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Social Network Analysis of the ISPIM Innovation Management Community

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Abstract: Scientific communities are bound together by common purpose and interests, and tangible evidence of the structure of such communities may be found by investigating co-authorship networks. We utilise social network analysis to analyse the network structure of ISPIM (International Society for Professional Innovation Management), using co-authorship data from six ISPIM events during the years 2009-2011. We find interesting evidence of the network structure, illustrating vividly the central authors and sub-components of the network. Related to this, results reveal surprisingly tight clustering based on geographical and institutional boundaries. We also find evidence of high performing authors which span these boundaries via significantly different strategies. Overall, the results help to uncover the underlying structure of the scholarly network behind ISPIM, which helps to better understand the key contributors and their networks, and also the development points and promising research collaboration opportunities.

Keywords: Innovation Management, ISPIM, Co-authorship, Social network analysis, Community

1 Introduction

"ISPIM is a family". You might have heard this saying if you have participated in a conference or a symposium organised by the International Society for Professional Innovation Management (later ISPIM). When the authors of this study heard this, it made us think about what kind of family ISPIM really is. Traditionally speaking, family members have tight relationships and they collaborate with each other all the time in order to do something together and keep up their relationships. Indeed scientific communities such as ISPIM are kinds of families where you can identify fathers and mothers – key persons who keep the family running – and second cousins who you rarely meet and barely know. As in the case of a family relationship, your "second cousin" might be someone else's mother or father or vice-versa. It all depends on the viewpoint and your position in the network of relatives. Also in the case of scientific communities,

social relationship and social networks are relevant, since they formulate the logic of doing and publishing research within a certain field such as innovation management.

As opposed to families, which are bonded by blood ties, scientific collaboration networks are hard to understand unless we measure and illustrate these collaboration relationships explicitly. Therefore in this study we examine the ISPIM network relationships in the form of co-authorship patterns, which is an approach recently used to study various types of scientific communities (see e.g. Newman 2001, Morlacchi et. al. 2005 and Vidgen et. al. 2007). The data is gathered from the published authors in ISPIM conferences and symposiums between 2009 and 2011. The goal of this study is to model and describe the structure of the ISPIM innovation management research community from the social network analysis (later SNA) point of view (for discussion on SNA, see e.g. Wasserman and Faust, 1994). By applying bibliographic analysis we identify who are the key authors, organizations and countries based on co-authorship relations and what kind of ties have been constructed among these participants.

This paper is organised as follows. Firstly, we introduce theoretical foundations of social networks, scientific communities, and related co-authorship analysis. Secondly, we present our research design including research objectives, data collection and key variables. Thirdly, we present our results based on network analysis. Finally, we conclude with our findings.

2 Scientific communities as social networks

Scientific communities are by nature networks between individual researchers, unified by a common agenda over topics, fields, or institutional settings (see e.g. Bourdieu, 2004). Therefore, in order to understand how individual academics and broader communities are formed and how they operate, it is important to understand the network of social relationships in which they are embedded. For this reason, we approach scientific communities in this paper through the lenses of *social network analysis*. Our approach is elaborated in the following sections.

2.1 Social network analysis

Empirical and theoretical applications of social network studies have cumulated in social sciences for over half a century already (e.g. Wasserman and Faust 1994, Scott 2000, Watts 1999). In social settings, social network analysis has underlying features from *social exchange theory*, where actors are viewed as being interdependent on each other, and the interconnections of actors do represent exchange of knowledge or other otherwise relevant activity (Blau, 1964; Wassermann and Faust, 1994). Social network analysis, on the other hand, is also a specific systematic methodology to analyse informal and formal social networks with a certain methodology, measures and tools (e.g. Wasserman and Faust, 1994). Social network analysis is formally based on *network theory* and *graph theory*, which are focused on analysing symmetric or asymmetric ties that connect discrete objects and actors (such as individuals, groups or companies) together.

The fundamental difference in social network analysis over non-network-type of studies is that it includes relevant relational information beyond the attributes of individual actors, which helps to understand how the behaviour of individuals and communities is related to the social structures in which they are embedded. (Yan and

Assimakopoulos, 2009). In this study, we adopt both theoretical and methodological approaches to social network analysis in investigating the co-authorship networks in a scientific community.

2.2 Scientific communities and co-authorship ties

Researchers' motivation and benefits to collaborate with each other has been quite widely studied (e.g. Beaver and Rosen 1978, 1979a, 1979b, Melin, 2000, Autry and Griffis 2005, Kuhn 1962, Barnett et. al. 1988). Recently, detailed analyses have been conducted over the network structure of multiple scientific communities such as information systems/ECIS conference (Vidgen et al., 2007), industrial marketing/IMP conference (Easton et al., 2003), and logistics (Cantor et al., 2010). Overall, these recent studies have shown that in-depth analysis of a chosen scientific community is useful and revealing, and that social network analysis is a prominent tool in visualizing and understanding how the scientific communities are structured.

In this context, we view co-authorship ties as a particularly valuable approach in examining the social structures and activity in a given scientific community. In particular, the benefit of investigating co-authorships (instead of co-citation analyses, for instance) is that it gives the possibility to investigate intentional relationships between the two or more authors (Vidgen et al., 2007). Co-authorship, per definition, requires some level of collaboration and can be thus considered as a sufficiently reliable indicator of actual knowledge sharing and creation between the given group of co-authors. It enables us to examine the social structures of scientific communities, revealing where the information flows, also potentially across formal boundaries within and beyond institutions, which is one major advantage of social network analysis in general (see e.g. Allen et al., 2007; Cross et al., 2002; Yan and Assimakopoulos, 2009).

2.3 ISPIM as a Scientific Community

In this study, we focus on the scientific community of ISPIM - an acronym for International Society for Professional Innovation Management. ISPIM originated from the initiatives of Professor Knut Holt from University of Trondheim at 1973 (for a detailed description of the conception of ISPIM, see Holt, 2006; ISPIM 2012). Prof. Holt organised a program called Needs Assessment and Information Behaviour (the NAIB Program). The objective of the program was to find tools and guidelines for the assessment of user needs in the product innovation process. The NAIB and related collaboration led eventually to the formal conception of ISPIM in Trondheim, Norway in June 1983. Due to increasing interest in innovation management in practice and academia, ISPIM has grown today as a popular forum for scientific and practitioner events across the globe. Currently ISPIM hosts two major scientific events per year (a conference in the Summer and a symposium at the end of the year). At the time of writing this study, it has 702 members from 62 countries.

ISPIM is an international scientific community in its pure sense, as it connects individual researchers unified by a common topic and interest (see e.g. Bourdieu, 2004). In the case of ISPIM, this topic innovation – Innovation can be defined as "a process of turning opportunity into new ideas and of putting these into widely used practice" (Tidd et al., 2005, 66) and innovation management as building and improving effective routines related to various aspects of innovation (ibid.). In addition to academics, throughout its

history, ISPIM has also included strong participation from business practitioners and consultants. However, in this study we explicitly focus on academic papers and related co-authorship, in order to specifically investigate ISPIM as a scientific, scholarly community.

3 Research Methodology

3.1Research Design

The goal of this study is to explicitly model and describe the structure of the ISPIM innovation management research community from the social network analysis point of view. Instead of citation and co-citation methods, which are more commonly used to evaluate scientific communities (e.g. Robinson and Adler, 1981, Cote et. al. 1991, Üsdiken and Pasadeos, 1995), we based our analysis on co-authorship ties, similarly to previous studies by Newman (2001), Morlacchi et. al. (2005) and Vidgen et. al. (2007). In our opinion, co-authorship is a key measure in accurately revealing the genuine collaborative relationship between researchers, in comparison to other methods such as citation and co-citation analyses. For instance, writing a scientific paper together requires significantly more hands-on collaboration when compared to more easily made citations. Furthermore, by applying bibliographic analysis, we identify who are the key authors and countries based on co-authorship relations and what kind of ties have been constructed among these actors.

In conducting the analysis on the network structure of the ISPIM community, we will utilise standard methodology and visualization tools of social network analysis, utilizing UCINET software (e.g. Wasserman and Faust, 1994; Borgatti et al., 1991). The adopted approach involves identification of the structure of the network, including the linkages between the authors and different types of actor roles in it (e.g. various centrality measures and roles for individual actors). We will also present exact descriptive statistics for the whole data, a set of top authors regarding centrality measures, as well as a visual analysis of the largest sub-components in the whole network.

3.2 Data Collection and Sample Selection

The data of our study is based on archival data of six ISPIM conference and symposium events between 2009 and 2011. The collected data includes information related to academic research publications, their authors, and the affiliations of the authors. The chosen scope has its potential advantages and disadvantages. The advantage is that focusing on the latest six events provides us with a picture of the recent state of the ISPIM innovation management community, and thus the focus is on the on-going collaboration within the network. The disadvantage is that some linkages which still may be active do not appear in our analysis. These issues should be kept in mind when interpreting the results.

The unit of analysis in this study is an ISPIM research paper with two or more authors. Following a bibliometric approach the following steps were conducted: Firstly, the reference list of all co-authored ISPIM publications was generated. Secondly, from each paper, author names, organizations, and countries were collected and double-checked to ensure that each author was identified correctly. Thirdly, co-authorship

relationships between all authors were measured and weighted (i.e. counting how many co-authored papers authors/organizations/countries had with each other). Fourthly, this verified data was then sorted, analysed and visualised with the help of Excel, SPSS, Ucinet and Netdraw software packages.

3.3 Key Measures

In social network analysis, there are numerous measures that can be used to measure centrality positioning of the nodes in a given network. A *node* refers here to any kind of actor within a network (e.g., an individual, a role, a company). Centrality measures help in determining the importance of a particular node in the network (Wassermann and Faust, 1994). Thus, in conducting the empirical analyses, we take the node's (here = authors or authors' countries) centrality positions as the unit of analysis. To indicate centrality of nodes, we utilise measures of *degree centrality* and *betweenness centrality*. We also measure the absolute co-authorship output from the study period for each node, which we call the *collaboration intensity*. These three measures are briefly described below.

Degree centrality (Freeman, 1979) is the most simple, most used and most easy-to-interpret measure of the node's network position. Degree centrality calculates how many direct connections each node has with other nodes in the network. Therefore, it directly shows how linked each node is to other nodes. A high degree centrality then indicates that the node has a central position in the network among other nodes (indicating e.g. a "hub" or otherwise relevant position). We also measure *collaboration intensity*, which is in principle the same measure as degree centrality, but which also takes into account if a certain co-authorship has been conducted multiple times (whereas in the degree centrality all unique co-authorship connections are counted only once). Thus, collaboration intensity can be interpreted as the total number of co-authorship connections in the measured period of time, not taking into account if these connections are to same or different authors.

Betweenness centrality (Freeman, 1979) departs from the above-mentioned measures in that it is used for investigating the structural position of a particular node between clusters of nodes in a network. Therefore it can be interpreted as measuring the nodes based on their position and role as a gatekeeper between two or more independent components. Such nodes may be in a structurally powerful position because they might be able to exploit their gatekeeper role for the purposes of knowledge and resource sharing between the separate parts of the network, for example.

To further facilitate the interpretation of the results, we will also conduct an analysis of *network components*. According to Hawe et. al. (2004), a component is a part of a network in which all authors are directly or indirectly connected by at least one connection. Thus, the component analysis will reveal those groups within the whole of the ISPIM network that are internally connected, but separate from each other.

4 Results

4.1 A Descriptive Profile of ISPIM publications from 2009 to 2011

In Table 1 we have presented a descriptive profile of the ISPIM conference and symposium publications based on the number of publications. Altogether, 789 ISPIM papers were published from 2009 to 2011. Of these, on average 184 were published from the annual conference and 79 from the annual symposium. This makes conferences over 2.3 times larger than symposiums when the number of publications is used as a metric.

Table 1. A Descriptive Profile of the number of ISPIM publications from 2009 to 2011

Event	**Conferences**			**Symposium**			
	2009 Vienna	2010 Bilbao	2011 Hamburg	2009 New York	2010 Quebec	2011 Wellington	Total
EU/Funded Project	0	3	1	0	0	0	4
Full Academic Paper	120	120	134	60	47	53	534
Funded Project	0	0	0	0	0	1	1
Practitioner Presentation	13	11	10	4	6	5	49
Short Academic Paper	65	42	33	32	18	11	201
Total	*198*	*176*	*178*	*96*	*71*	*70*	789

According to the classification profile based on percentage shares in Table 2, about 2/3 of the published papers are full academic papers (percentage ranges from 61 to 76 per cent between events). The second largest category is short academic papers, which represent about 1/4 share of the all publications. However, the variance between events is substantially larger compared to full papers, since the percentage share of the short papers ranges from 16 to 33 per cent. Compared to academic papers, the practitioner publications category share is significantly smaller and on average it only has around a 6 per cent share. Funded EU and other projects papers are only published randomly by ISPIM (less than 1 per cent of the all publications).

Table 2. A Descriptive Profile of the percentage share of ISPIM publications from 2009 to 2011

Event	**Conferences**			**Symposium**			
	2009 Vienna	2010 Bilbao	2011 Hamburg	2009 New York	2010 Quebec	2011 Wellington	Total
EU/Funded Project	0 %	2 %	1 %	0 %	0 %	0 %	0.5 %
Full Academic Paper	61 %	68 %	75 %	63 %	66 %	76 %	68 %
Funded Project	0 %	0 %	0 %	0 %	0 %	1 %	0.1 %
Practitioner Presentation	7 %	6 %	6 %	4 %	8 %	7 %	6 %
Short Academic Paper	33 %	24 %	19 %	33 %	25 %	16 %	25 %

As a result, even if ISPIM events have participants from academic communities and practitioners such as industrialists, consultants and public sector actors, it appears that the

majority of ISPIM publications are made by academics (or at least a large majority of publications are filed as academic papers).

Since in this study we were especially interested in evaluating co-authorship relationships, in Table 3 we have presented a crosstab for number of authors and publication type. It seems that project papers and practitioner presentations are typically written individually (i.e. all these publications had only one author) whereas writing a full or short scientific paper is more likely to be written in a small group (about 23 per cent of these publications had a single author). In general, the number of authors in ISPIM publication remains less than four (87 per cent of the publications had 3 or less authors). About 9 per cent of the papers have four authors, while five or six author papers have only 4 per cent share combined. Based on these results, the most interesting categories for our further analysis are full and short academic papers, since only those fulfil our requirement for unit of analysis (i.e. those include co-authored publications) and representing the majority of publications.

Table 3. A crosstab of the author count and publication type by number of publications and percentage share

Author count	EU Project or Funded Project	Full Academic Paper	Funded Project	Practitioner Present.	Short Academic Paper	Total	Total cum. %
1	4 (100%)	118 (22%)	1 (100%)	49 (100%)	49 (24%)	221 (28%)	28
2	0	191 (36%)	0	0	75 (37%)	266 (34%)	62
3	0	156 (29%)	0	0	47 (23%)	203 (26%)	87
4	0	50 (9%)	0	0	21 (10%)	71 (9%)	96
5	0	9 (2%)	0	0	6 (3%)	15 (2%)	98
6	0	10 (2%)	0	0	3 (1%)	13 (2%)	100
Total	4	534	1	49	201	789	
Total%	0.5%	67.7%	0.1%	6.2%	25.5%	100%	

4.2 Country level analysis of the ISPIM publications

In order to understand more about the structure of ISPIM multi-authored publications, a country analysis was conducted. In Table 4 we have presented a crosstab for the number of authors and number of countries per publication.

Table 4. A crosstab of the author count and number of countries in one publication

Author count	One county	Two countries	Three countries	Total
1	221 (28%)	-	-	221 (28%)
2	253 (32%)	13 (1.6%)	-	266 (34%)
3	171 (22%)	32 (4.1%)	-	203 (26%)
4	50 (6%)	17 (2.2%)	4 (0.5%)	71 (9%)
5	11 (1%)	3 (0.4%)	1 (0.1%)	15 (2%)
6	9 (1%)	3 (0.4%)	1 (0.1%)	13 (2%)
Total	715 (90.6%)	68 (8.6%)	6 (0.8%)	789 (100%)

It appeared that 715 out of 789 publications (91 per cent) are made by authors from the same country. Occasionally authors of individual ISPIM publication come from two different countries (68 publications had authors from two countries resulting 9 per cent share) and only randomly from three different countries (in all 6 publications, resulting

less than 1 per cent share). The most common setup for international collaboration is three authors from two different countries (4.1 per cent).

From 2009 to 2011 ISPIM publications were made by 1250 authors from 55 different countries. According to Table 5 Germany and Finland are clearly the leading countries regarding number of authors in the ISPIM community. Altogether there were 191 German and 179 Finnish authors who in all represent nearly 30 percentage share of all authors. The third biggest country was Spain with 91 authors and fourth was United Kingdom (UK) with 69 authors.

Table 5. Number of authors per country: TOP 20 countries

Rank	Country	Author count	Author %	Rank	Country	Author count	Author %
1	Germany	191	15,3	11	Brazil	33	2,6 %
2	Finland	179	14,3	12	Belgium	31	2,5 %
3	Spain	91	7,3	13	USA	30	2,4 %
4	UK	69	5,5	14	Australia	29	2,3 %
5	Taiwan	57	4,6	15	Switzerland	29	2,3 %
6	Austria	47	3,8	16	Canada	27	2,2 %
7	Sweden	45	3,6	17	New Zealand	27	2,2 %
8	Netherlands	41	3,3	18	Italy	25	2,0 %
9	Japan	39	3,1	19	South Korea	23	1,8 %
10	France	36	2,9	20	Luxembourg	17	1,4 %

In order to evaluate in more detail what kinds of relationships are occurring between countries, an ego analysis at the country level was conducted with the help of Ucinet and Netdraw software packages (Table 6 on the next page). Thus, instead of using individual authors as a measure, in this analysis we converted each author to represent their home country. In the case of *degree centrality* measure, which measures the number of direct ties that an actor has (Freeman, 1979), the simultaneous inter-country co-authorship occurrences were calculated only once to show the actual amount of diversity of such activities. However, the simultaneous occurrences were taken into account in the case of *collaboration intensity* measure, helping to better show the volume of collaboration.

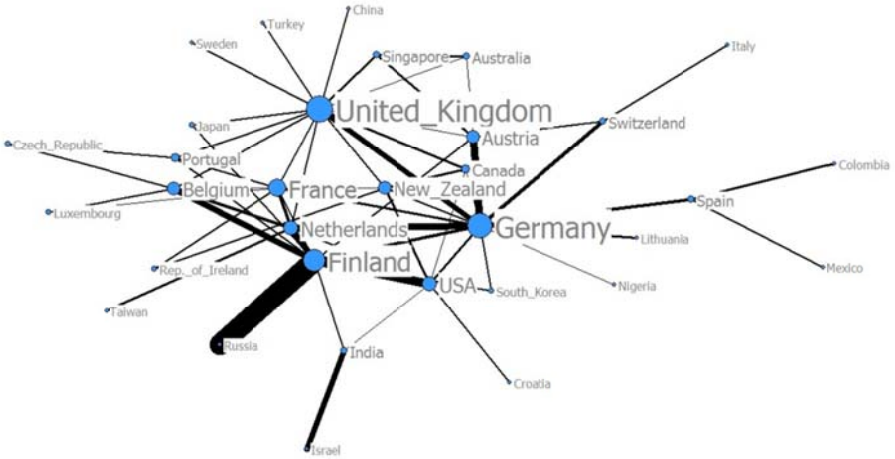
33 out of 55 countries (60 per cent) had collaborated internationally. To facilitate the understanding of the complex phenomenon of multi-actor social networks, we also visualised country level ISPIM co-author network relationships in Figure 1 (see next page). In order to visualise the differences between countries more clearly, we also weighted some of the key measures in Figure 1. *First*, the lines between countries are weighted according to the number of co-authorships. The stronger the black line is, the more co-publications countries have made together. Here, if two authors had written more than one publication, their contribution was taken into account multiple times.

As shown in Figure 1, the line between Finland and Russia is the strongest (they have 27 connections). For example in the case of 1) USA and Canada and 2) Austria and Australia the line is thinnest since those countries have only 1 connection with each other. When all connections are included to count (i.e. collaboration intensity measure), Finland is the leading country with 72 connections, Germany second with 54 connections and UK third with 33 connections. Other major players are Netherlands (32 connections), Russia (27), USA (24) and Belgium (20). Rest of the countries results are presented in next page Table 6 *collaboration intensity* column.

Table 6. ISPIM publication network– Ego analysis at country level from Vienna 2009 to New Zealand 2011

	Betweenness centrality			Degree centrality			Collaboration intensity	
1	Germany	200,6	1	UK	15	1	Finland	72
2	UK	151,1	2	Germany	14	2	Germany	54
3	Finland	105,3	3	Finland	12	3	UK	33
4	Spain	61,0	4	France	10	4	Netherlands	32
5	USA	51,1	5	Netherlands	8	5	Russia	27
6	France	49,5	6	USA	8	6	USA	24
7	Netherlands	42,0	7	Austria	7	7	Belgium	20
8	Austria	33,1	8	Belgium	7	8	Austria	19
9	India	31,0	9	New Zealand	7	9	France	18
10	Switzerland	31,0	10	Portugal	5	10	New Zealand	13
11	Belgium	27,4	11	Canada	4	11	India	11
12	New Zealand	16,9	12	India	4	12	Switzerland	9
13	Portugal	14,5	13	Singapore	4	13	Singapore	9
14	Canada	3,4	14	Spain	4	14	Spain	9
15	Japan	1,9	15	Switzerland	4	15	Portugal	8
16	Czech Rep.	0,3	16	Australia	3	16	Canada	8
17	Australia	0	17	Czech Rep.	3	17	Israel	8
17	China	0	18	Japan	3	18	Australia	5
17	Colombia	0	19	Luxembourg	3	19	South Korea	4
17	Croatia	0	20	Ireland	3	20	Czech Rep.	4
17	Israel	0	21	South Korea	3	21	Ireland	4
17	Italy	0	22	China	2	22	Japan	4
17	Lithuania	0	23	Israel	2	23	Taiwan	3
17	Luxembourg	0	24	Italy	2	24	Colombia	3
17	Mexico	0	25	Russia	2	25	Luxembourg	3
17	Nigeria	0	26	Sweden	2	26	Lithuania	3
17	Ireland	0	27	Colombia	1	27	Croatia	2
17	Russia	0	27	Croatia	1	28	Mexico	2
17	Singapore	0	27	Lithuania	1	29	China	2
17	South Korea	0	27	Mexico	1	30	Italy	2
17	Sweden	0	27	Nigeria	1	31	Turkey	2
17	Taiwan	0	27	Taiwan	1	32	Sweden	2
17	Turkey	0	27	Turkey	1	33	Nigeria	1

Figure 1. ISPIM co-author network at country level between 2009 and 2011



Second, the size of the circle in front the country name is weighed on the basis on the number of individual connections (i.e. *degree centrality* measure column). The bigger the circle is, the more individual connections the country has. United Kingdom circle is the biggest with 15 individual connections, Germany the second biggest with 14 connections and Finland third largest with 12 connections. Runner-ups are France with (10 connections), Netherlands (8), and USA (8), Austria (7) and New Zealand (7). In Table 6 *degree centrality* column we have presented the rest of the country-specific results.

As we could assume based on the simple descriptive statistics, the countries which were leading in the number of co-authored papers, have also leading and central positions in the network analysis. Following in-depth analysis reveals the underlying reasons what kind of collaboration each county is doing with other countries. Germany with largest number of authors (191) has the most central position in terms of betweenness of the ISPIM country network (*betweenness centrality* value in Table 6 is 200.6). Interestingly, the second largest author country Finland (179 authors) is not second but the third most central country within ISPIM network (*betweenness centrality* = 105.3). Authors from United Kingdom (*betweenness centrality* = 151.1) are a bit more diversely connected actors in the network than Finland resulting second most central position for them. Overall, in our opinion these three countries (Germany, Finland and United Kingdom) are forming the backbone of the ISPIM international network in terms of both centrality and volume of co-authorship connections.

In order to evaluate the relative internationalisation interest and internationalisation strategy among different countries, *internationalisation ratio* was defined by dividing *degree centrality* and *number of authors.* Since this measure does not take into account multiple publications between authors, *internationalisation volume ratio* was defined by dividing *collaboration intensity* with the *number of authors*. We named this measure as *internationalisation volume ratio.* Results are shown in Table 7.

Table 7. Internationalisation ratio TOP 20 countries

	Country	**Degree / Number of authors**		**Int. ratio**		**Country**	**Intensity. / Number of authors**		**Int. vol. ratio**
1	France	10	36	0,28	1	USA	24	30	0,80
2	USA	8	30	0,27	2	Netherlands	32	41	0,78
3	New Zealand	7	27	0,26	3	Belgium	20	31	0,65
4	Belgium	7	31	0,23	4	France	18	36	0,50
5	UK	15	69	0,22	5	New Zealand	13	27	0,48
6	Netherland	8	41	0,20	6	UK	33	69	0,48
7	Luxembourg	3	17	0,18	7	Austria	19	47	0,40
8	Austria	7	47	0,15	8	Finland	72	179	0,40
9	Canada	4	27	0,15	9	Switzerland	9	29	0,31
10	Switzerland	4	29	0,14	10	Canada	8	27	0,30
11	South Korea	3	23	0,13	11	Germany	54	191	0,28
12	Australia	3	29	0,10	12	Luxembourg	3	17	0,18
13	Italy	2	25	0,08	13	South Korea	4	23	0,17
14	Japan	3	39	0,08	14	Australia	5	29	0,17
15	Germany	14	191	0,07	15	Japan	4	39	0,10
16	Finland	12	179	0,07	16	Spain	9	91	0,10
17	Sweden	2	45	0,04	17	Italy	2	25	0,08
18	Spain	4	91	0,04	18	Taiwan	3	57	0,05
19	Taiwan	1	57	0,02	19	Sweden	2	45	0,04
20	Brazil	0	33	0,00	20	Brazil	0	33	0,00

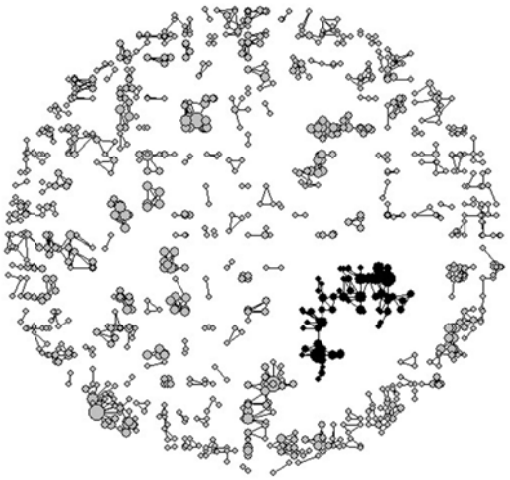
Interestingly, those from ISPIM backbone countries like United Kingdom, which in all had only 69 different authors compared to German's 191 and Finland's 179 authors, has clearly been more aggressive international collaborator. United Kingdom internationalisation ratio was 0.22 compared to German's and Finland's 0.07. In the case of volume based internationalisation comparison United Kingdom is clearly beating Germany (0.48 vs. 0.28) while United Kingdom and Finland are performing almost evenly (0.48 vs. 0.40). This indicates that Finland is favouring more intensive international relationships in comparison to two other major ISPIM actors. Finland's position from this perceptive can be partially explained by strong collaboration between three Russian researchers from St. Petersburg State University and five researchers from Lappeenranta University of Technology in Finland.

When other TOP 10 high number author countries are evaluated in more detail, it appeared that Taiwan and Sweden took an opposite direction compared to the United Kingdom and ended up at the bottom of the TOP 20 internationalisation ratio ranking. It appeared that Sweden-based authors had only one internationally co-authored publication, which was actually made by a Swedish author visiting the UK at the time of publication. Furthermore, in the case of Taiwan, only one author out of 26 had collaborated three times with the same Dutch author. Moreover, authors from the USA seem to value international collaboration within the ISPIM community since they have the second best *internationalisation ratio* value (0.27) and the best *internationalisation volume ratio* (0.80). There are definitely different strategies regarding internationalisation among authors from different countries participating in the ISPIM community.

4.3 Component analysis

In order to understand the ISPIM network structure more deeply, we conducted a component analysis which reveals the separate co-authorship groups within the ISPIM network. In Figure 2, we have visualised the ISPIM co-author network on the basis of component structure. The main component is highlighted in black and all the other remaining 284 components are coloured grey.

Figure 2. ISPIM co-author network component structure where the main component is visualised in black)



Altogether the ISPIM network included 1095 different authors who have co-authored one or more ISPIM publication. As Figure 2 illustrates, the majority of components are very small. In Table 8 we have named the major components on the basis of component members and their home country and have presented descriptive statistics regarding the component structure.

Table 8. Components descriptive statistics

	Name	**Size**	**%**	**Rank**	**Name**	Size	**%**
1	Finland led by multiple key authors	82	7,5	11	2 comp.	8	0.7
2	Germany led by JLeker	20	1,8	12	6 comp.	7	0.6
3	VTT Finland led by 3 key authors	18	1,6	13	16 comp.	6	0.5
4	Luxemburg led by ALMention	17	1,5	14	22 comp.	5	0.5
5	Sweden led by BBergvall Kårenborn	16	1,5	15	34 comp.	4	0.4
6	UK led by JBessant	15	1,4	16	86 comp.	3	0.3
7	Switzerland led by RBooutellier	14	1,3	17	108 comp.	2	0.2
8	Taiwan led by 3 key authors	13	1,2				
9	VTT Finland Oulu led by MPikkarainen	10	0,9				
10	2 components	9	0,8				

According to our component analysis, 108 components (38 per cent of all components) include only two authors, 86 components (30 per cent) include three authors, 34 components (12 per cent) include four authors and 22 components (8 per cent) include five authors. As a summary, 2/3 of the co-authored publications are made by ISPIM sub networks which include 5 or fewer authors.

The main component (i.e. largest component), which was visualised in black in Figure 2, includes 82 authors who mainly come from Finland. The detailed structure of the main component and the names of the authors and their relationships are presented on the next page in Figure 3 and followed by Table 9 presenting an ego analysis of main individual ISPIM co-authors. Besides the author's name, a country code was added to help us identify what kind of role each country has in the key author listing. In Table 9, depending on the variable, 29 to 37 individual author names are presented in order to keep the table in one page size. Moreover, the eight largest major components are also visualised in Appendix 1 and Appendix 2 Figures 1 to 4.

The results show, combined with the visual examination of Figure 3 and the appendices, that certain authors are clearly situated in central positions in their networks. Further examination also shows some variation between the measures. *Firstly*, the results clearly show that the authors situated high in betweenness centrality are those who combine and bridge two major clusters within the whole main component. *Secondly*, the main component involves several authors that have co-authored a lot within their network, and have also collaborated with a diverse network of authors. Interestingly, however, some authors outside the main component score notably high in the degree centrality. This result shows that such authors collaborate quite diversely in their particular areas within the whole ISPIM network.

Figure 3. Main component visualisation

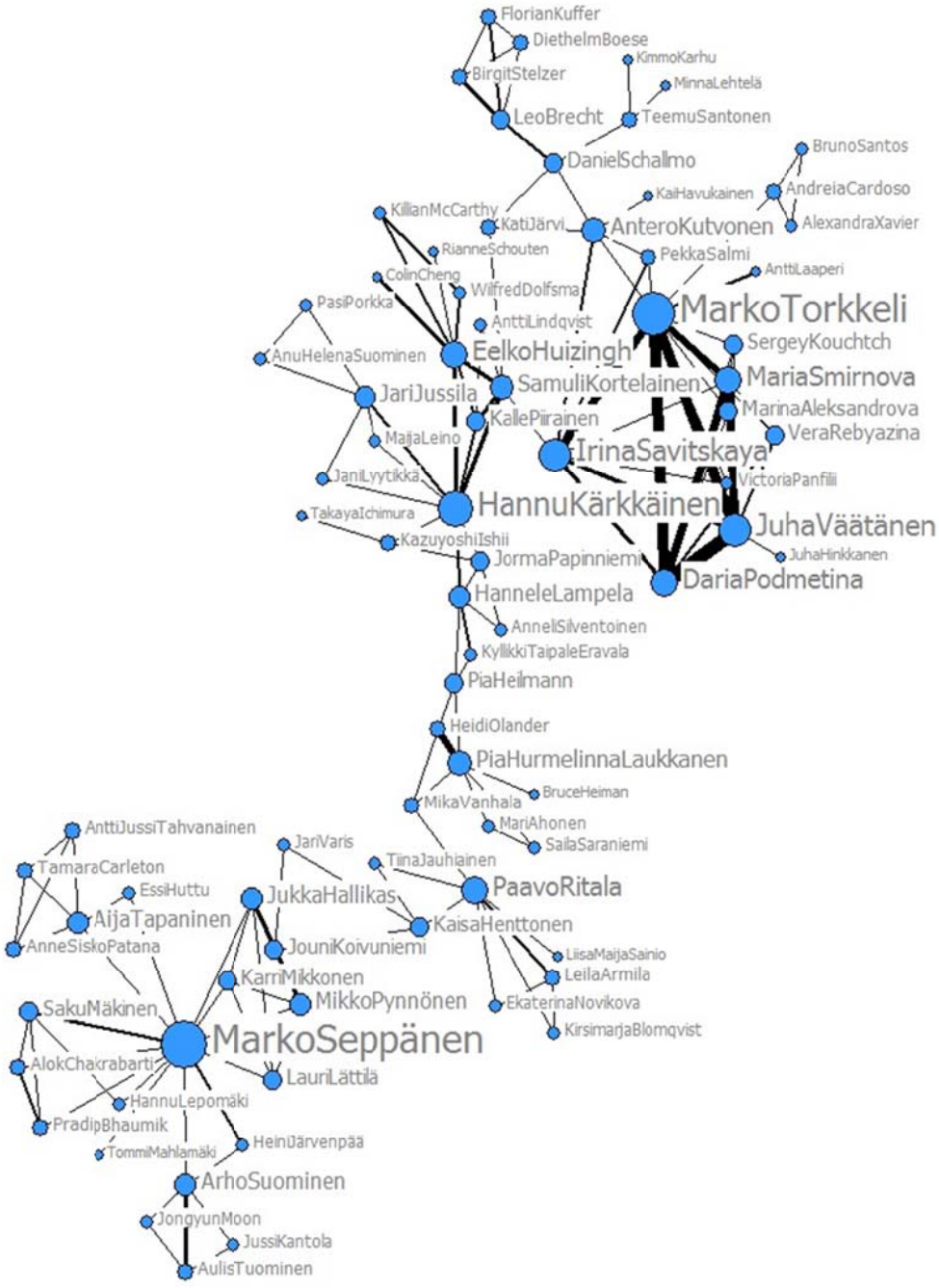


Table 9. ISPIM publication network – Ego analysis 1 of 1097 authors from Vienna 2009 to New Zealand 2011

	Betweenness centrality			**Degree centrality**			**Collaboration intensity**	
1	HKärkkäinen *FIN*	1847	1	BBergvall-K… *S*	15	1	MTorkkeli *FIN*	39
2	HLampela *FIN*	1648	2	JLeker *GER*	13	2	JVäätänen *FIN*	35
3	PHeilmann *FIN*	1610	3	JBessant *UK*	13	3	DPodmetina *FIN*	34
4	PRitala *FIN*	1584	4	MSeppänen *FIN*	13	4	MSmirnova *RUS*	23
5	MVanhala *FIN*	1508	5	MTorkkeli *FIN*	12	5	JLeker *GER*	21
6	SKortelainen *FIN*	1459	6	JPaasi *FIN*	12	6	ISavitskaya *FIN*	20
7	KHenttonen *FIN*	1298	7	KValkokari *FIN*	12	7	JPaasi *FIN*	20
8	JKoivuniemi *FIN*	1220	8	MPikkarainen *FIN*	10	8	KValkokari *FIN*	19
9	MSeppänen *FIN*	1070	9	HKärkkäinen *FIN*	9	9	BBergvall-K… *S*	18
10	PHurmelinna… *FIN*	941	10	ALMention *L*	8	10	EHuizingh *NL*	16
11	ISavitskaya *FIN*	873	11	GSchuh *GER*	8	11	HKärkkäinen *FIN*	16
12	HOlander *FIN*	705	12	ISavitskaya *FIN*	8	12	TLuoma *FIN*	15
13	MPynnönen *FIN*	558	13	KLChi *RC*	8	13	MSeppänen *FIN*	15
14	JHallikas *FIN*	558	14	MKTsai *RC*	8	14	FcMiralles *E*	14
15	DSchallmo *GER*	530	15	TLuoma *FIN*	8	15	MMartinez..*E*	13
16	KJärvi *FIN*	504	16	JVäätänen *FIN*	8	16	JBessant *UK*	13
17	MTorkkeli *FIN*	425	17	DPodmetina *FIN*	7	17	SKortelainen *FIN*	12
18	EHuizingh *NL*	313	18	EHuizingh *NL*	7	18	DChiaroni *I*	11
19	ASuominen *FIN*	235	19	MSmirnova *RUS*	7	19	FFrattini *I*	11
20	ATapaninen *FIN*	234	20	PRitala *FIN*	7	20	TMeristö *FIN*	11
21	LBrecht *GER*	234	21	RBoutellier *CH*	7	21	JLaitinen *FIN*	11
22	AKutvonen *FIN*	213	22	W-Chung *RC*	7	22	GSchuh *GER*	11
23	TSantonen *FIN*	159	23	AÖhrwall… *S*	6	23	MPikkarainen *FIN*	10
24	JJussila *FIN*	159	24	AKutvonen *FIN*	6	24	PHurmelinna...*FIN*	10
25	ACardoso *P*	158	25	FMTseng *RC*	6	25	K-LChi *RC*	9
26	JLeker *GER*	130	26	FReymann *GER*	6	26	HTuohimaa *FIN*	9
27	JVäätänen *FIN*	124	27	FMiralles *E*	6	27	MGomez Ji…*E*	9
28	ALMention *L*	93	28	JLSolleiro *MEX*	6	28	RGarcia Esc…*E*	9
29	KIshii *J*	80	29	KSumikura *J*	6	29	M-KTsai *RC*	9
30	CSCurran *GER*	78	30	OOmta *NL*	6	30	*12 authors*	8
31	JBessant *UK*	77	31	PHurmelinna...*FIN*	6	31	*16 authors*	7
32	BBergvall-K…*S*	77	32	SKortelainen *FIN*	6	32	*38 authors*	6
33	KValkokari *FIN*	71	33	96 authors	5	33	*84 authors*	5
34	ARousseau *L*	60	34	76 authors	4	34	*77 authors*	4
35	JPapinniemi *FIN*	60	35	196 authors	3	35	*185 authors*	3
36	PJBarlatier *CH*	59		395 authors	2	36	*364 authors*	2
37	RBoutellier *CH*	52		300 authors	1		*290 authors*	1

NOTE: Some of the surnames have been shortened due to the space limitation. After each author, we have presented their home country as following country codes: 1) Finland = FIN, 2) Germany = GER, 3) Italy = I, 4) Japan = J, 5) Luxemburg = L, 6) Mexico = MEX, 7) Netherlands = NL, 8) Portugal = P, 9) Russia = RUS, 10) Spain = E, 11) Sweden = S, 12) Switzerland = CH, 13) Taiwan = RC and 14) United Kingdom = UK.

4.4 Ego analysis of individual ISPIM co-authors

In general, in looking at country-specific affiliations, authors from Finland are clearly leading in each category. In the case of the *Betweenness centrality* measure, the first 14 authors are from Finland and in all 24 out of 37 authors are Finnish (i.e. 65 per cent). Finland is also performing well in the case of *degree* (14 out of 32 authors i.e. 44 per cent) and *collaboration intensity* (15 out of 29 authors i.e. 52 per cent) measure listings.

The second most important country is Germany with significantly less performance (4 authors in the case of *Betweenness*, 3 authors in *degree centrality* and 2 authors in *collaboration intensity*). Other countries have more mixed and less significant presence regarding our key measure.

The most diversely connected (in terms of degree centrality) Finnish actors in the main component are Marko Seppänen from Tampere University of Technology with 13 connections and Marko Torkkeli from Lappeenranta University of Technology with 12 connections. As stated in the component analysis section, there are multiple authors outside the main component, who have notably high degree centrality. Among these actors are JPaasi (12 connections), KValkokari (12) and MPikkarainen (10). Interestingly JPaasi and KValkokari belong on a different component than MPikkarainen even if they belong to the same organization (VTT). However, the first two are from the city of Tampere and the latter is from Oulu. Geographical distance between these cities is nearly 500 kilometres. This makes intensive research collaboration more difficult compared to a neighbouring colleague. Other interesting and highly connected authors are the top ranking Birgitta Bergvall-Kåreborn (15 connections) from Luleå University of Technology (Sweden), Jens Leker (13 connections) from University of Muenster (Germany) and John Bessant (13 connections) from University of Exeter (United Kingdom). Detailed analysis of their connection reveal opposite strategies: 1) domestic and 2) international collaboration. Bergvall-Kåreborn has only Swedish connections and Leker has one international connection. On the contrary, 6 out of 13 connections in the case of John Bessant are international. These results are understandable based on the high share of single country publications in the overall data (91 per cent), but as the examples show, there is variation between the authors in this regard.

When *collaboration intensity* results are evaluated, it again reveals a strong Finnish presence. Widely-connected (12 different connections) Marko Torkkeli from Lappeenranta University of Technology is leading the collaboration intensity ranking with 39 hits, followed by his colleagues Juha Väätänen (35), Daria Podmetina (34) and sixth-ranked Irina Savitskaya (20). Interestingly, their high ranking in collaboration intensity can be partially explained especially by extensive collaboration with Russian author Maria Smirnova (23) from St. Petersburg State University. Clearly their international strategy has been multi-authored studies within a tight research group. This is somewhat different to John Bessant's multi author approach, for instance, where co-authorships have typically been conducted with different partners in each publication event. Surprisingly, geographical distance (in terms of research collaboration and research group formation tightness) can be offered as a partial explanation also in the case of Lappeenranta University of Technology and St. Petersburg State University collaboration in general. Even if Lappeenranta and St. Petersburg cities are located in different countries, they are actually only 180 kilometres from each other. It is also known that Lappeenranta University of Technology has a strategic focus on the Russian market, which may explain some of the intensity of the collaboration.

At the moment, the most central actor in terms of betweenness centrality in the ISPIM co-author network is Hannu Kärkkäinen from Tampere University of Technology, Finland. His *betweenness centrality* value is 1847. Based on the visual analysis, he has the most mixed strategy among the high performing authors in ISPIM network. He has strong collaboration with authors from his home university, authors from Lappeenranta University of Technology and some international connections. This mixture of diverse, yet connected partners, makes him an important gate-keeper within the ISPIM

community. Several other authors also show up particularly highly in betweenness centrality, due to their unique position between various highly connected co-authorship clusters in the main component. These authors represent mainly Lappeenranta University of Technology, Finland (authors ranked in places 2-8 in betweenness centrality, Table 9).

To summarise our findings, it seems that there are multiple strategies to become a high-performing ISPIM community member, including: 1) strong domestic collaboration with close geographical distance actors, 2) widespread one-time international collaboration with multiple authors, 3) tight international collaboration with small, but long-term research groups and 4) mixture strategy which combines multiple approaches.

5 Conclusions

In this study, we have conducted a co-authorship-based social network analysis of the ISPIM innovation management community during the years 2009-2011. The results add to our understanding of how scientific networks are formed in general, and especially in the field of innovation management. By analysing co-authorship networks of ISPIM, this paper is the first attempt to understand the structure of this particular community, and can thus reveal interesting implications, as well as future research possibilities.

Overall, the results reveal the network structure in the co-authorship network, which shows that the ISPIM network is constructed from multiple sub-networks with one or several key actors in a central network position, and from a large number of isolated co-authorship pairs or groups. Thus, the network, as a whole, does not follow an intuitive core/periphery model (Borgatti and Everett, 1999), where in the centre, there is a dense and tightly connected network of key actors. Our results reveal a more scattered picture where the research collaboration within the ISPIM community is quite clustered and based mostly on the country of authors' origins. In our opinion, this is a natural consequence of the relevance of face-to-face interaction in research work, as well as a matter of practicality – people tend to co-author with people they can easily interact with. However, in order to ensure the dissemination of knowledge, capabilities, and insights within the network, a larger amount of international collaboration could also be quite useful. This could also ensure inclusion of new members outside the current community. Thus, the results call for further and stronger international collaboration among the innovation management scholars of ISPIM and beyond.

In practical terms, the conducted social network analysis on the ISPIM community provides practical insights to the members of this particular community and beyond. It helps to analyse the structure and central actors in the network, which can be helpful in tracking e.g. key authors, prominent speakers, or potential places of collaboration within and beyond the community. Furthermore, since our results are covering author and country viewpoints, this study will be valuable not only for authors in the ISPIM community, but also for those who are interested to evaluate innovation related research activities at country level.

Our study has limitations based on sample selection and timeframe. Our assessment of research collaboration is thus tied to formal co-authorships, and to the time period 2009-2011. Thus, the research admittedly leaves out many collaborative linkages that do exist between individual researchers outside the data analysed here. However, we believe that this study still provides quite a comprehensive outlook on the structure of the ISPIM community in its recent state. To gain even more insight, further research could enlarge

the timeframe to cover a longer time period, as well as find new network connections beyond the researcher and country-related linkages.

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Appendix 1:

Appendix 1: Major components 2 to 5

Figure 1: Major component 2: Germany

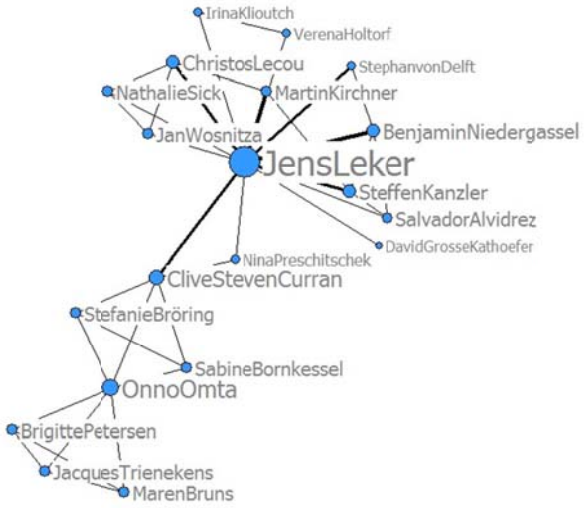


Figure 2: Major component 3: VTT Finland

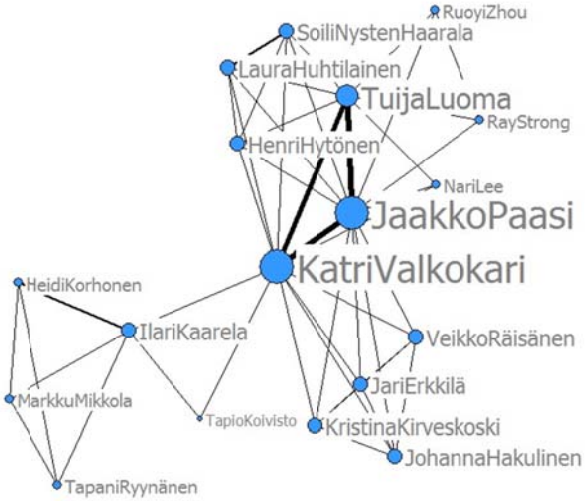


Figure 3: Major component 4: Luxemburg

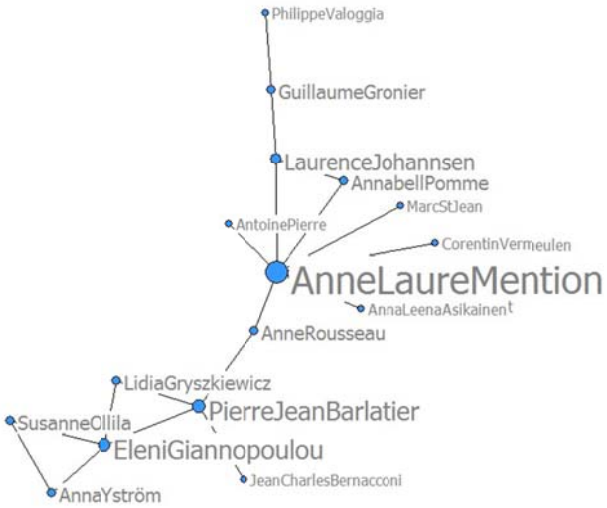
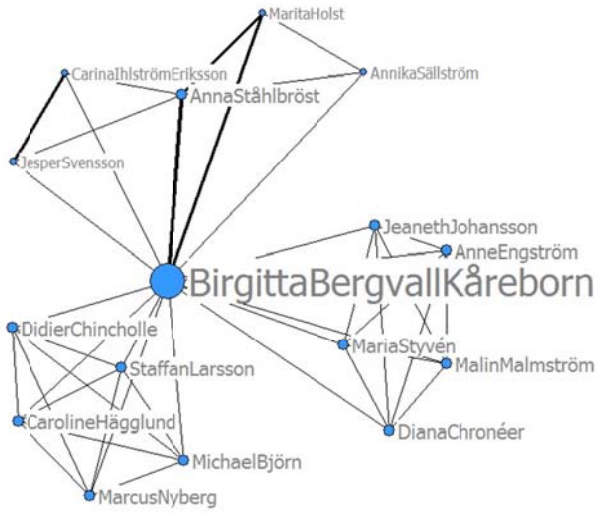


Figure 4: Major component 5: BBBergvallKårenborn (Sweden)



Appendix 2: Major components 6 to 9

Figure 1: Major component 6: JBessant

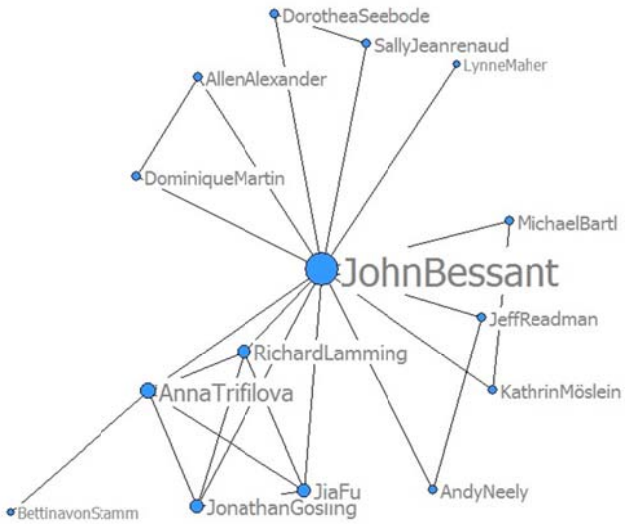


Figure 2: Major component 6: RBoutellier (Switzerland)

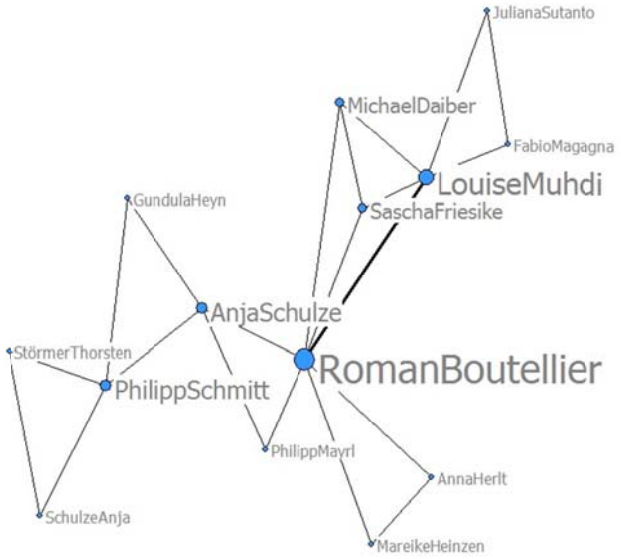


Figure 3: Major component 7: Taiwan

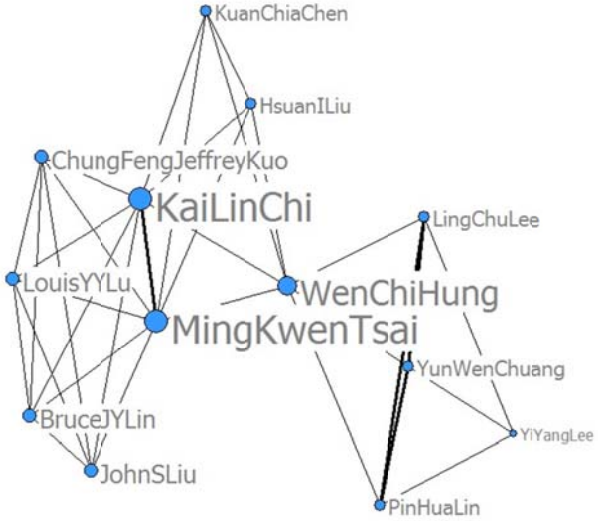


Figure 4: Major component 8: MPikkarainen (VTT Finland, Oulu)