Personal Communication Ties and Organizational Collaborations in Networks of Science, Education, and Business

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Abstract

The literature suggests that the success of innovation clusters is based on personal networks that connect members of scientific, educational and business organizations stimulating more formalized cross-boundary collaborations between the three sectors. However, it is still unclear if such organizational collaborations actually correspond to these personal ties and which aspects of personal communication are most strongly associated with organizational collaborations. To investigate this, we applied network analysis to study an innovation cluster in Algarve, Portugal. We found correspondence between personal ties and cross-boundary organizational collaborations. Moreover, the collaborations appeared to correlate most strongly with emotional attachments between individuals.

Keywords: Personal ties; organizational collaborations; emotional attachment; network analysis; regional innovation cluster; science, education and business.

Introduction

It is acknowledged that the collaboration between science, education and business provides benefits both to each of the sectors and to society as a whole, as it conditions the creation of new knowledge and innovation (Bruneel, d'Este, & Salter, 2010). Building innovation systems that integrate science, education and business despite differences in the specific goals of the sectors is now a common policy task for many countries striving towards the transition to knowledge-based economies. Network structures of organizational collaborations across the sectoral boundaries are considered to be one of the most important means to provide such integration. Such structures (1) involve joint innovation efforts putting research results into new products and services introduced to the market, (2) enable flexible exchange of resources and knowledge sharing crucial for innovation, (3) induce cross-sectoral personnel mobility, and (4) stimulate the creation of new innovation-oriented enterprises (Breschi & Lissoni, 2003; Jaffe, Trajtenberg, & Henderson, 1993; Krätke, 2011; Malerba, 2009; Robinson, Rip, & Mangematin, 2007).

The majority of studies on innovation-oriented science, education and business collaborations have focused primarily on generalized science-industry or formal inter-organizational links between research and business, mostly in so-called 'high-tech' industries (Bania, Calkins, & Dalenberg, 1992; Meyer-Krahmer & Schmoch, 1998). These studies addressed the aggregate effects of university research on knowledge production in companies (Anselin, Varga, & Ács, 1997; Jaffe, 1989), certain types of knowledge interactions such as citations of university research in company patents (Jaffe et al., 1993), personnel mobility (Bania et al., 1992), joint publications (Hicks, Isard, & Martin, 1996), and the formation of new 'spin-off' companies by university members (Parker & Zilberman, 1993). However, in recent decades, researchers also have recognized the value of less formal networks of personal communication ties

forming the basis for trust (Newell & Swan, 2000), information exchange (Grandori & Soda, 1995), practice sharing (Brown & Duguid, 2001) and knowledge creation (Easterby-Smith, Lyles, & Tsang, 2008; Pinch & Henry, 1999). Scholars have seen such networks as underpinning the emergence and development of relations between organizations because personal ties involving informal interactions enable common 'language' and culture (Bonaccorsi & Piccaluga, 1994) as well as cognitive closeness (Balconi & Laboranti, 2006; Gubbins & Dooley, 2014; Lorenzen, 2001; Boschma & Lambooy, 1999). These ties also induce 'personal chemistry' among the individuals that makes them more open to the new ideas of each other, hear each other's needs, and accept that there is something to learn from the other partners (Taylor, 2005, p. 481), bonded by feelings of personal obligations and emotional closeness (Huber, 2012, p. 1179), such as sympathy, friendship, or astonishment, which are achieved throughout joint work or leisure. Hence, networks of personal ties can be expected to provide a good basis for mutual understanding and collaboration across the boundaries of science, education and business despite their specific goals, strategies, norms and values.

The role of communication across boundaries in a knowledge-based economy including organizations, activities, disciplines, fields, etc. has been emphasized by researchers from the business and technical communication field (Rice, 2009; Spinuzzi, 2007). Yet, to the best of our knowledge, the relation between concrete personal communication ties and cross-boundary organizational collaborations between science, education and business has not been examined. In other words, it is still unclear if presence of personal communication ties connecting members of two organizations which belong to different sectors is related to more formal collaborations between the organizations. Consequently, there is no information on which particular aspects of such personal ties are the most relevant to the presence of the cross-boundary collaborations. To fill this gap we suggest to focus exclusively on networks

of links across the sectoral boundaries answering: *How are organizational collaborations across the boundaries of science, education and business related to different aspects of personal ties between these organizations?*

This investigation applies network analysis, a structural approach broadly used to understand patterns of relationships between nodes, such as people or organizations. Network analysis explains phenomena primarily with the ways these relationships are configured into larger structures. It gives a secondary role to properties of nodes, meanings of the relationships to them, the particular ways interactions unfold, and the contexts of interactions. Consequently, data collection techniques used in network analysis, such as the most widespread method of sociometric questions (Wasserman & Faust, 1994), are first and foremost capturing who is linked to whom.

This focus on the structures of links has significant explanatory capacity. The patterns of relations, when mapped, allow us to visualize and explore the set of connections between individuals or organizations. This structure can then be described with statistics that capture characteristics of the network in order to explain various phenomena. For instance, such measures as network density and centralization allow us to locate blocks and overloads in exchanges of information, knowledge and resources. They also enable researchers and practitioners to identify if information, knowledge and resources tend to be channeled via a few central nodes or distributed more evenly among the nodes, thus identifying the possible imbalances in distribution of information, knowledge and resources – and hence power imbalances. Centrality measures characterize positions of certain nodes in the networks and therefore help to identify roles particular individuals or organizations play in structures of exchanges with others. For example, Zwijze-Koning and de Jong (2015) show how network analysis can be applied to assess communication in organizations and uncover

communication problems.

Moreover, network analysis allows finding how structural properties of relational patterns affect performance, knowledge diffusion, and innovation potential. For instance, using network analysis of technology-based alliances in the pharmaceutical, chemical and automotive industries Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van den Oord (2008) found that novelty creation, absorption of innovations, and the resulting number of patents depend on overall density of the network and on the ability of organizations to connect parts of the network, which is captured by betweenness centrality measure. In a study of collaborations between universities and industry in microelectronics Balconi & Laboranti (2006) applied network analysis to reveal how research progress is enabled by the specific patterns of personal ties between academic and industrial researchers. The study detected particular types of interpersonal structures associated with higher research performance (measured by patents applied for and citations received): strongly connected teams mixing researchers from academy and industry. Analyses of networks of research institutes and of innovating companies by Cowan & Jonard (2004) showed that the extent of knowledge diffusion in these is affected by the network structure. It was found that the highest diffusion performance is achieved when the networks contain denser clusters of links with sparser structures between the clusters. Ouimet, Landry, & Amara (2004) explored network positions of companies within the Quebec optics and photonics cluster and found that the amounts of ties organizations have are positively related to radical innovation.

A series of studies (Cruz, Gonçalves, Pinto, Pintassilgo, & Guerreiro, 2011; Gonçalves, Cruz, Pinto, Pintassilgo, & Guerreiro, 2011), including a large comparative project within the 7th EU Framework program project KIMEERA (Cooke, Porter, Cruz, & Pinto, 2011), used network analysis to study a science-driven maritime innovation cluster located in the Algarve

region of Portugal. The cluster is composed of 25 entities (university faculties, research centers and companies). It is an attractive case for analysis, not only because research and education in marine science in the Algarve are among the global leaders in this field, but also because for maritime clusters in general (Chang, 2011) and for this cluster in particular, cooperation between science, education and business is essential (Cooke et al., 2011). Based on interview data that captured collaborations between organizations, the researchers have shown that despite efforts put into stimulation of cooperation by administrations, innovation intermediaries and participants of the cluster, organizational collaborations across the sectoral boundaries in Algarve are still insufficient (Comissão de Coordenação e Desenvolvimento Regional do Algarve [CCDR], 2008; 2009; Cruz et al., 2011; Gonçalves et al., 2011). It has also been suggested that these collaborations could benefit from personal communication ties between members of organizational entities (Cooke et al., 2011; Cruz et al., 2011; Gonçalves et al., 2011).

These studies gained insights on the importance of personal communication for the cluster and have shown high relevance of network analysis for studying this case. However, the data on structures of relations they used included only organizational collaborations, but not personal ties, which turned out to be crucial for the collaborations between science, education and business only as a result of the analysis. Besides, the network analysis conducted by these researchers was limited to mapping of the network and interpretation of several basic network-level descriptive statistics, without looking for the underlying principles of structure formation. Therefore, it is still not clear, to what extent the personal ties are actually relevant for the development of organizational collaborations in the cluster. Our study bridges this gap collecting also the data on personal ties and using network correlation analysis in order to test for association between structures of personal communication ties and structures of organizational collaborations.

In the following sections, we build on the background of literature on correspondence between personal communication networks and organizational collaboration networks in regional innovation clusters – including university-industry – in general, as well as specific aspects of the personal communication ties. Based on a survey conducted by the authors, the characteristics of the cluster's organizational level collaborations between science, education and business, as well as the structures of personal cross-boundary ties within the cluster are studied. Having described the main features of the empirical case context and of the data, we outline network mapping procedures and network analysis techniques applied. Then we compare the networks visually inspecting them and interpreting standard network statistics. Further on, we use QAP correlation procedure to test to what extent organizational collaborations are associated with different aspects of personal ties. Finally, the findings and possible future avenues are discussed and some practical implications, as well as limitations are outlined.

Literature Review and Description of Analytical Focus

Networks of Personal Ties and Organizational Collaborations

Organizational networks, where organizations are nodes and lines are the connections between them, such as collaborations, alliances, and resource exchanges, have been thoroughly investigated in recent decades showing that these networks are highly relevant to innovation (Hargadon & Sutton, 1997; Malerba, 2009). Also, it has been shown that those relations are always embedded in inter-personal communication networks across boundaries of organizations or units (Granovetter, 1973; 1985). In these networks nodes represent individual members and lines stand for connections between them. Personal networks – especially face-to-face interactions – enable sharing of practice and knowledge between

organizations (Brown & Duguid, 2000; Easterby-Smith et al., 2008) as well as diffusion of innovation (Ceci & Iubatti, 2012). Therefore, organizations embedded in personal networks are more innovative (Brass, Galaskiewicz, Greve, & Tsai, 2004). Moreover, personal networks create common interests, worldviews and cultures allowing organizations to overcome what Grandori & Soda (1995) termed the 'psychological distance' between their cognitive and emotional orientations, as well as the distance between their organizational profiles, hence enabling trust (Eisenhardt & Schoonhoven, 1996). As a result, embeddedness in personal communication structures motivates organizations to pursue goals not linked to immediate economic revenues, but rather to the long-term strengthening of their networks. Besides, personal ties are "capable of generating other, more institutionalized forms of coordination" (Grandori & Soda, 1995, p. 199). Overall, personal networks form the basis of integration and cooperation between organizations.

The Role of Personal Ties in Relations between Science, Education and Business

Research reports that personal communication plays a particularly important role in university-industry collaborations (Kaufmann & Tödtling, 2000). For instance, studies on university-industry knowledge interactions reveal that personal communication is the most widespread type of exchange between universities and industry (Arundel & Geuna, 2004); that science partners regularly use their personal networks to contribute to innovation networks (Bower & Keogh, 1996); that researchers' individual characteristics have a stronger impact on university-industry knowledge interactions than the characteristics of their department or university (D'Este & Patel, 2007). The scholars also show that university-industry knowledge dissemination and technology transfer are often carried out via informal contacts (Østergaard, 2009). Informal interactions between university scientists and managers/entrepreneurs in the private sector are particularly important in this regard (Siegel

et al., 2003), for which informal communication, public events, and consulting are among the main knowledge transfer channels (Gubbins & Dooley, 2014). Such contacts are also the reason why the literature suggests that the agglomeration of research institutions and companies within innovation clusters appears to be important (Arundel & Geuna, 2004).

Personal contacts between science, education and business entities have also been shown to enrich the pool of candidates for recruitment, create intellectual capital, raise cross-functional team effectiveness, enable employee turnover, provide competencies in entrepreneurship to science and education, give universities access to regional production networks, and make internationalization for business and education easier (Chakrabarti & Santoro, 2004). Via personal ties faculty members and students can be engaged in joint university-industry projects, consulting and expertise, so that universities gain practical expertise and resources, while companies receive creative and high-tech solutions (Perkman & Walsh, 2007).

Consequently, we can expect that personal communication ties across the boundaries of science, education and business stimulate the establishment of organizational collaborations, promoting the growth of integration between the sectors. However, to date, most studies of personal relations in collaborative innovation and organizational cooperation focused on benefits and negative effects for individuals and organizations to occupy certain network positions (Burt, 1980; Granovetter, 1973; Inkpen & Tsang, 2005; see Provan, Fish, & Sydow, 2007 for a summary). To our knowledge, no studies have examined the *correspondence* between personal communication ties across organizational boundaries and organizational collaborations in networks of science, education and business (or university-industry): this is where we intend to make our contribution.

Aspects of Personal Ties across the Boundaries of Science, Education and Business

Personal ties have multiple aspects. They cannot be reduced to simple indicators, such as frequency of communication. In his influential work, Granovetter (1973) has suggested that communication ties may be distinguished by "the amount of time, emotional intensity, intimacy (mutual confiding), and reciprocal services which characterize [them]" (p. 1360). Padgett and Powell (2012) later argued that the multidimensionality of network relations particularly contributes to knowledge sharing and to the establishment of new relations. Thus, another important task is to identify, which aspects of personal communication ties are particularly relevant to the existence and development of organizational collaborations.

Little is known about the impact that different aspects of personal communication have on organizational collaboration, particularly in regional innovation clusters - such understanding needs to be based on more general studies. First, network studies traditionally account for communication frequency (e.g., Granovetter, 1973): The more often individuals interact, the higher may be the chances of their organizations to be involved in more formal collaborations.

Second, there is a consensus that an important function of personal communication ties across university-industry boundaries is the exchange of knowledge between organizations, development of a joint 'language' and a common research culture, formation of a common knowledge base (Bonaccorsi & Piccaluga, 1994), cognitive coordination (Gubbins & Dooley, 2014; Lorenzen, 2001) and cognitive proximity (Boschma & Lambooy, 1999). Therefore, the intellectual (cognitive) dimension of personal communication ties should be taken into account when considering knowledge-sharing and innovation-oriented collaborations between science, education and business.

Third, as - already - Granovetter's (1973) classical work has argued, emotional attachment between individuals that develops throughout communication is important. Cova and Salle (2000) refer to the emotional superstructure of a relationship. Matzler, Renzl, Müller, Herting, & Mooradian (2008) found empirical evidence of the impact of enduring individual characteristics on knowledge sharing. It is "personal rapport and chemistry among the individuals" that make organizational alliances emerge and work, as "inter-personal trust is also built up when people are prepared to be open to new ideas, to listen to each other and to accept that there is something to learn from the other alliance partners" (Taylor, 2005, p. 481), going beyond formal relations (Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van den Oord, 2008). It has been shown that "the most important knowledge relations are based on high levels of feelings of personal obligations and emotional closeness" (Huber, 2012, p. 1179).

Based on the abovementioned literature we suggest focusing on such aspects of personal ties as frequency of communication, intellectual influence, and emotional attachment and test if these correspond to organizational collaborations and what their relevance is in comparison to each other.

Recent research has suggested that it would be an interesting extension of the network analysis of regional clusters to account also for tie strength (Giuliani, 2013). Studies including empirical research of knowledge and innovation collaborations argue that complex knowledge transfer in networks requires what Granovetter (1973) termed as strong ties – those based on intense and frequent interactions between partners (Hansen, 1999). Such ties are especially stimulating for the development of trust and mutual understanding, most often working via face-to-face interactions (Storper & Venables, 2004). Strong ties allow going beyond self-oriented interests of the actors and, therefore, to be particularly relevant for

development of cross-boundary collaborations between science, education and business. Following this literature, our focus when studying personal ties will be on those exhibiting higher frequency of communication, stronger intellectual influence, and stronger emotional attachment.

The Empirical Case

To get an insight into the relations between different aspects of personal ties and organizational collaborations in networks of science, education and business, we studied a specific regional innovation setting: The Algarve maritime cluster in Portugal.

The Algarve region includes unique marine ecosystems (e.g., the Ria Formosa) that provide numerous opportunities for maritime studies unavailable anywhere else in the world, putting marine research and education of Algarve (the primary disciplines involved being biology, chemistry and physics) among the global leaders in the field. There are many unique natural tourist attractions as well. However, this case has drawn our attention primarily because administrations and local experts make a notable attempt to use the existing innovative potential in order to transform the region from a state of economic periphery driven by agriculture and fisheries to a knowledge-based innovation cluster. As we show below, integration of science, education and business in the region is pivotal for this effort.

The ocean is central to the economy of the Algarve and its essential role in the progress and diversification of maritime activities are the essence of the region's development, as acknowledged in major programs and strategic plans for the region pushed by the Regional Development Coordination Commission (CCDR, 2006; 2007; 2008; 2009) as well as in scientific studies (Cruz et al., 2011; Gonçalves, et al., 2011). In maritime-oriented regions business, research and education organizations are usually operating in diverse areas, such as

shipping, shipbuilding, offshore services, inland waterways, pharma, yacht building, marine equipment, seaports, maritime services, fishing, marine food production, navy, waterworks, and coastal tourism (see an extensive overview in: Cooke et al., 2011). Involvement in maritime economy makes all those diverse organizations join into maritime clusters creating "<…> a network of firm, research, development and innovation units and training organizations <…> which cooperate with the aim of technology innovation and of increasing maritime industry's performance" (Chang, 2011, p. 489). In the case of the Algarve, maritime production and services (food production and aquaculture, coastal tourism and knowledge-driven services) get linked with research units producing knowledge in maritime science and educational institutions providing human resources (CCDR, 2008; 2009; Cruz et al., 2011; Gonçalves et al., 2011).

In the Algarve maritime cluster, research and education entities are a group of different units of the University of Algarve (faculties and schools, research units, and other entities). It is mainly them who provide not only knowledge, technology, and human resources, but also create innovation-oriented business organizations as spin-offs and start-up companies founded by alumni/employees of the university. In coastal tourism Algarve companies engage in collaborative R&D projects with university faculties and research centers to deliver innovation in tourist services, management, economy, environmental issues and energy use for tourist activities. In maritime food production and maritime services research centers generate knowledge companies can use. Faculties provide training and human resources both for the companies and the research centers.

Although cooperation does take place, qualitative studies have reported insufficient collaborations between research centers, companies and faculties (Cooke et al., 2011; Gonçalves et al., 2011). The most important barriers to collaborations between science, education and business in the region appear to result from the lack of mutual understanding

across the sectoral boundaries. Consequently, the potential benefits of cross-boundary cooperation for each of the sectors, though highlighted by administrations and experts, are often underestimated. Companies, for instance, do not clearly comprehend the potential contribution of science done in the university research centers to business. Managers have limited vision of the broader innovative potential their business has. They rely on core innovations they initially started their companies with as well as on internal R&D and neglect other opportunities for research-driven development. Hence, their interest in cooperation with research centers and faculties is low. Simultaneously, research units experience difficulties in communicating science and in transferring knowledge (Cooke et al., 2011, pp. 42, 44, 66)..

Moreover, research and education are behind the companies' demand for human resources and research services (Ibid., p. 45). Education does not respect the needs of science and business giving a teaching load that leaves time neither for fundamental research nor for R&D. Meanwhile, pursuing an academic career demands publications, which hinders participation in applied research for business. Thus, differences in goals, norms and values of the autonomously operating science, education and business hinder collaborations in the cluster. The experts highlight the necessity of better coordination between different types of activities and of a common vision on how the cluster should be developed: "[w]e need a strategic vision that encompasses within Sea activities more than fisheries, that includes several sectors and other communities" (Ibid., p. 42).

Our literature review suggests, that personal relationships could be a solution. According to local experts and cluster participants, personal communication across boundaries is important to overcome the existing barriers to cooperation, to enable common vision of organizations in the cluster (Gonçalves et al., 2011), and to facilitate knowledge transfer, for which people are central and informal channels are pivotal, noting that relations of trust are among the crucial components of this informal personalized communication (Cooke et al., 2011, pp. 65, 67).

There are many communication activities (conferences, meetings, as well as informal interactions, etc.) organized in the cluster to bring together representatives of science, education and business organizations, to form personal communication ties between them, and hence, to induce cross-boundary collaborations.

It seems plausible that personal communication known to induce trust and personal closeness could help to overcome the barrier of misunderstanding that hinders cooperation between science, education and business in the cluster. Nevertheless, the prior research only addressed patterns of organizational collaborations, but investigated neither concrete structures of personal ties, nor relations between these and organizational collaborations in the cluster. Our ambition is to explore the role of personal ties, which are stimulated in an attempt to overcome the barriers for cooperation between science, education and business. We use statistical network analysis techniques to infer the structure of personal ties and to test the extent different aspects of such ties actually correspond to the network of cross-boundary organizational collaborations.

Method and Data

The empirical study included the following steps: (1) mapping and analysis of organizational collaboration network; (2) mapping and analysis of personal networks; (3) correlation analysis of organizational-level links and personal-level networks. Each of these steps is described in greater detail below.

Network of Organizational Collaborations

Organizational collaboration network of science, education and business examined in this study includes 25 nodes: (1) companies in aquaculture, marine equipment, fishing, maritime

services, food production, waterworks, coastal tourism and leisure, entertainment; (2) university departments in marine sciences and technology, economics, management, hospitality and tourism; and (3) research centers in marine technology, marine and environmental sciences, hydrology, fish farming, information science, tourism and leisure studies (Table 1).

This network is based on a dataset collected by Cruz et al. (2011) [1]. They conducted 45 semi-structured expert interviews with the Algarve maritime cluster participants, including companies, university departments, research centers, and innovation intermediaries. In order to trace the collaboration linkages the interviewers asked: *Who are your organization's partners?* The collaborations involved knowledge and technology exchanges, personnel mobility, joint R&D projects, spin-offs and start-ups creation. Each of the organizations and their partners named were then considered as network nodes. The resulting network included 154 nodes.

We supplemented and verified the network using open-source data on partnerships, and filtered out intermediaries and those nodes in the initial set that did not actually base in the Algarve region, but were only linked to local organizations.

INSERT TABLE 1 ABOUT HERE

Further, because of our interest in studying only links between science, education and business, non-cross-sectoral ties were removed, so that the final network represented

exclusively the direct links corresponding to collaborations between science, education and business entities.

Next, we calculated conventional descriptive statistics for the network, such as overall network density and degree, closeness and betweenness centrality measures for all the nodes (Wasserman & Faust, 1994). Network density was calculated as a proportion of existing links in the amount of all possible links in the network. In other words, this measure indicates how thick the network is. Degree centrality was calculated as a sum of links a node has. It indicates the amount of direct connections linking a node to other ones. Closeness centrality was calculated as the inverse sum of the distances between a node and all other nodes; distance standing for a connection between two nodes via the smallest number of links. Hence, it shows how close the node is to all other ones in the network. Betweenness centrality stands for the amount of shortest network paths (routes comprised of sequences of links leading from one node to another) passing through a node. It measures how often the node appears to be on the shortest way between other nodes. High values of these centrality measures indicate a powerful position of a node in the structure of relations, especially when one (same) node is the most central according to several centrality measures.

Networks of Personal Ties

In order to map different aspects of personal ties between employees of science, education and business entities we conducted an e-mail survey using sociometric questions which infer who is connected to whom. This technique is conventionally utilized in network analysis of regional innovation clusters (Ceci & Iubatti, 2012; Giuliani, 2013). According to the focus of our study, the questionnaires covered the three aspects of personal ties between individuals: frequency of communication, stronger intellectual influence, and stronger emotional attachment.

In particular, we sent questionnaires to the members of faculties, researchers and employees of companies in the cluster, the names and e-mails of whom were obtained from the organizations' webpages and via direct contacts with representatives of the organizations. Each questionnaire, firstly, asked about respondent's name, the place of employment, position, and the size of their organization. In addition, respondents were asked: *In your opinion, to what extent is trilateral collaboration between companies, research centers and university faculties/schools is developed in Algarve?*

Secondly, to track personal ties the respondents were invited to list their contacts from other sectors, each time selecting an entity where a contact is employed in from a drop-down list. For each of the contacts named we then asked respondents to answer (1) *How many times a month do you communicate? (2) How strong is the intellectual influence of this contact on you?* and *(3) How strong is your emotional attachment to this individual?* Participants could respond to the questions by selecting strength of a tie from 0 to 4 from drop-down lists. In the communication frequency scale '0' corresponded to *1 or less times per month,* while '4' meant *15 or more times per month.* In intellectual influence and emotional attachment scales '0' meant *no influence/attachment,* while '4' referred to *very strong influence/attachment.* An exemplary questionnaire is presented in Appendix A (version for employees of companies).

Note that interpretation of the terms 'intellectual influence' and 'emotional attachment' by the respondents when they described their links to other people could vary. By intellectual influence the respondents could mean valuing the other person's work, following his/her ideas, impact of one's opinion on them, and so forth. Emotional attachments, in general, refer to the feeling of emotional closeness to the other person. The particular type of closeness could involve enduring sympathy, friendly feelings, joy and happiness about the partner, gratitude to the partner, astonishment achieved throughout joint work, or other positive

emotions and feelings. Very diverse positive emotions may induce personal attachment and create strong bonds between individuals (Bowlby, 1973; Shaver & Hazan, 1993; Mikulincer and Shaver, 2005). Hence, we did not specify any particular emotion to the respondents, as our goal was not to differentiate between these various interpretations *within* the three aspects of personal ties but to compare *between* them. Similarly, we did not differentiate between different types of intellectual influence.

We also did not trace the history of personal relations. Intellectual influences and attachments could appear from joint teamwork, throughout studying at the university as classmates, via participation in the same professional associations, neighboring, and so on.

In total, 128 respondents took part in our study. Out of them, 61 represent university faculties, 47 are from the research centers, and 20 come from companies.

The survey data was aggregated the way that each unique combination of an organizational entity and a contact's name was mapped as a separate node. Thus, when an individual was a member of more than one entity - e.g., a company and a faculty - one node was recorded for the company and another for the faculty, following the interlocking directorate tradition (Burt, 1980). The resulting network included 155 nodes linked with ties of strength varying from 0 to 4. The nodes representing members of more than one entity were linked with ties of maximal strength.

Next, we produced three networks connecting the 25 organizations included in the analysis and representing different aspects of personal ties: (1) frequent personal communication network, (2) strong intellectual influence network, and (3) strong emotional attachments network. In order to do that, in each of the three aspects of personal relations separately we took an average of strengths of all personal ties connecting employees of every dyad of

organizations. The resulting numbers were considered as strengths of personal ties between the organizations in each of the three networks, where tie strengths varied from 0 to 4.

To produce networks of *frequent* communication, *strong* intellectual influence, and *strong* emotional attachment we only kept ties stronger than 2 and discarded the rest.

Then, the degree, closeness and betweenness centralities of the nodes in the three personal networks were calculated using the same procedures as those indicated for organizational collaboration networks in the previous section.

Correspondence between Networks of Personal Ties and Organizational Collaborations

To check for correspondence between organizational and personal networks in the Algarve maritime cluster, we applied the Quadratic Assignment Procedure (QAP) correlation (Hubert & Schultz, 1976) to the pairs of networks. QAP is designed to test for co-dependencies between different types of links connecting the same nodes. For example, to check if probability of information exchange is related to monetary exchanges, Hanneman and Riddle (2005) used a dataset of the two types of links between 10 organizations. They hypothesized that the network of information links would be positively correlated with the network of monetary links. In other words, they expected the pairs of organizations engaged in one type of relations also to be more likely to engage in the other. Alternatively, the two types of links could have nothing to do with each other. Similarly, we can hypothesize that collaborations between organizations are positively related to strong personal ties between their employees. Moreover, we can compare the relevance of different aspects of personal ties to collaborations - by comparing the correlation coefficients collaborations have with the different aspects of personal ties. So we tested for correspondence between, on the one hand, links in organizational collaborations network and, on the other hand, ties in each of the three

aspects of personal ties: (1) frequent personal communication, (2) strong intellectual influence, (3) strong emotional attachment. A conventional proportion of .05 or less suggested a non-chance relationship. We computed statistical significance in the tests with UCINet (Borgatti, Everett, & Freeman, 2002) using permutation trials (10,000 per run) and considered the Jaccard coefficient as recommended by Hanneman and Riddle (2005). Note that only actually existing lines are used by QAP to establish correlations (Broekel, 2015) which is useful in such a loosely connected setting as science, education and business collaboration.

Empirical Results

Visualizations of the networks

The network of cross-sectoral collaborations is presented in Figure 1.

Focusing exclusively on cross-boundary links between science, education and business entities we can clearly see even in the visualization that the organizational collaborations between science, education and business in the Algarve maritime cluster are fewer than they could be. Network density is only 5%, which characterizes the level of collaboration in the cluster in general, as well as conditions for knowledge diffusion (compare with the results of Krätke's (2011) study of research-industry networks in Germany, where densities ranged from 17% to 26%). Most of the companies in the cluster - like "Aqualvor" (food), "Natura" (tourism), "Zoomarine" (entertainment) - are completely disconnected from the network.

INSERT FIGURE 1 ABOUT HERE

Meanwhile, the network of cross-boundary organizational collaborations we mapped shows that several companies, e.g., "Marsensing" (marine sensing and underwater acoustic technologies), "Ecoceanus" (ecological tourism), "Sparos" (fish feeding and nutrition), do maintain sustainable collaborations with research centers. For example, "Marsensing" carries out R&D projects on underwater acoustics engaging in collaborations with SIPLAB (Information Processing Laboratory), CIMA (Centre for Marine and Environmental Research), and CCMAR (Centre for Marine Sciences of Algarve) which do research in acoustics, marine ecosystems, and oceanology. Some of the companies were also created as spin-offs from the research centers, like "Sparos" is a spin-off from CCMAR.

Visual inspection of the network reveals that although there are some cross-boundary collaborations in the cluster, these are scarce. The network structure demonstrates existence of the barriers for collaboration between science, education and business sectors. Correspondingly, we observe that most of the companies in the network of organizational collaborations are still isolated, and the faculties occupy peripheral positions in the cross-boundary network. Consequently, despite research centers are quite well-connected, the development of the cluster in general is hindered.

Figure 2 illustrates the network of personal ties across the boundaries of science, education and business entities in the cluster (all the three aspects of personal communication are aggregated). Even from the visualization one can notice the striking difference in the amount of links and in the positions of many nodes compared to the organizational collaborations network. Namely, when it comes to personal ties, research centers are not dominant any more, while faculties and companies are in significantly more central positions.

INSERT TABLE 2 ABOUT HERE

Especially visible is the Faculty of Sciences and Technology of the University of Algarve (FCT), which – probably thanks to its alumni employed in the companies and the research centers – has more ties than any other node.

Positions of organizational entities in the two networks

Calculating degree, closeness and betweenness centralities in the network of cross-boundary collaborations we find that the highest levels of those measures are recorded by science bodies (Table 2). This is visible even in the network visualization (Fig. 1), where many network paths inevitably pass through CIMA and CCMAR. These two research centers also have more connections than other entities and are generally in a fewer steps to other nodes than other entities. It implies that the centers have contractual relations and alliances with many other entities. It also means they control flows of resources passing through the network and have easier access to more diverse resources possessed by other entities. For example, CCMAR has many possibilities to benefit from relations across sectoral boundaries (e.g., sell their research results, developments and expertise, create joint ventures with companies, or lend equipment to them) using the connections with the five companies it is directly linked to.

INSERT TABLE 2 ABOUT HERE

Considering the university not as a single whole, but as a network connecting centers and faculties allowed us to reveal that faculties are in fact almost absent from the list of central

nodes in the organizational collaborations network. So it is not the whole university that is central, but the university's research centers, while its faculties are peripheral. For instance, the company Aguas Algarve (Waters of Algarve) would search for employees or expertise in the CIMA with which it has an established collaboration, rather than in ESGHT (School of Management, Hospitality and Tourism of the University of Algarve). Even if Aguas Algarve would like to collaborate with ESGHT, high chances are that it would have to ask for help in CIMA to establish this contact. The same refers to the other companies CIMA also has direct links to, such as "Marsensing" and "ECOCEANUS".

The different aspects of personal ties are clearly dominated by The Faculty of Sciences and Technology of the University of Algarve (FCT) that has the highest network centrality measures (Table 3). Its central position in the network of frequent communication ties allows the employees of FCT to receive information from employees of many other entities and to be on the information route between employees of different entities in the cluster most often, hence obtaining valuable information the fastest ways via informal channels. In the intellectual influence network, high centralities that we observe indicate that FCT gets and accumulates knowledge from multiple sources via direct and indirect personal connections. Such a position allows the faculty members to spread and absorb ideas, create work teams, and start joint projects easier. High centrality in the network of emotional attachments shows that the personnel of FCT has a basis for mutual confidence, support, and promotion with employees of many other entities. The beneficial position of FCT in networks of personal ties induces the chances of its employees to generate new scientific and business ideas, create start-ups, and engage in inter-organizational mobility across sectoral boundaries.

INSERT TABLE 3 ABOUT HERE

As for the companies, they are not dominating in the networks of personal ties, being less central than research centers and FCT. However, they are significantly more central in personal networks than in the network of organizational collaborations, often having personal ties to FCT and to one or several ties to the research centers. For instance, "Sparos" is quite high in all the three main centrality measures in the network of intellectual influence, which allows it to informally collect knowledge on research and developments in marine biology from multiple sources (such as CCMAR and IPIMAR) and to bridge informal knowledge flows in the network. "Marsensing" is one of the most central nodes by degree and betweenness in the network of emotional attachments. Hence, its employees are not only in close friendly relations with researchers, developers and faculty members involved in acoustics, studies on marine ecosystems, and oceanology, but also bridge paths that connect the network of emotional attachments in the cluster.

Correspondence between Networks of Personal Ties and Organizational Collaborations

The results of correlations of cross-sectoral collaboration links and the three types of strong personal ties are: 28.57% for communication frequency[2], 30.43% for intellectual influence[3], and 40.00% for emotional attachment[4]. This indicates the extent of correspondence between direct cross-boundary organizational collaborations and particular aspects of interpersonal communication – high frequency, strong intellectual influence, and strong emotional attachment. The coefficients are not too high considering that the Jaccard coefficient was used. This formally confirms our observations about limited correspondence between

organizational collaborations and personal ties in the cluster made during visual inspection and analysis of network statistics.

It should be stressed, that emotional attachments show the strongest correspondence among the three aspects we considered. In other words, emotional attachments turned out to co-depend with organizational links across the sectoral boundaries more than frequency of personal communication or intellectual influence.

Discussion

The literature shows that performance and technology innovation in maritime industry depend on local networks including companies, research centers, and educational organizations. In the Algarve maritime cluster, administrations and local experts see a common goal in developing a cluster that links maritime business (food production and aquaculture, coastal tourism and knowledge-driven services) with research units and educational institutions. Research centers offer companies and educational institutions knowledge and technology. They also participate in the creation of innovation-oriented spin-offs and/or in foundation of companies by alumni and employees of the university faculties. Companies get engaged in collaborative R&D projects with faculties and research centers to deliver innovative equipment and technologies in acoustics, marine ecosystems, oceanology, management, economy, and energy use. Faculties conduct educational programs and provide human resources both for the companies and the research centers.

Nevertheless, despite the acknowledged need for cooperation and a lot of effort put into this, scholars studying the cluster, experts and cluster participants report insufficient collaborations across the boundaries of science, education and business. As we have found,

the crucial barrier here is the lack of mutual understanding across the sectoral boundaries. Hence, the three sectors in the cluster develop rather autonomously. Research centers, companies and faculties often do not know the needs of each other; underestimate the potential of cooperation and its impact on the development of the cluster as a whole. Correspondingly, most of the companies are isolated from the network of organizational collaborations, and the faculties occupy peripheral positions in it. So, although research centers are quite well connected, the development of the cluster in general is hindered.

Based on the literature on the role of personal networks in integration of science, education and business, cross-sectoral collaborations could be expected to benefit from personal ties between members of organizational entities. Such ties could induce trust, mutual obligations and intellectual closeness across the sectoral boundaries and hence stimulate more formal collaborations. Informants, including administrations, local experts and employees of organizations in the cluster, also stress the corresponding potential of personal ties.

In order to formally check the relevance of personal ties, we mapped the structure of personal network in the cluster and compared it to the network of organizational collaborations. The personal network appeared to be quite dense, a university faculty (FCT) and several companies being in significantly more central positions than in the network of organizational collaborations. However, when we statistically tested the extent different aspects of personal ties actually correspond to the network of cross-boundary organizational collaborations, we found that the level of correspondence between personal ties and organizational collaborations in the cluster is modest. This indicates that the potential of the existing inter-personal ties in overcoming the barrier of insufficient coordination between science, education and business is not fully used.

Based on the literature, we argued that to understand how personal ties may be better utilized, different aspects of these should be compared. We found that from the three aspects of personal ties considered, emotional attachments were most strongly associated with organizational-level collaborations across the sectoral boundaries. This result suggests – corresponding to Taylor's (2005) and Gilsing et al.'s (2008) arguments – that personal 'chemistry' and going beyond formal relations are pivotal. Huber (2012) also showed the importance of "high levels of feelings of personal obligations and emotional closeness" between collaborates (p. 1179). In a similar vein, the stream of studies on buyer–supplier relationships has empirically shown the role of emotions in their communication experience (Witkowski & Thibodeau, 1999), and argued that the personal emotions of boundary spanners are important (Andersen & Kumar, 2006). It is also worth mentioning, that network studies on the diffusion of emotions have revealed that, over time, emotions promote perceptions of trustworthiness and stimulate more formal exchanges, not vice versa (Schaefer & Kornienko, 2009; Andersen & Kumar, 2006).

In the context of the literature on personal relationships, our findings may be explained by the attachment theory, arguing that very diverse positive emotions, such as gratitude, joy, and happiness, as well as feelings of being accepted and valued are crucial for the development of strong bonds between individuals. Positive emotions and feelings motivate individuals to be continuously sensitive and responsive to each other creating a cycle that induces mutual positive behavior and therefore strengthens personal ties (Bowlby, 1973; Shaver & Hazan, 1993; Mikulincer and Shaver, 2005). Hence, emotions may not only help to sustain and strengthen personal cross-boundary ties, but also encourage sensitivity to and acceptance of needs, goals and values of a person belonging to another sector, helping to deal with misunderstandings across the boundaries.

Hence, efforts in overcoming the barriers between science, education and business can be based on sustainable emotional bonds between individuals. In particular, emotional attachments could be used to induce mutual understanding across the boundaries of the sectors and thus to enable cross-boundary organizational collaborations. Personal emotions between people who do research, teach at the faculties, work at companies could help to induce mutual understanding and confidence, by encouraging each other in going beyond self-oriented sectoral interests and in jointly developing the cluster. For instance, friendly communication of representatives of companies and research centers with faculty members on each other's needs and opportunities, emotional support and engagement could enable finding solutions and evoke confidence to motivate creation of joint educational programs with business and science at the faculties, which would correspond the needs of companies and research centers in human resources. Emotionally supported by managers of companies or researchers, faculty members could get interested in applied research and generate particular project ideas, which later could result in formal establishment of company-endowed professorships and chairs. Employees of companies could gain emotional support from fellow researchers and professors in understanding the available research findings, be encouraged to see the potential benefits of putting them into practice, and gain confidence in the success of joint R&D projects and training programs. As a result, employees of companies could obtain broader visions of the existing opportunities for science-driven innovative development, and start more joint R&D projects with research centers and educational programs with the faculties.

In Algarve, the Faculty of Sciences and Technology (FCT), occupying a very central position in the personal network, could become the center for spanning the boundaries between science, education and business, building on the existing emotional attachments. Network position of the faculty implies that there are certain individuals in the FCT who are

emotionally close to people in other organizations. These individuals could be the drivers of organizational-level collaborations, using the enduring sympathy, friendships, and astonishment with joint work. They could promote mutual confidence and understanding, going beyond self-oriented interests of the sectors with their specific goals, norms and values, in order to jointly develop the cluster. These individuals are to be supported in overcoming the existing institutional, cultural and legal barriers for those to grow into organizational collaborations, with a particular emphasis on nurturing the emotional aspect of personal relations. Individuals who are central in networks of emotional attachments may be trained in leadership and put into positions of cross-boundary projects leaders and organizers of events.

Limitations and Future Prospects

First, although the Algarve maritime cluster combines several industries - making the findings more generalizable (Kenney & Patton, 2005), this study indeed carries the traces of its single-case study methodology: it provides limited opportunities for the generalization of its conclusions (Ceci & Iubatti, 2012; Giuliani, 2013). For instance, Portugal is characterized by the so-called 'high context culture' which - according to Hall (1976) - is relational, collectivist, intuitive, and contemplative. Therefore, further comparisons with other regional clusters embedded in different cultural, economic, and institutional contexts replicating this research design are needed to make the results more generalizable. In particular, those could be extreme cases with strongly differing cultures, levels of economic development of the regions, and institutional environments.

Second, our interest in this paper was to compare the relation of different aspects of interpersonal networks and inter-organizational networks across the boundaries rather than investigate the nuances within the aspects, such as the particular kinds of emotions and how they formed. The importance of emotional aspect was an outcome, rather than the focus of

analysis. Consequently, another limitation of our findings is the lack of specificity in the variety of interpretations of emotions captured by the survey data, which would, indeed, be interesting to have, considering the results obtained. These variations can be addressed by further - qualitative - studies. While we used surveys, in the future it is necessary to also apply qualitative tools (e.g., ethnographies) – to gather data on different dimensions of emotions in interpersonal communication. Use of data collection tools more nuanced than surveys is also necessary in the future to account for relations which individuals are not aware of, including those via non-human agents, like documents, ideas, beliefs, and objects. Qualitative analysis would also be crucial to consider not only the structure, but also the content of exchanges taking place in the networks. Above that, further studies of inter-personal emotional structures as networks, probably implying reinterpretation of what conventional network statistics mean, can help in understanding how integration between science, education and business can be achieved using the potential of personal communication ties.

Third, the existing theorizations on how emotions impact interpersonal ties are still – all in all – scarce. Most of the studies on emotions focus on individual properties, even in the literature on inter-personal relationships. For instance, "much of attachment research has become the study of internalized features of personality, rather than the study of current attachment relationships" (Cassidy & Shaver, 1999, pp. 21-43). Hence, there are limited opportunities for broader interpretations of our findings. Perhaps, the results of this study, together with those of other empirical inquiries considering emotions in the relational perspective of network analysis, will stimulate further theorizations.

Conclusion

This study applied network analysis to investigate integration between science, education and

business sectors in the maritime cluster of the Algarve region of Portugal. Experts and previous researchers have argued that such integration is important for the development of the cluster and that personal ties are crucial for the integration. We sought to explore the relation between organizational collaborations and different aspects of personal ties across the boundaries of science, education and business. The distinctive feature of this analysis is that it goes beyond properties of individuals and companies as well as the content of dyadic exchanges, instead focusing on overall structural patterns of personal and organizational links. Usage of a statistical network-analytical approach allowed us to reveal, among other things, that structures of strong emotional attachments are more relevant for cross-boundary collaborations between research centers, university faculties and companies than frequent communications or strong intellectual influences. Moreover, network analysis enabled finding the entity capable to span the boundaries in the Algarve maritime cluster, - Faculty of Sciences and Technology. Using its central position, especially in the network of emotional attachments, FCT could support mutual understanding and trust, thus inducing coordination between the three sectors and helping to establish cross-boundary organizational collaborations. The results of applying network analysis also highlighted the need for development of theorizations on networks of emotional attachments, by contrast to the currently prevailing individual-focused accounts of emotions.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Notes

1. The data was kindly provided by R. Pinto, University of Algarve.

2. Here and further $p < 0.0001$. Mean $= 2.45\%$.

3. Mean $= 2.88\%$.

4. Mean $= 3.40\%$.

References

Andersen, P. H., & Kumar, R. (2006). Emotions, trust and relationship development in business relationships: A conceptual model for buyer-seller dyads. Industrial marketing management, 35(4), 522-535.

Anselin, L., Varga, A., & Ács, Z. (1997). Local geographic spillovers between university research and high technology innovations. Journal of urban economics, 42(3), 422-448.

Arundel, A., & Geuna, A. (2004). Proximity and the use of public science by innovative European firms. Economics of innovation and new technology, 13(6), 559-580.

Balconi, M., & Laboranti, A. (2006). University–industry interactions in applied research: The case of microelectronics. Research Policy, 35(10), 1616-1630.

Bania, N., Calkins, L., & Dalenberg, R. (1992). The effects of regional science and technology policy on the geographic distribution of industrial R&D laboratories. Journal of Regional science, 32(2), 209-228.

Bonaccorsi, A., & Piccaluga, A. (1994). A theoretical framework for the evaluation of university-industry relationships. R&D management, 24(3), 229-247.

Borgatti, S. P., Everett, M. G., & Freeman, L. C. (2002). Ucinet for Windows: Software for social network analysis. Boston, MA: Harvard University Press.

Bowlby, J. (1973). *Attachment and loss: Vol. 2. Separation: Anxiety and anger*. New York: Basic Books.

Brass, D. J., Galaskiewicz, J., Greve, H. R., & Tsai, W. (2004). Taking stock of networks and organizations: A multilevel perspective. Academy of management journal, 47(6), 795-817.

Breschi, S., & Lissoni, F. (2003). Mobility and social networks: Localised knowledge spillovers revisited. CESPRI Working Paper No 142, University Bocconi, Milan, Italy.

Broekel, T. (2015). The co-evolution of proximities – a network level study. Regional studies, 49(6), 921-935.

Brown, J. S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. Organization science, 12(2), 198-213.

Bruneel, J., d'Este, P., & Salter, A. (2010). Investigating the factors that diminish the barriers to university-industry collaboration. Research policy, 39(7), 858-868.

Burt, R. S. (1980). Cooptive corporate actor networks: A reconsideration of interlocking directorates involving American manufacturing. Administrative science quarterly, 25(4), 557-582.

Cassidy, J. & Shaver, P. R. (Eds). (1999). Handbook of attachment: Theory, research, and clinical applications. New York, NY, US: Guilford Press.

CCDR Algarve. (2006). Estratégia de Desenvolvimento do Algarve 2007- 2013. Faro, Portugal: Comissão de Coordenação e Desenvolvimento Regional do Algarve.

CCDR Algarve. (2007). Plano Regional de Ordenamento do Território do Algarve. Faro, Portugal: Comissão de Coordenação e Desenvolvimento Regional do Algarve.

CCDR Algarve. (2008). Perfil e Potencial Económico-Social do Turismo Náutico no Algarve. Faro, Portugal: Comissão de Coordenação e Desenvolvimento Regional do Algarve.

CCDR Algarve. (2009). Agenda Regional do Mar Algarve. Contributos para o Plano de Acção para o Cluster Mar Algarve. Faro, Portugal: Comissão de Coordenação e Desenvolvimento Regional do Algarve.

Ceci, F., & Iubatti, D. (2012). Personal relationships and innovation diffusion in SME networks: A content analysis approach. Research policy, 41(3), 565-579.

Chakrabarti, A. K., & Santoro, M. D. (2004). Building social capital and learning environment in university–industry relationships. International journal of learning and intellectual capital, 1(1), 19-36.

Chang, Y.C. (2011). Maritime Clusters: What can be learnt from the South West of England. Ocean & coastal management, 54, 488-494.

Cooke, P., Porter, J., Cruz, A. R., & Pinto, H. (2011). Maritime clusters: Institutions and innovation actors in the Atlantic area. KIMERAA project Report. Faro, Portugal: University of Algarve.

Cova, B., & Salle, R. (2000). Rituals in managing extrabusiness relationships in international project marketing: A conceptual framework. International business review, 9(6), 669-685.

Cowan, R., & Jonard, N. (2004). Network structure and the diffusion of knowledge. Journal of economic Dynamics and Control, 28(8), 1557-1575.

Cruz, A. R., Gonçalves, A. I., Pinto, H., Pintassilgo, P., & Guerreiro, J. (2011). Looking for the core of a knowledge-based sea cluster: A social network analysis in a maritime region. European regional science association conference papers, 11, 510-529.

D'Este, P., & Patel, P. (2007). University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? Research policy, 36(9), 1295-1313.

Easterby-Smith, M., Lyles, M. A. & Tsang, E. W. (2008). Inter-organizational knowledge transfer: Current themes and future prospects. Journal of management studies, 45(4), 677-690.

Eisenhardt, K. M., & Schoonhoven, C. B. (1996). Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms. Organization science, 7(2), 136-150.

Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G., & van den Oord, A. (2008). Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. Research policy, 37(10), 1717-1731.

Giuliani, E. (2013). Network dynamics in regional clusters: Evidence from Chile. Research policy, 42(8), 1406-1419.

Gonçalves, A. I., Cruz, A. R., Pinto, H., Pintassilgo, P., & Guerreiro, J. (2011). Coastal tourism and possibilities for consolidating a regional sea cluster: Insights from Algarve's innovation actors. Tourism & management studies, 1, 70-79.

Grandori, A., & Soda, G. (1995). Inter-firm networks: Antecedents, mechanisms and forms. Organization studies, 16(2), 183-214.

Granovetter, M. (1973). The strength of weak ties: A network theory revisited. Sociological theory, 1(1), 201-233.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. American journal of sociology, 91, 481-510.

Gubbins, C., & Dooley, L. (2014). Exploring social network dynamics driving knowledge management for innovation. Journal of management inquiry, 23(2), 162-185.

Hall, E. T. (1976). Beyond Culture. New York, NY: Anchor Books.

Hanneman, R. A., & Riddle, M. (2005). Introduction to social network methods. Riverside, CA: University of California.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. Administrative science quarterly, 44(1), 82-111.

Hargadon, A. B., & Sutton, R. I. (1997). Technology brokering and innovation in a product development firm. Administrative science quarterly, 42, 716-49.

Hicks, D. M., Isard, P. A., & Martin, B. R. (1996). A morphology of Japanese and European corporate research networks. Research policy, 25(3), 359-378.

Huber, F. (2012). On the role and interrelationship of spatial, social and cognitive proximity: Personal knowledge relationships of R&D workers in the Cambridge information technology cluster. Regional studies, 46(9), 1169-1182.

Hubert, L., & Schultz, J. (1976). Quadratic assignment as a general data analysis strategy. British journal of mathematical and statistical psychology, 29(2), 190-241.

Inkpen, A. C., & Tsang, E. W. (2005). Social capital, networks, and knowledge transfer. Academy of management review, 30(1), 146-165.

Jaffe, A. B. (1989). Real effects of academic research. The American economic review, 79(5), 957-970.

Jaffe, A. M., Trajtenberg, M., & Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. Quarterly journal of economics, 108(3), 577-598.

Kaufmann, A., & Tödtling, F. (2000). System of innovation in traditional industrial regions: The case of Styria in a comparative perspective. Regional studies, 34, 29-40.

Kenney, M., & Patton, D. (2005). Entrepreneurial geographies: support networks in three high-technology industries. Economic geography, 81(2), 201-228.

Krätke, S. (2011). The creative capital of cities: Interactive knowledge creation and the urbanization economies of innovation. Hoboken, NJ: John Wiley & Sons.

Lorenzen, M. (2001). Ties, trust, and trade: Elements of a theory of coordination in industrial clusters. International studies of management and organization, 31(4), 14-34.

Malerba, F. (Ed.). (2009). Innovation networks in industries. Cheltenham, United Kingdom: Edward Elgar Publishing.

Matzler, K., Renzl, B., Müller, J., Herting, S., & Mooradian, T. A. (2008). Personality traits and knowledge sharing. Journal of economic psychology, 29(3), 301-313.

Meyer-Krahmer, F., & Schmoch, U. (1998). Science-based technologies: University-industry interactions in four fields. Research policy, 27(8), 835-851.

Mikulincer, M., & Shaver, P. R. (2005). Attachment theory and emotions in close relationships: Exploring the attachment-related dynamics of emotional reactions to relational events. *Personal Relationships*, 12(2), 149-168.

Newell, S., & Swan, J. (2000). Trust and inter-organizational networking. Human relations, 53(10), 1287-1328.

Østergaard, C. R. (2009). Knowledge flows through social networks in a cluster: Comparing university and industry links. Structural change and economic dynamics, 20(3), 196-210.

Padgett, J. F., & Powell, W. W. (2012). The emergence of organizations and markets. Princeton, NJ: Princeton University Press.

Parker, D. D., & Zilberman, D. (1993). University technology transfers: Impacts on local and US economies. Contemporary economic policy, 11(2), 87-99.

Perkman, M., & Walsh, K. (2007). University–industry relationships and open innovation: Towards a research agenda. International Journal of Management Reviews, 9(4), 259-280.

Pinch, S., & Henry, N. (1999). Paul Krugman's geographical economics, industrial clustering and the British motor sport industry. Regional studies, 33(9), 815-827.

Pinto, H., & Guerreiro, J. (2010). Innovation regional planning and latent dimensions: The case of the Algarve region. The annals of regional science, 44(2), 315-329.

Provan, K. G., Fish, A., & Sydow, J. (2007). Inter-organizational networks at the network level: A review of the empirical literature on whole networks. Journal of management, 33(3), 479-516.

Rice, J. (2009). Network exchanges, identity, writing. Journal of business and technical communication, 23(3), 294-317.

Robinson, D. K., Rip, A., & Mangematin, V. (2007). Technological agglomeration and the emergence of clusters and networks in nanotechnology. Research policy, 36(6), 871-879.

Schaefer, D. R., & Kornienko, O. (2009). Building cohesion in positively connected exchange networks. Social psychology quarterly, 72(4), 384-402.

Shaver, P. R., & Hazan, C. (1993). Adult romantic attachment: Theory and evidence. In D. Perlman & W. Jones (Eds), *Advances in personal relationships*, 29-70. London: Jessica Kingsley.

Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N. (2003). Commercial knowledge transfers from universities to firms: Improving the effectiveness of university-industry collaboration. The journal of high technology management research, 14(1), 111-133.

Spinuzzi, C. (2007). Guest editor's introduction: Technical communication in the age of distributed work mobility and composition. Technical communication quarterly, 16, 265-277.

Storper, M., & Venables, A. J. (2004). Buzz: Face-to-face contact and the urban economy. Journal of economic geography, 4(4), 351-370.

Taylor, A. (2005). An operations perspective on strategic alliance success factors: An exploratory study of alliance managers in the software industry. International journal of operations and production management, 25(5), 469-490.

Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications. Cambridge, United Kingdom: Cambridge University Press.

Witkowski, T. H., & Thibodeau, E. J. (1999). Personal bonding processes in international marketing relationships. Journal of business research, 46, 315-325.

Zwijze-Koning, K. H., & de Jong, M. D. T. (2015). Network analysis as a communication audit instrument: Uncovering communicative strengths and weaknesses within organizations. Journal of business and technical communication, 29(1), 36-60.

Table 1: Nodes in Algarve maritime cluster network

Full title	Short name	Sector
Aqualvor - Activities in Aquaculture Ltd	AQUALVOR	Business
Big Game Fishing	Big Game	Business
Centre of Marine Sciences, University of Algarve	CCMAR	Science
Coastal and Marine Environments Research Centre, University of Algarve	CIACOMAR	Science
Centre for Marine and Environmental Research, University of Algarve	CIMA	Science
Technological Research Centre of the Algarve, University of Algarve	CINTAL	Science
Centre for Studies in Travel and Leisure, University of Algarve	CITel	Science
Company of Fisheries of Algarve	ComPes	Business
Ecoceanus, Unipessoal, Lda	ECOCEANUS	Business
School of Management, Hospitality and Tourism, University of Algarve	ESGHT	Education
Faculty of Sciences and Technology, University of Algarve	FCT	Science
Faculty of Economics, University of Algarve	FE	Education
International Centre for Coastal Ecohydrology, University of Algarve	ICCE	Science
Inovsea, Lda	INOVSEA	Business
Research Institute of Fisheries and Sea, University of Algarve	IPIMAR	Science

Marsensing, Lda	Marsensing	Business
Natura	Natura	Business
Necton, Portuguese Culture Marine Company, SA	NECTON	Business
Portuguese Company of Sanitized Salt, SA	SALEXPOR	Business
Information Processing Laboratory, University of Algarve	SIPLAB	Science
Sparos, Lda	SPAROS	Business
Sunquays	Sunquays	Business
Vitacress	VITACRESS	Business
Waters of Algarve	Águas Algarve	Business
Zoomarine	Zoomarine	Business

Table 2: Nodes with highest centralities in organizational collaborations network

Degree		Closeness		Betweenness	
CCMAR	0.26087	CCMAR	0.09504	CCMAR	0.21344
CIMA	0.17391	Marsensing	0.09465	CIMA	0.14888
Marsensing	0.17391	ECOCEANUS	0.09388	Marsensing	0.13241
ECOCEANUS	0.13043	CIMA	0.09350	ECOCEANUS	0.09618
Águas Algarve	0.08696	FCT	0.09091	Águas Algarve	0.05138

Table 3: Nodes with highest centralities in the networks of strong personal ties

Degree		Closeness		Betweenness	
Frequency of communication					
FCT	0.21739	FCT	0.05852	FCT	0.06126
CCMAR	0.13043	CCMAR	0.05808	CIMA	0.02372
Big Game	0.08696	Big Game	0.05793	CCMAR	0.01186
CIMA	0.08696	CIMA	0.05793	IPIMAR	0.00791
IPIMAR	0.08696	IPIMAR	0.05793	SPAROS	0.00198
Intellectual influence					
FCT	0.30435	FCT	0.06628	FCT	0.11462
CCMAR	0.13043	CIMA	0.06553	CIMA	0.05929
CIMA	0.13043	CCMAR	0.06516	CCMAR	0.00198
SPAROS	0.13043	SPAROS	0.06516	SPAROS	0.00198
Big Game	0.08696	Big Game	0.06497	other nodes	0.00000
Emotional attachment					
FCT	0.34783	FCT	0.08214	FCT	0.15244
Marsensing	0.21739	Marsensing	0.08127	CCMAR	0.05573

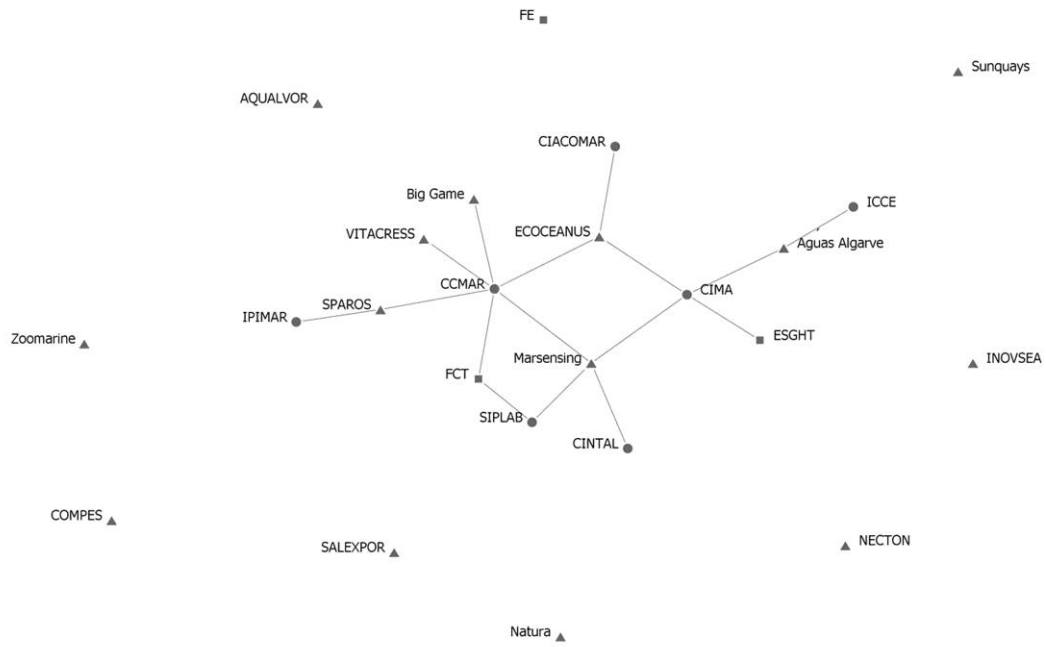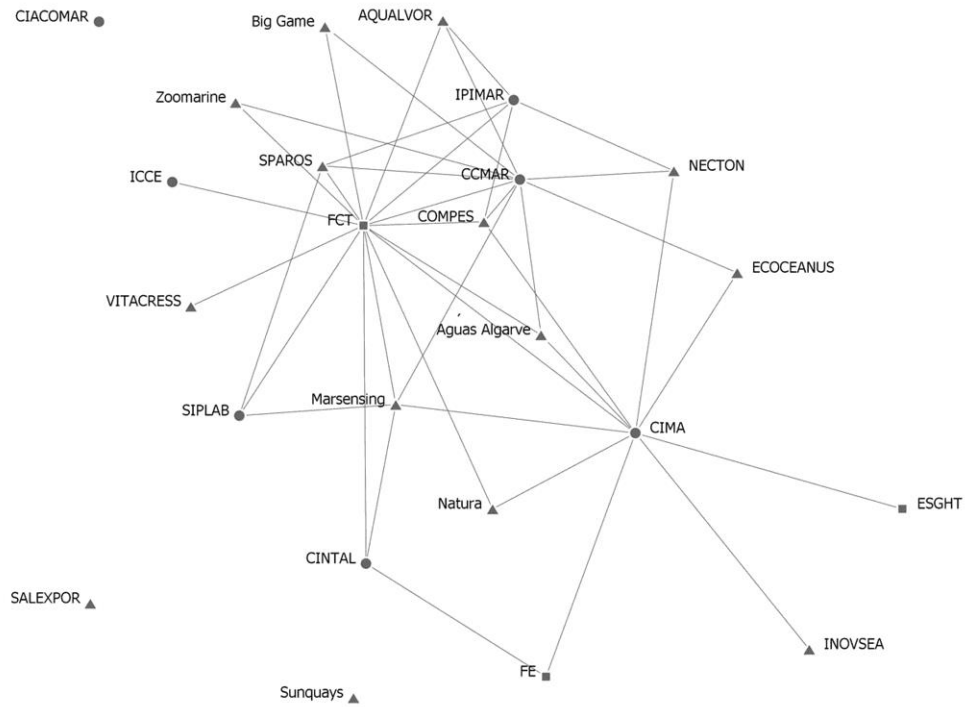| CCMAR | 0.17391 | CCMAR | 0.08042 | CIMA | 0.04348 |
| CIMA | 0.13043 | CIMA | 0.07986 | CINTAL | 0.04348 |
| CINTAL | 0.13043 | CINTAL | 0.07986 | Marsensing | 0.04058 |

FIGURE 1. Organizational Collaboration Network

FIGURE 2. Personal Communication Network

APPENDIX A. EXEMPLARY QUESTIONNAIRE

A version for employees of companies, translated from Portuguese

1. Please state your name in the field below.

2. Please state the name of the company you currently work at in the field below.

3. Please state your position in the company in the field below.

4. Please select the number of employees in your company from the drop-down list below.

Please select

5. In your opinion, to what extent is trilateral collaboration between companies, research centers and university faculties/schools is developed in Algarve?

Please select

6. Please describe your interaction with the most important contact persons in the research centers and/or university faculties/schools of Algarve. Write down contacts' names in the first column and select their research centers and/or university faculties/schools in the second column. (There may be two or more important contact persons from the same organization). Then answer the questions about each contact person in respective rows by selecting from the drop-down lists.

Contact person name	Research centre / faculty / school name	How many times a month do you communicate?	How strong is the *intellectual* influence of this contact on you?	How strong is your *emotional* attachment to this individual?
	Please select	Please select	Please select	Please select

	Please select	Please select	Please select	Please select
	Please select	Please select	Please select	Please select
	Please select	Please select	Please select	Please select
	Please select	Please select	Please select	Please select
	Please select	Please select	Please select	Please select
	Please select	Please select	Please select	Please select
	Please select	Please select	Please select	Please select

Do you want your name to be kept confidential?

Please select

Would you give a 30 minute interview on the topics covered by this questionnaire?

Please select

Thank you for your kind assistance!

Nikita Basov obtained his PhD in Sociology from St Petersburg State University. He is currently the Scientific Manager of the Center for German and European Studies (St Petersburg State University – Bielefeld University) and Senior researcher at the Faculty of Sociology of St Petersburg State University. His main field is social network analysis.

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