies, 49, 28-43

Saint John, C., Pouder, R., (2006) Technology Clusters versus Industry Clusters: Resources, Networks, and Regional Advantages, Growth and Change, 37, 141–171

Saxenian, A.L., (1990), Regional Networks and the Resurgence of Silicon Valley, California Management Review, 33, 89 - 112

Schmitz, H., Nadvi, K., (1999), Clustering and Industrialization: Introduction, World Development, 29, 1503-1514

Sorensen, O., , Audia, P.G, (2000), The Social Structure of Entrepreneurial Activity: Geographic Concentration of Footwear Production in the United States, 1940–1989, American Journal of Sociology, 2, 424-462

Spencer, G.M., Vinodrai, T., Gertler, M.S., and Wolfe, D.A., (2010), Do Clusters Make a Difference? Defining and Assessing their Economic Performance, Regional Studies, 44, 697 – 715

Spender, J. C., (1996), Making Knowledge the Basis of a Dynamic Theory of the Firm, Strategic Management Journal, 17, 45-62.

Staber, U., (1998), Inter-firm Cooperation and Competition in Industrial Districts, Organization Studies, 19, 701-724.

Staber, U., (2007), A Matter of Distrust: Explaining the Persistence of Dysfunctional Beliefs in Regional Clusters, Growth and Change, Vol. 38, 341-363.

Starbuck, W., H. (1976), Organizations and their Environments, In Marvin D. Dunnettet, M. D., (ed.), Handbook of Industrial and Organizational Psychology, 1069-1123, Chicago, Rand McNally,

Tallman, S., Jenkins, M., Henry, N., and Pinch, S., (2004), Knowledge, Clusters and competitive Advantage, Academy of Management Review, 29, 258- 271

Tanaka, J. (1987). How big is big enough? Sample size and goodness of-fit in structural equation models with latent variables. Child Development, 58, 134-146.

Ter Wal, A.L.J., and Boschma, R., (2011) Co-evolution of Firms, Industries and Networks in Space, Regional Studies, 45, 919-933

de Vaan, M., Boschma, R., and Frenken, K., (2013), Clustering and Firm Performance in Project-based Industries: the Case of the Global Video Game Industry, 1972 – 2007, Journal of Economic Geography, 13, 965-991

Visser, E-J., (1999), A Comparaison of Clustered and Dispersed Firms in the Small-Scale Clothing Industry of Lima, World Development, 9, 1553-1570

Whittington, Owen Smith, Powell, W., (2009), Networks, Propinquity, and Innovation in Knowledge-intensive Industries, Administrative Science Quarterly, 54, 90-122