Gatekeepers and Bridges: Technical Cooperation, Innovation and Trans-Regional Brokerage in European SME Networks

Abstract

We study the structures of European technical cooperation networks using social network analysis to examine ways in which some countries' companies have high reported innovation levels while others are more adept at strengthening their competitive advantage through strategic social capital decisions. Data from a recent large survey on the internationalisation of small and medium enterprises (SMEs) is used to identify a European technical cooperation network. This network is analysed using social capital and brokerage to reveal measures of centrality, bridging, density and structural equivalence. The longer established European members show similar structural equivalence, while the same is true for the new and smaller member states. Regression analysis shows a strong relationship with innovativeness as dependent variable and structural equivalence and bridging as explanatory variables. The main findings are, firstly, that the innovativeness of a body of structurally equivalent countries is positively related to the gatekeeper role of its countries. Secondly a country's innovativeness is positively related to the outgoing ability of its firms to bridge structural holes across country boundaries, while it is negatively related to egonet density and occupation of a liaison role. We discuss how this brings enhanced understanding to companies and business development organisations about areas for trans-regional business improvement.

Introduction and Literature Review

Firms are able to draw on a range of external sources to search for new ideas, such as customers, consumers, universities, and suppliers (Brunswicker & Hutschek, 2010). Product developers within firms can deliberately try to reach new contacts in disconnected domains to develop innovative ideas (Simon & Tellier, 2011). Many of these sources cross trans-regional boundaries. There is evidence within Europe that being open for innovation generally pays off provided that suitable marketing strategy is adopted (Teichert & Bounchen, 2011) together with an outgoing approach to technological cooperation in a technologically advanced environment (Sofka & Grimpe, 2010). Open innovation is defined by Chesbrough (2003) in terms of the way in which the network boundaries of firms are porous allowing scope for interaction with their environment as opposed to the traditional closed approach to innovation. Recent research focuses on how strategic inter-firm cooperation enhances value creation (Enkel, 2010; Lee et al., 2010). The question of payoff is, however, debated with regard to the desirability of openness when considering the single firm or collaborative strategy (Knudsen & Mortensen, 2010; Badawy, 2010; Dahlander & Gann, 2010). This issue is also discussed in a Canadian context (Li & Vanhaverbeke, 2009) where it is argued that inter-industry cooperation within Canada has a positive effect while inter-country cooperation outside Canada has a negative effect unless the countries are nearby for the sake of communication and coordination. More broadly strategic and managerial issues arise concerning economic control and the fostering of success and the viability of firms (Dittrich & Duysters, 2007). On the one hand there are major issues in the model of the managed economy with its emphasis on concern about excessive profits and the abuses of market dominance. While on the other hand in the model of the entrepreneurial economy the issues of international growth, competitiveness and employment are important (Hagedoorn et al., 2006; Roijakkers & Hagedoorn, 2007, P. 225).

The term ‘structural hole’ was introduced by Burt (1992) to describe aspects of positional advantage or disadvantage determined by the way they are embedded in neighbourhoods. A structural hole is an absent tie or relationship between partners in a firm’s network. Burt’s (1992; 2005) work on brokerage and the structure of competition showed that firms which occupy a position which bridges structural holes are better positioned to outperform other firms which do not occupy such positions. A key part is played by ‘bridges’ who act as links between clusters of firms as information benefits are expected to travel over bridges. One of the tasks for a strategic firm in building an efficient technological innovation network is to focus on the maintenance of bridge ties between groups of firms in the neighbourhood. Bridge ties are valuable in separating non-redundant information sources so that non-overlapping innovative ideas are brought together (Raegans & McEvily, 2003; Feng et al., 2011). The structure of alliance networks, then, strongly influences their potential for knowledge creation (Schilling & Phelps, 2007) with non-redundant connections contracting the distance between firms.

Granovetter (1985) highlights the influence of social structure on market behaviour arguing that ‘there is evidence all around us of the extent to which business relations are mixed up with social ones’. The cohesion of a body of firms broadly describes their social structure or the way in which they hang together whereas the concept of structural equivalence describes the way in which they behave similarly with regard to their pattern of network bonds, such as symmetry transitivity and reflexivity, even if they do not actually have ties with each other (Freidkin, N. 1998; Mizruchi, 1990). The theory of structural equivalence has developed through the use of block models (White et al., 1976; Breiger et al., 1975) and has subsequently been used in the analysis of business networks (Burt, 1987; Todeva, 2006; Pallotti et al., 2011), where the leading assumption is that structurally equivalent actors tend to mimic each other which, for firms, means that they tend to form similar tie structures when they engage in competitive and cooperative behaviour. The structurally equivalent blocks can also be incorporated into the methods of Gould and Fernandez (1989) to categorise brokerage roles, such as gatekeeper and liaison by group membership. It is then possible to investigate these role relationships between the blocks as well as the overall success of a country or block of countries typically measured by some criterion such as market share or innovativeness of products. Granovetter (1985) argues that standards of behaviour and trust are generated ‘because of the long-term relations of contractors and subcontractors, as well as the embeddedness of those relations in a (business) community’. The extent to which a typical firm has the freedom and access to such a community may depend on a clearer understanding of this behaviour.

Zaheer & Bell (2005) develop five hypotheses using a variety of mutual fund data sources gathered from the industry experts in Canada. They then test these hypotheses using statistical and social network methods and argue that a firm’s innovative capabilities and its network structure both enhance firm performance, while the innovativeness of its contacts does not do so directly. However, indirectly, they argue that innovative firms that bridge structural holes do get a further performance boost suggesting that firms need to structure their network with non-redundant contacts to capture the information benefits from structural holes. They conclude that managers must balance their internal capabilities for producing innovative products with their efforts to develop and maintain strategic network contacts for generating valuable information. Soda (2011) develops two hypotheses relating to innovation in the field of strategic alliances and firm's networks in the automotive industry and argues that brokerage positions and network sparseness produce positive effects on firm innovation, while the presence of a firm in a very cohesive network lowers the innovation potential, contrary to earlier research claims (Coleman, 1988).

In the following sections we describe our methods, establish our hypotheses and outline our results. We both summarise and discuss our findings and close with implications for practice.

Methodology

The methodology employed in this paper is based on previous work which emphasises the performance enhancing advantages of strategically chosen network structures as well as the ability of a firm to innovate. One area is the work on centrality carried out by Granovetter (1973). Another area is the work of White et al. (1976), Brieger et al. (1975) and Friedkin (1998) outlining the significance of structural equivalence and its relationship to performance and behaviour in a network. Another is the area of brokerage and structural holes advanced by Burt (1992). More specifically our study focuses on the works of Zaheer & Bell (2005) and Soda (2011) since these provide supported evidence for strategic structures and internal policies which enhance firm performance. Since our data is sourced in a European context we also base our methods on findings that support the positive relationship between innovative firm policies, good marketing and network strategy and the enhancement of performance (Sofka & Grimpe, 2010). We use these findings to identify and categorise European countries showing evidence of strategic technical cooperation with firms in other European countries. The categories relate to areas of current interest, such as countries with high innovation levels, occupying dense networks, having central or bridging positions or who share structurally equivalent positions with other countries. We also use the methods of Gould and Fernandez (1989) to categorise brokerage roles, such as gatekeeper and liaison by group membership. We then use least squares regression analysis to identify a relationship between innovativeness as dependent variable and a number of network measures as explanatory variables.

The Data

The data were extracted from a survey carried out by EIM (Business and Policy Research) in 2009 of 9,480 SMEs in 33 European countries (including some countries such as Turkey which is currently outside the EU) during spring 2009. The number of SMEs interviewed in each country was in proportion to the population size of the country. 7% of the SMEs in the 33 countries surveyed had technological cooperation with enterprises abroad: the larger the company the more likely is the occurrence of technical cooperation. Initial findings were published in a report (EIM, 2010).

Technical Cooperation Matrix

One of the questions in the survey asks the respondent who represents the SME to name the company's three top countries with respect to technical cooperation abroad (EIM, 2010). We use this data to construct a technical cooperation matrix consisting of all the countries in Europe. The entries in the matrix are weighted averages of the scores given by SMEs in a particular country to their preference for technical cooperation with firms or organisations in other countries. So, for instance, 6 Danish companies named Sweden as first choice for technical cooperation, 4 as second choice and none as third choice, giving an overall preference of Danish firms for technical cooperation with Swedish firms of 0.5 x 6 + 0.3 x 4 + 0.2 x 0 = 4.2 (where we have used 0.5, 0.3 and 0.2 for the weightings given to the first, second and third choices respectively). In this way we develop a 33x33 matrix with elements containing the weighted average scores for SMEs in all 33 European countries. These weighted averages measure the typical score for SMEs in a particular country. We introduce the term 'country typical SME' (CTSME) representing the average or typical SME in a certain country with which these scores are associated. The matrix can then be viewed as a valued sociogram for analysis using sociometric methods displaying features which are characteristic of network data. Firstly the matrix is asymmetric. Denmark's preferences for technical cooperation with Sweden are not the same as Sweden's for Denmark. We can therefore identify ways in which power is structured in the network. We can also uncover evidence of structural holes and other network features. The scores in this matrix do not, however, refer to any particular SME and so the ties in the sociometric analysis represent ties between CTSMEs and measure the likelihood that technical cooperation relationships such as bridges between firms and equivalence between structural blocks exist, since the more preferences that are expressed for cooperation with a particular country then the more likely it is that ties exist between the countries' firms.

Technical Cooperation Networks

One of our tasks is to identify countries whose technical cooperation networks fall into certain categories. We then speculate as to the strategic and performance benefits enjoyed by firms in countries falling into these categories based on the assumption that success is typically measured by some criterion such as market share or innovativeness of products. Our analysis therefore makes use of earlier hypotheses proposed by Zaheer & Bell (2005) and Soda (2011). The categories we examine are:

Category 1: CTSME has a high proportion of innovative firms

Category 2: CTSME has an egonet with low density

Category 3: CTSME occupies a central position (as measured by indegree, outdegree and betweenness) in the European technical cooperation network

Category 4: CTSME occupies a bridging position with regard to technical cooperation

Category 5: CTSME has high structural equivalence (to the extent to which countries firms are connected to the same others) with certain other CTSMEs

Our methodology therefore categorises countries on the strategic and structural characteristics of the technical cooperation networks formed by their firms. We make use of the social network software UCINET (Borgatti and Everett, 2002) to calculate the measures of centrality and brokerage. We then formulate a number of hypotheses and perform regression analysis with innovativeness as dependent variable.

Results

Innovative Firms (Category 1)

Innovative activity is measured dichotomously and indicates whether the SME introduced any new product on the market in the period 2006-2008. Table 1 shows the proportion of firms in each country who have introduced such a new product. Some information was not forthcoming from the data set (or was limited in its scope). We were not, for example, able to extract precise details on the type of innovation in which the firms were engaged. Nor were we able to discover the amount of R&D carried out by the firms. Analysis of variance and Tukey post hoc tests gave significant results (*p=0.000*) following comparison of the product innovation occurring in each country. Iceland, Turkey, Bulgaria, Finland, Poland, Lithuania and Norway all have high proportions (>30%) while France, Luxembourg, United Kingdom and Portugal have low proportions (<15%) with the other countries falling between the two extremes.

Egonet Density (Category 2)

A country's ego-network includes the specific country and all the countries that are connected to it through technical cooperation (the connection could be either a link named by that country or a link from another country naming it). We make use of the measure of the density of each country's egonet. This gives some indication of the degree of cohesion within that country's overseas innovation network.

Table 2 illustrates the egonet density for each country. This figure measures the density of the network that surrounds it. This is the ratio between the number of ties in the network that links each country to its partners (including the links between the partners) and the total number of links that would be possible in the ego network. Expressed mathematically this is $D=2g/(n*(n-1))$, where g is the number of actual ties between all countries in the egonet and n is the number of countries in the egonet. This acts as an indication of the degree of cohesion within that country's overseas innovation network. According to Soda (2011) we would want a low density network to increase the likelihood of increased performance. We see that the countries with the largest egonets and lowest densities are Germany followed by Italy, UK, France, the Netherlands and Spain.

Centrality (Category 3)

The centrality of a country with respect to its firms which engage in technical cooperation abroad is most simply measured by the number of network ties surrounding the country. If this is the case then countries with the highest centrality tend to be the most powerful as information will tend to flow through them before it reaches others. The simplest measures of centrality are indegree (measured by the total of the incoming weighted ties naming SMEs in a particular country) and outdegree (measured by the total of the outgoing weighted ties named by SMEs in a particular country). For indegree we see from Table 1 that Germany has the highest (95.08) followed by Italy (34.92), UK (27.60) and France (21.88) with all other countries having measures below 18. Conversely these countries were among the lowest for outdegree while the countries with high outdegree (Iceland at 30.81) tended to be among the lowest for indegree. This is a defining feature of the European technical cooperation network and undoubtedly leads to many of the structural nuances which appear when carrying out network analysis and identifying strategic business characteristics. If we also consider that a small number of strategically placed ties can significantly increase the connectivity of the network (Watts, 1999) then the identification of weak ties with this capability can be of crucial importance (Granovetter, 1973).

Freeman Node Betweenness Centrality

Countries with the highest betweenness centrality are in the best position to exploit such a strategy and we use the Freeman (1979) measure of node centrality to identify such countries in our analysis. If we add up, for each country, the proportion of times that they are "between" other countries as far as SME preference for technical cooperation is concerned, we get this measure of node centrality. We make use of the geodesic paths between all nodes to calculate this measure. For example, if A is a certain country then the more SMEs in other countries that depend on A to make connections with other countries the higher will A's score be for this measure of centrality. This is therefore a measure of A's power in the network with regard to technical cooperation connectivity and is shown in Table 1.

	Innovate	EgoNet%	Density	Indegree	Outdegree	Betweenness	Bridging
Austria	0.23	87.90	0.35	12.46	9.27	34.21	30
Belgium	0.19	84.80	0.36	11.03	7.96	11.97	20
Bulgaria	0.35	63.60	0.39	2.08	10.10	7.31	36
Croatia	0.20	45.50	0.47	1.57	10.18	1.63	22
Cyprus	0.26	27.30	0.50	0.49	9.52	0.13	16
Czech	0.28	60.60	0.43	7.25	4.67	10.72	12
Denmark	0.26	72.70	0.44	13.00	10.76	17.01	30
Estonia	0.19	51.50	0.53	2.18	13.80	3.39	32
Finland	0.34	66.70	0.45	9.78	6.75	16.46	23
France	0.11	97.00	0.31	21.88	1.82	28.67	20
Germany	0.23	100.00	0.23	95.08	3.84	48.68	30
Greece	0.22	57.60	0.44	6.02	9.22	37.10	57
Hungary	0.18	60.60	0.42	3.50	6.70	13.23	24
Iceland	0.44	54.50	0.44	0.17	30.81	31.26	65
Ireland	0.18	45.50	0.51	1.53	5.86	0.58	16
Italy	0.21	100.00	0.29	34.92	2.97	63.10	28
Latvia	0.22	54.50	0.51	2.13	16.98	0.98	34
Liechten	0.17	21.20	0.68	0.00	6.59	0.00	12
Lithuania	0.31	57.60	0.48	1.80	14.04	6.83	36
Luxem	0.12	27.30	0.66	0.24	9.32	0.40	16
Macedon	0.30	51.50	0.42	0.20	15.77	3.17	30
Malta	0.23	42.40	0.71	0.25	10.24	0.00	24
Netherlands	0.23	93.90	0.33	16.04	6.57	27.20	26
Norway	0.31	78.80	0.37	8.19	21.15	88.83	65
Poland	0.32	69.70	0.41	5.67	9.24	39.94	36
Portugal	0.15	48.50	0.46	0.68	7.17	5.12	26
Romania	0.18	63.60	0.42	2.50	12.84	17.95	36
Slovakia	0.22	60.60	0.39	2.24	13.10	12.87	28
Slovenia	0.19	54.50	0.50	2.19	10.46	6.91	26
Spain	0.18	93.90	0.34	9.53	5.30	19.88	28
Sweden	0.27	78.80	0.37	17.97	11.57	35.91	32
Turkey	0.35	66.70	0.45	7.57	8.30	12.86	34
UK	0.14	97.00	0.31	27.60	4.90	83.69	34

Table 1 Network and Brokerage Measures

Table 1 gives high scores (>50) to Norway, UK and Italy and low scores (<1) to Malta, Liechtenstein, Cyprus, Luxemburg, Ireland and Latvia. To get further clarification of this we make use of the Freeman edge betweenness centrality score (not shown), which determines which relations between countries are central rather than which countries themselves are central. Using this measure reveals that Norway scores particularly well with Iceland and Estonia, while for the UK this is Ireland, Croatia and Macedonia. In addition Italy score highly with Greece and Luxemburg, while Germany scores highly with Lithuania, Poland scores highly with Latvia and Greece scores highly with Cyprus.

Bridging (Category 4)

A feature of structural hole theory is the key part played by 'bridges' who act as links between clusters of actors as information benefits are expected to travel over bridges. The task for a strategic player in building an efficient technological innovation network in his or her neighbourhood is to focus on the maintenance of bridge ties between groups of actors in both the local and global neighbourhoods. A bridge is an edge (i.e. a tie between two countries) whose removal disconnects the (technical cooperation) graph. A k-local bridge is an edge whose removal increases the distance of its endpoints to a value of k or more. We utilise the UCINET routine (Borgatti et al., 2002) which calculates the distance between the endpoints of each adjacent pair of vertices (countries) in the graph when the edge connecting them is deleted.

Table 1 shows the values of the k-local bridge distances for each country summed across all other countries. The top three countries (Iceland, Norway and Greece) have very high scores but also are characterised by high variability within the scores. So, while most edge scores for most countries are 2 some edge scores are much higher which leads to a greater sum shown in Table 1 as well as a higher variability. This can be illustrated by reference to each individual case. The edge between Iceland and Malta, for instance, has an individual score of 33, which, as the number of countries in the network, is the maximum possible score attainable. This is because Iceland is the only country whose SMEs express a preference for technical cooperation with companies in Malta. Similarly the edge between Norway and Iceland also has an individual score of 33, the maximum attainable for the edge. This is because Norway is the only country with SMEs naming a preference for Icelandic companies with regard to technical cooperation. The same applies to the relationship between Greece and Cyprus, since Greece is the only country whose SMEs name Cyprus.

Structural Equivalence (Category 5)

The concept of structurally equivalent block applies to a group of countries that have similar relationships with the same other countries in the technical cooperation network. In this context structural similarity may stimulate a competitive orientation in which countries' firms are attentive to each other's status and interests (Burt, 1987). Accordingly the strategy for countries in the same block may be initially identified as following a joint policy of increasing innovativeness since their networks are structurally equivalent. We apply this concept to the data in this study and identify, initially two, then four structurally equivalent blocks (SE Blocks), making use of the UCINET structural equivalence optimisation routine (Borgatti et al., 2002). The two structurally equivalent blocks are:

1: Austria Belgium Denmark Finland France Germany Italy Netherlands Norway Poland Spain Sweden UK
2: Bulgaria Croatia Cyprus Czech Estonia Greece Hungary Iceland Ireland Latvia Liechtenstein Lithuania Luxemburg Macedonia Malta Portugal Romania Slovakia Slovenia Turkey

The results indicate that the longer established European members show similar structural equivalence, while the same is true for the new (and smaller) member states.

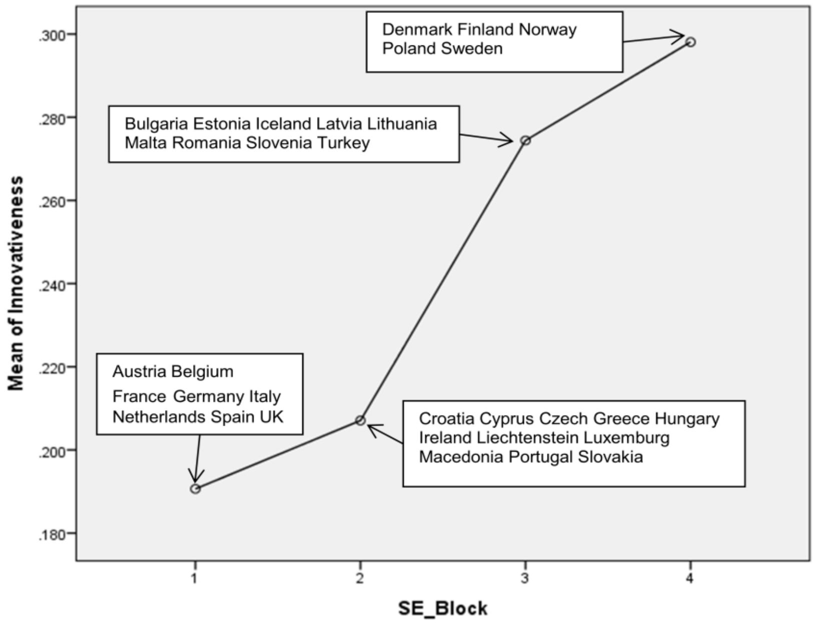

Figure 1 Means Plot for Four Structurally Equivalent Blocks

Further analysis identifies four blocks, which are illustrated in Figure 1 which shows that certain Baltic Sea countries (Block 4) exhibit common structural equivalence. These countries also have higher innovation scores. The countries with the lowest innovation scores lie in the structurally equivalent block in mainland Europe. Many of the countries that have recently joined Europe are in the middle two blocks regarding innovation.

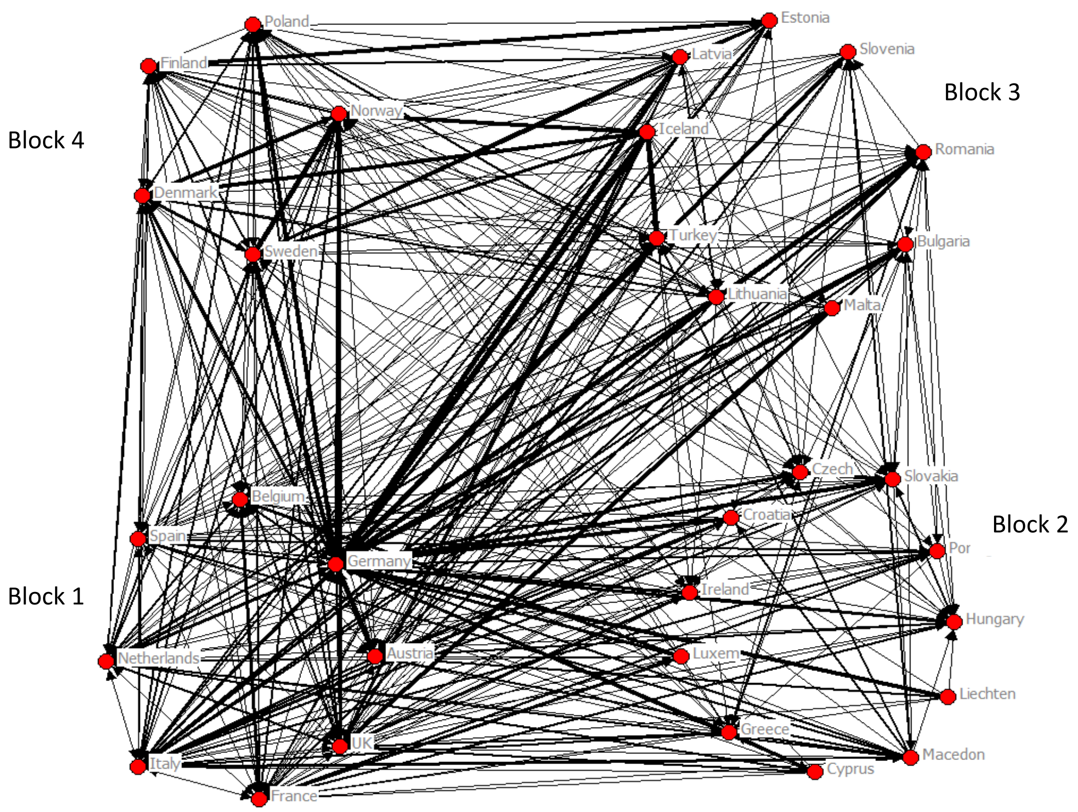

Figure 2 Digraph illustrating Structurally Equivalent Blocks
(Produced using Netdraw. Line size indicates strength of tie)

Figure 2 shows the countries covered by the survey in the European network together with the directional edges connecting them and the grouping into structurally equivalent blocks. The line sizing indicates the strength of the relationship between the countries. The blocked adjacency matrix derived from carrying out structural equivalence shows that blocks 1 and 4 (Figures 1 and 2), constituting the oldest established EU countries, attract dense ties from other blocks with the exception of block 2 which does not have as many dense ties to block 4 as to other blocks.

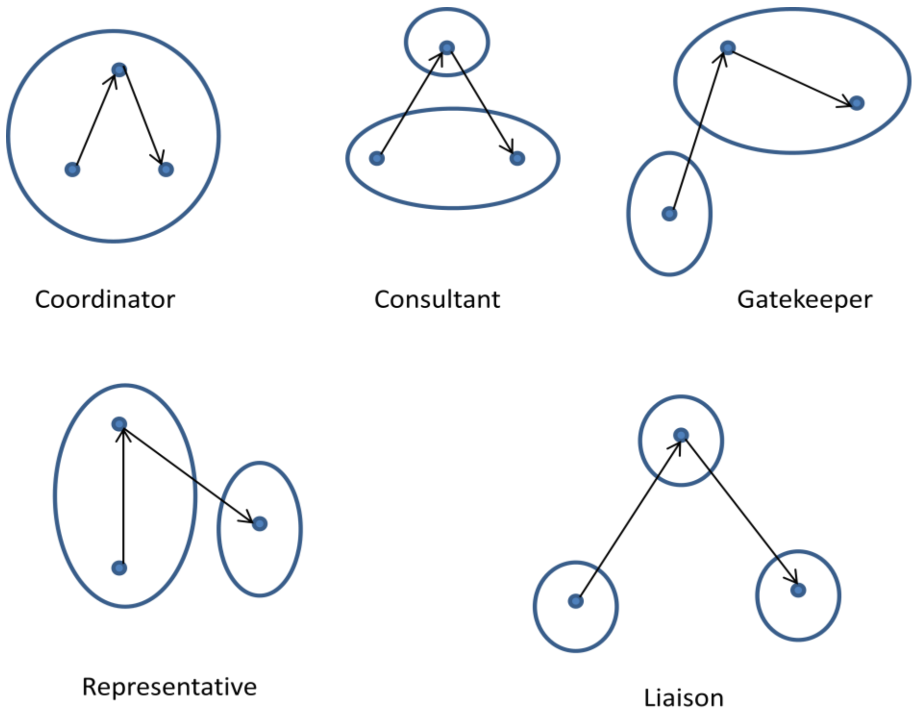

Figure 3. Five types of brokerage relation. Solid points are countries; ellipses and circles correspond to Block boundaries. The top point in each triad represents a broker (Gould and Fernandez, 1989)

Finally we used Gould and Fernandez (1989) methods making use of the structurally equivalent blocks to categorise the brokerage roles by group membership. Figure 3 illustrates the roles played by a broker, which in this case represents a country's typical SME (CTSME) within a block of structurally equivalent countries. The CTSME can act as a broker in five different ways. For instance a broker acting as a gatekeeper receives technical knowledge from a CTSME in a different country block and then shares this knowledge with a CTSME in another country within its own block.

Tables 2 and 3 result from performing brokerage analysis using the UCINET software (Borgatti et al., 2002). In Table 2 the countries, having been previously partitioned into structurally equivalent blocks, have been given brokerage scores where each row counts the weighted number of times that each country plays each of the five roles in the whole graph. The weighting is used because, in this context, we are more interested in group relations between blocks of countries. As an example suppose that a country, B, acts as a representative between countries A and C (Figure 3) while some other actor, D, is also acting as a representative between A and C (not shown in Figure 3) then B and D would each get half the score for this role rather than the full score.

	Coordinator	Gatekeeper	Representative	Consultant	Liaison	Total
Block	---------------	---------------	--------------------	--------------	----------	--------
Austria	0	0.9	5.497	10.494	16.999	33.89
Belgium	0.67	0.76	2.538	2.6	6.231	12.799
Germany	0.368	0.95	3.593	1.042	7.363	13.316
Italy	0.316	2.892	9.723	14.908	15.212	43.051
UK	0.67	0.725	18.669	13.497	27.294	60.855
Spain	0.1	1.851	1.982	3.428	12.544	19.904
Netherlands	0	0.425	5.069	4.53	14.479	24.503
France	0	1.518	4.25	8.158	18.099	32.025
Average	***0.266***	***1.253***	***6.415***	***7.332***	***14.778***	***30.043***
Cyprus	0	0	0.125	0	0	0.125
Croatia	0.81	0.811	0.125	0	0	1.746
Ireland	0.125	0.236	0.143	0	0	0.504
Greece	1.125	6.661	0.278	0.1	0.993	9.156
Hungary	1.343	1.325	4.322	1.095	2.525	10.61
Czech	0.643	1.135	3.311	1.944	3.583	10.616
Macedon	0.5	0.111	0.958	0	0.726	2.296
Luxem	0	0	0	0.243	0.143	0.386
Liechten	0	0	0	0	0	0
Slovakia	3	4.111	3.686	0.669	1.084	12.55
Portugal	0	2.381	0	0.1	1.393	3.873
Average	***0.686***	***1.525***	***1.177***	***0.377***	***0.950***	***4.715***
Bulgaria	0.333	2.31	0.768	1.035	2.385	6.831
Lithuania	0.367	2.367	0.4	0.111	0.597	3.842
Latvia	0	0.333	0.31	0.111	0	0.754
Romania	1.167	5.819	1.497	1.729	4.49	14.702
Estonia	0	2.333	0	0.292	0.403	3.028
Slovenia	0	0	1.211	1.234	2.693	5.138
Malta	0	0	0	0	0	0
Turkey	0.75	2.317	1.548	1.802	3.869	10.286
Iceland	0	1	0	0	0.111	1.111
Average	***0.291***	***1.831***	***0.637***	***0.702***	***1.616***	***5.077***
Denmark	0.403	1.869	2.101	2.002	4.919	11.294
Finland	0	0.492	1.98	3.808	6.746	13.026
Sweden	0.111	5.773	0.81	4.935	12.969	24.598
Norway	0	1.629	4.768	13.878	21.366	41.64
Poland	0	1.877	5.297	5.455	18.917	31.546
Average	***0.103***	***2.328***	***2.991***	***6.016***	***12.983***	***24.421***

Table 2 Brokerage Role Scores (Weighted Method)

Table 2 shows that UK has the highest total score due to its brokerage activity as a representative, liaison and consultant involving countries in Group 2 and to a lesser extent group 4. These countries include Ireland and Cyprus with which the UK has strong ties. The next highest scorer is Italy which again acts as a representative, consultant and liaison but also gatekeeper involving Group 2 and to a lesser extent Group 4. Italy has contacts with Group 2 countries Greece, Portugal and Ireland as well as contacts with Group 4 countries Poland and Finland. The third highest scorer is Norway which plays a central role as liaison between Group 3 and Groups 1&2 as well as acting as a consultant for Group 3 and representative for Group 1

Block 1	*1*	*2*	*3*	*4*
1	0.25	4.25	1.25	0.88
2	1.00	5.88	2.38	3.63
3	0.00	4.75	1.25	0.38
4	0.00	3.00	0.75	0.00
Block 2	*1*	*2*	*3*	*4*
1	0.00	0.45	0.36	0.09
2	0.18	0.73	0.45	0.36
3	0.00	0.73	0.18	0.00
4	0.00	0.36	0.18	0.00
Block 3	*1*	*2*	*3*	*4*
1	0.00	0.44	0.56	0.22
2	0.11	0.56	0.56	0.33
3	0.00	0.44	0.22	0.11
4	0.00	0.22	0.67	0.00
Block 4	*1*	*2*	*3*	*4*
1	0.20	1.40	4.40	0.60
2	0.40	1.20	4.60	1.20
3	0.00	2.00	4.80	0.60
4	0.00	1.00	2.00	0.00

Table 3 Brokerage Block Relations (Average Scores)

Table 3 illustrates the frequency with which countries in each block are involved in relations among and within each of the other blocks. We see, for instance, that the countries of Block 1 (Austria, Belgium, Germany etc.) have stronger relations with countries in block 2 than other blocks. The score 5.88 refers to the role of consultant indicating the amount of connections made by block 1 countries acting as a consultant to block two countries by connecting a member of block 2 to another member of block 2 (1-2-2). The main consultants in block 1 are Italy, UK and Austria (Table 2). The score 4.25 refers to the role of representative indicating the amount of connections made by block 1 countries acting as a representative in block 2 (1-1-2). The main representative in block 1 is UK mostly involving block 2. The UK's other significant roles are as a consultant for block 2 and as a liaison between blocks 2 and 3 and also between blocks 2 and 4. The role of gatekeeper is reflected for each block by the scores attracted from other blocks. So, for instance, block 1 attracts a score of 1.0 from block 2 due mainly to the role of Italy as a gatekeeper (2-1-1). The main gatekeepers for block 2 are Greece and Slovakia, while for block 3 the main gatekeeper is Romania. The gate-keeping role for block 4 is mainly carried out by Sweden through attracting ties from block 2 countries giving a score of 1.20 (2-4-4).

Summary Analysis

We summarise by attending to the relationship between innovativeness (category 1) and the other categories outlined above. Least squares regression found little relationship between innovation and egonet size but a weak negative relationship between innovation and density which was not statistically significant (*R-Square=0.007, p=0.64).* There is a strong positive linear relationship between a country's outdegree and its innovation (*R-Square=0.327, p=0.0005*), but no significant relationship between indegree or betweenness centrality and innovation. There is a positive linear relationship between occupying a bridging position and innovativeness (*R-Square=0.275, p=0.002)*. Some values indicate mild exceptions (>1.5 Standard deviations). For instance Finland and Turkey (as well as Bulgaria, Czech Republic and Iceland) have higher innovativeness levels than predicted by their bridging positions while the UK (as well as France and Greece) has a lower innovation level than predicted.

Analysis of variance on the levels of innovativeness of countries attached to structurally equivalent blocks show that when the countries were divided into two structural blocks there is no significant difference between the innovativeness of the blocks. However when they are split into four blocks there is a significant difference (*ANOVA, p=0.007*) with the greatest difference between block 1 and blocks 3 and 4. There is a strong correlation between innovativeness (averaged over a block) and the CTSME gatekeeper role, while there is a negative correlation between innovativeness and the liaison role (Table 4). Mild effects were registered for the other roles. These were a positive relation between coordinator and innovativeness and a negative relationship between innovativeness and representative or consultant.

	Innovate	Gatekeeper Block Average	Density	Bridging	Outdegree	Liaison
Innovate	1	.550**	-.084	.516**	.568**	-.090
Gatekeeper Block Average	.550**	1	.256	.368*	.466**	-.052
Density	-.084	.256	1	-.258	.198	-.641**
Bridging	.516**	.368*	-.258	1	.693**	.202
Outdegree	.568**	.466**	.198	.693**	1	-.252
Liaison	-.090	-.052	-.641**	.202	-.252	1

**p<0.05; **p<0.01(Two-tailed)*

Table 4 Means, standard deviations and correlations

In Table 4 we present a correlation matrix and descriptive statistics for our variables. We then formulate a number of multiple regression models with innovativeness as dependent variable:

Hypothesis 1: CTSMEs enhance their innovativeness by having high outdegree

Hypothesis 2: CTSMEs enhance their innovativeness by bridging structural holes

Hypothesis 3: CTSMEs reduce their innovativeness by occupying dense networks

Hypothesis 4: CTSMEs reduce their innovativeness by occupying a liaison role

Hypothesis 5: Gatekeeper CTSMEs enhance their block's innovativeness

Dependent Variable	**Hypothesis**	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
Innovativeness		Coeff	Sig	Coeff	Sig	Coeff	Sig	Coeff	Sig
Explanatory Variable									
Constant		.235	.000	.235	.000	.235	.000	.226	.000
Outdegree	1	.023	.192			.027	.022		
Bridging	2	.005	.762	.023	.060				
Density	3	-.031	.038	-.027	.065	-.033	.018	-.033	.013
Liaison	4	-.020	.156	-.027	.050	-.019	.157	-.026	.039
Gatekeeper Block Average	5	.035	.006	.038	.003	.036	.004	.042	.000
Bridging*Outdegree	1&2							.014	.007
VIF		*<3.5*		*<2.1*		*<1.9*		*<1.9*	
R-Squared Adj.		*0.448*		*0.432*		*0.466*		*0.504*	

Table 5 Results of Regression Analysis

Table 5 shows the results of four models. Four of our five hypotheses relate to the association between CTSMEs enhancing their innovativeness and four factors. The first hypothesis associates high outdegree, the second associates the bridging of structural holes, the third associates a negative effect of dense networks, while the fourth associates a negative effect of occupying a liaison brokerage role. All four of these hypotheses are supported. The fifth hypothesis associates a CTSME's gatekeeper role with the innovativeness of the block to which the broker belongs. This hypothesis is also supported. Model 4 replaces the bridging and outdegree variables with a single variable, interpreted as outgoing bridgers, CTSMEs who achieve bridging through outgoing ties rather than through incoming ties.

We summarise the main structural characteristics for each block as follows:

1.) SE Block 1. The countries in this block have high brokerage totals with strong scores for representative, consultant and liaison roles (Table 2). They are representatives for block 2 and 3 countries as well as liaisons (2-3 and 3-2) and consultants and gatekeepers for Block 2 countries (Table 3). The main gatekeeper is Italy which attracts ties from block 2. The block 1 countries are homogeneous with regard to bridging (Table 1) with the exceptions of France (low bridging level) and the UK (high bridging level).
2.) SE Block 2. The countries in this block have the lowest brokerage totals. They are consultants and representatives for block 3 as well as coordinators for block 2 and gatekeepers for blocks 1 and 3. The main gatekeepers are Greece and Slovakia. The block 2 countries have medium to low scores for bridging capacity (with the exception of Greece which has a high score and Czech Republic and Liechtenstein with very low scores) as well as medium to low scores for innovativeness with the exceptions of Macedonia and the Czech Republic which have high scores.

3.) SE Block 3. The countries in this block have low brokerage scores. They are gatekeepers for blocks 2, 3 and 4 as well as consultants for block 2 (Table 3). The main gatekeeper is Romania which maintains ties with all other blocks. The block 3 countries have high scores for bridging capacity (with the exception of Malta and Slovenia) as well as medium to high scores for innovativeness (with the exceptions of Romania, Estonia and Slovenia) which have lower scores.
4.) SE Block 4. The countries in this block have high brokerage scores. They are gatekeepers and consultants for blocks 2, 1 and 3 as well as liaisons (1-3, 2-3) and representatives for block 3. The main gatekeeper for this block is Sweden, which attracts ties from block 2 countries. The countries in block 4 have high scores for innovativeness as well as medium to high scores, with the exception of Finland, for bridging capacity.

Conclusion (including implications for practice)

Small firms operating in trans-regional markets face important decisions about how to improve performance. Previous research indicates that improvement is achieved through increasing innovativeness and/or improving network and brokerage capacity, typically measured using centrality, bridging of structural holes and network density with regard to technical cooperation. We demonstrate a positive association between a country's typical SME (CTSME) bridging score and its innovativeness. We also investigate the way in which CTSMEs achieve competitive advantage through embeddedness in a structurally equivalent block of countries with regard to technical cooperation. Each structurally equivalent block operates in a distinct manner which characterises its role. The role of liaison has a significant negative association with the innovativeness of a CTSME. On the other hand, the role of gatekeeper is positively associated with the innovativeness of the block to which the CTSME belongs. The block containing the large European countries has high representative, consultancy and liaison status in relationship to other blocks as well as having the lowest average for innovativeness. On the other hand the Baltic Sea block has a significant gatekeeper role, mainly due to Sweden's network activity, and maintains high innovativeness.

The role of gatekeeper is strongly associated with innovativeness but is of most benefit to the block rather than to the broker (CTSME). This makes sense if we consider that the gatekeeper broker (CTSME) attracts technical cooperation from another block and then passes it on to other countries within its own block. For gatekeepers technical cooperation benefits countries with similar structural behaviour and hence also the broker. On the other hand a more direct benefit accrues to a broker acting as a bridge across a structural hole in the technical cooperation network. There is also a direct loss to the broker acting within a dense egonetwork, since there are fewer opportunities for bridging. Similarly the liaison role has a direct negative effect on the broker (CTSME) performing this role, since technical cooperation attracted from a country in another block is then passed to a country in a different block benefitting neither the broker nor the block to which the broker belongs.

Key strategic considerations follow from closer inspection of the structurally equivalent blocks. The countries in these blocks may be more sensitive about following a joint policy of harmonising innovation and bridging capacity due to the similarities in their network structures. The practical implications vary depending on the block which the country belongs to. Block 1 countries might benefit from adopting gatekeeper roles, since they already have strong network links with blocks 2 and 3. The step from liaison, representative or consultant to gatekeeper is not necessarily a large one as reference to Figure 3 shows though this might require some cooperative imagination. They might also extend their brokerage influence by greater technical cooperation with block 4 countries in the Baltic Sea. Block 2 countries might improve their gate-keeping role with blocks 1 and 3 through improved bridging. Block 3 countries might continue to improve their gate-keeping role with the other three blocks while also maintaining their bridging capacity. Block 4 countries might increase their brokerage strength by extending Sweden's gate-keeping position to attract ties from blocks 1 and 3.

Specific advice to countries' companies can also be derived from the appearance of gaps in the technical cooperation matrix together with the position of the company's country within its structurally equivalent block. For instance, companies in the Czech Republic might decide to explore technical cooperation ties with French, Romanian or Hungarian companies where there appear to be bridging opportunities. They might also extend their search to countries in Block 4 such as Norway and Denmark in order to explore opportunities arising from the weak ties between blocks 2 and 4. Finland, on the other hand, could explore technical cooperation ties with companies in a range of European countries including Austria, Belgium, Croatia, Greece, Ireland, Liechtenstein, Luxemburg, Macedonia, Portugal, Romania or Slovenia, all of which present possible bridging opportunities. France has both the lowest innovativeness score as well as a low bridging score and so might strengthen its position within the block by increasing both innovativeness as well as bridging ability as well as seek opportunities to act as a gatekeeper. UK would need mainly to increase the innovativeness of its firms in order to strengthen its position within the block since it already occupies a strong bridging position, as well as seeking gate-keeping opportunities. Portugal, Romania and Estonia might seek to improve innovation while Slovenia, Luxembourg, Liechtenstein and Ireland might improve both innovation as well as bridging ability. Malta and Turkey, on the other hand, might identify more ties with bridging potential.

Firms and business development organisations seeking an effective technical cooperation strategy need to take into account the features of the particular markets in which they are based and engage in open innovation that exploits a wide range of knowledge. The strategy should recognise the advantages of seeking cooperation ties with firms that bridge structural holes in the network. It should also take into account existing structural features relating to the block position that the firm's country holds in the broader European network. Achieving both of these strategic goals is more likely to be successful if the firms are well supported by their regional business development organisations and national policy makers since these organisations often have a better understanding of the trans-regional business network.

The methods used in this study have some limitations. One limitation is that the respondents in the IEM Survey (2009) were asked if they had introduced any new product or service in the market in the last three years but the nature of the innovation was not specified. Their innovation was therefore self-reported and not subsequently checked for relevance or accuracy. The use of brokerage theory in the context of preference for technical cooperation with European countries abroad also has limitations. One is that since each firm names only a country and not another firm the brokerage and other scores do not actually reflect relationships between firms. But we argue that they do measure the likelihood that technical cooperation relationships such as bridges between firms and equivalence between structural blocks exist, since the more preferences that are expressed for cooperation with a particular country then the more likely it is that ties exist between the countries' firms.

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