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An assessment model for virtual communities of practice: a study in the oil and gas industry

Abstract

This paper proposes a model to assess the level of maturity in Virtual Communities of Practice (VCoPs). The model is based on a theoretical construction attained from the analysis of previous frameworks proposed in literature. Using this construction, we have proposed eight main organizational, managerial and technological levers to improve the performance of VCoPs. Additionally, the model presents the analysis of four performance metrics obtained from these VCoP management levers. The model presented can be used as a benchmarking tool for analysing how companies perform in their management of VCoPs. After developing the model, we applied it to a benchmarking study of four global oil and gas companies. Our results include a performance comparison among these companies as well as the main practices and technologies they use to achieve success in the management of VCoP.

Keywords: Virtual communities of practice; maturity assessment model; benchmarking; oil and gas industry

1. Introduction

The concept of Communities of Practice (CoPs) was introduced by Lave and Wenger (1991), who used the term to refer to a group of people sharing knowledge, problems, solutions, information and news about a specific issue. By engaging in these activities, people can promote group learning through reciprocal interaction (Wenger et al., 2002). Initially, a CoP was constructed for members to interact face-to-face, but this changed with the advance of technology. Today, the literature is more focused on Virtual Communities of Practice (VCoPs), which refers to a group of people who interact, learn together and build relationships using specific social media, potentially crossing geographical and political boundaries to pursue mutual interests or goals while developing a sense of membership and reciprocal commitment (Leave and Wenger, 1991; Kowch and Schwier, 1997; Wenger et al., 2002; Jeon et al., 2011). VCoPs are also gaining momentum in the business world, especially in large companies, by helping to bring together experts in different sectors and regions, enabling a common base of knowledge to be built between people scattered in different places (Song et al., 2007; Montoya et al., 2009). Among the industries showing increasing interest in VCoPs is the oil and gas sector, where these communities are seen as a powerful knowledge management tool (Corso et al., 2009), since teams and experts are frequently located in different facilities and across different countries. Thus, VCoPs are a way to reduce displacement costs for experts who traditionally would have been on site to help solve a specific problem. VCoP can also provide the means to share best practice, and so standardise organisational processes and incorporate the most successful practices and tools implemented by experts (Scarso et al., 2009).

Several different approaches can be used to introduce VCoPs in the oil and gas industry. Some companies have adopted models that focus on individual initiatives, with no centralised VCoP management functions (Grant, 2013). Other companies have adopted structured models for their VCoP, whereby the members' actions are coordinated by a central management team. As a consequence, there is no single strategy to address VCoPs (Corso et al., 2012). Prior research is not helpful in this respect since studies have only concentrated on the distinctive features of VCoP within this sector (Scarso et al., 2009). Moreover, since previous studies are not concerned with the standardisation and systematisation of best practice, this, in turn, means that it is difficult to perform benchmarking or maturity assessment analyses in the industry.

The main contribution of this paper is the development of an assessment model that provides an overview of the strengths and the weaknesses of a company's VCoP management system, allowing a comparison to be made with other organisations in a specific industry. The model also helps to identify the potential actions that can be taken to improve the maturity of a VCoP

within the considered industry. It follows that the model presented in this paper has the two main purposes of acting as an assessment tool for a specific company and as a benchmarking tool for VCoP performance among several different companies.

The remainder of the paper is structured as follows. First, we will introduce our theoretical background (Section 2) to three main fields in VCoP assessment: the approach involving CoP influencing factors, the knowledge management field and the CoP management model approach. After this, we will explain the methodological procedures used in this paper (Section 3). In Section 4, we will present our results in two parts: the proposal of an assessment model and the application of this assessment model to an empirical study in the oil and gas industry. Finally, we will present the discussion and conclusion to this paper (Section 6).

2. Theoretical Background

A VCoP can be established at two different levels, as either internal or external communities. External communities bring together scattered members who are not from the same company, such as those in web-based communities (Tang and Yang, 2005). Internal communities, instead, represent common interests within the same company, i.e. the members work in the same company or are connected to this company (e.g. the company's employees and suppliers) (Nätti and Still, 2007). Our study focuses specifically on the latter type of VCoP.

These VCoPs can be evaluated according to several perspectives. Several models, frameworks and domains have been suggested in the literature, and these should be considered when assessing a community. As a starting point, Wenger et al. (2002) defined three CoP properties that should be taken into consideration when making such an assessment:

- *Domain*, which refers to the area of interest;
- *Community*, which refers to the interconnecting relationships and the development of a sense of reciprocal commitment;
- *Practices*, which refers to the shared repertory of competences and resources developed by members.

Some authors have developed different models to evaluate VCoP in terms of these three properties, while others have developed models for evaluating knowledge management and knowledge-sharing initiatives within CoPs. Based on Lee *et al.* (2010) and Kim *et al.* (2012), this section is organised as follows. First, we reviewed prior research covering a more general approach to the assessment of VCoP influencing factors. Then, we reviewed prior research on VCoP assessment, concentrating specifically on knowledge sharing strategies. Finally, we re-

viewed prior models that suggested general practices for managing VCoP. In all the sections, we have briefly presented the various viewpoints and highlighted the gaps that have yet to be addressed and which we aim to fill with this paper. These elements are used in Section 4.1, when presenting the construction of our model.

2.1 Studies on Influence Factors for a CoP

A first stream of the literature includes studies concerned with models that can evaluate how various organisational and individual factors can affect the performance of a CoP. These studies measure the possible influencing factors, generally by testing them through quantitative survey approaches using multivariate techniques.

One of the models in this stream is that proposed by Lee *et al.* (2015), who developed a theory-driven model to measure the participation intensity of project managers in CoP, as well as the benefits for both the individual and the organisation resulting from such participation. They discovered that reputation (extrinsic motivator), enjoyment (intrinsic motivator) and management support are factors that impact on the participation intensity of project managers in communities of practice. They did not find evidence of any influence arising from the use of Web 2.0 technologies (Corso *et al.*, 2013), although their research was limited to traditional face-to-face communities and they had no empirical data from VCoP.

Kirkman *et al.* (2011) proposed a model to explain the effectiveness of CoPs by integrating these communities and organisational teams. They showed that external leadership, empowerment and task interdependence were positively related to the organisational effectiveness of CoP. They did not, however, explore the influence of CoP composition, member interaction or use of different technologies. In addition, the impact of participating in a community on an individual's personal development was also left unaddressed.

Chu *et al.* (2014) identified personality traits suited to different types of CoP, analysing three different personality traits - agreeableness, conscientiousness and openness to experience - to examine the impact which they have on different CoP management strategies. These authors focused on the relationship between personality traits and CoP management strategies, while they did not examine other factors that could affect knowledge sharing, such as use of technology, member interaction and the organisation's culture.

Finally, Bertone *et al.* (2013) proposed a conceptual framework for assessing and understanding CoPs. This study contains a guideline of six sequential factors for achieving better results from CoP: available resources, strategies to mobilise resources (i.e. effective use of ICT), knowledge management processes, expansion of knowledge, knowledge-based policy decisions and practices (i.e. acceptance of change). This proposal was, however, not applied to any

practical cases, meaning that empirical research is needed to validate the authors' framework and to provide additional information about the six factors proposed.

2.2 Studies on Knowledge Management for CoP

Several specific models are proposed in the literature regarding the use of knowledge in both CoPs and VCoPs. These models are mostly concerned with inciting companies to gain the most from a community by sharing and retaining its knowledge. For instance, Lee et al. (2014a) formulated a metric for measuring the risk of knowledge drain associated with a person leaving the CoP in quantitative terms, looking at two possible situations: when the employee leaving is a network leader and when the employee leaving is an isolated expert. They selected six indicators to determine the importance of an individual in a knowledge network: degree centrality, betweenness centrality, closeness centrality, eigenvector centrality, weight of edges and individual expertise level. In another work, Lee et al. (2014b) developed what they referred to as the bottleneck impact score, a metric to evaluate the structural healthiness of a CoP. This was achieved by measuring the pervasiveness and seriousness of two possible barriers to knowledge-sharing initiatives, the master–apprentice relationship and knowledge drain. Although the proposed metric takes each member's general level of expertise into account, it does not indicate the quality of knowledge transferred during each interaction. Furthermore, this metric does not look at leadership or development matters when assessing the issue of knowledge drain.

Using social network analysis, Kim et al. (2012) developed a diagnosis framework for identifying knowledge sharing activities in a CoP. The authors suggested that communities can be classified according to four knowledge-sharing strategies, which are defined as learning, active, inactive and spreading communities. Their suggestions, however, do not include strategies associated with community management and development, which may be important when evaluating CoPs.

Two models proposed by Jeon et al. (2011) and Sharratt and Usoro (2002) addressed the factors that affect knowledge sharing. In Jeon et al. (2011), key individual, social and organisational factors are identified and validated. Using the Triandis model, in this study they detected that the perceived consequences – like affect (meaning the affective aspect of attitude), social factors and facilitating conditions – have a significant influence on knowledge sharing in CoP. Other variables such as managerial issues and technological utilisation were, however, not considered. Sharratt and Usoro (2002), on the other hand, developed a theoretical model involving the factors that affect knowledge-sharing in an Online CoP - an inter-organisational

VCoP. These factors include trust, recognition, information system, organisational structure and value congruence. The model developed by Sharratt and Usoro (2002) was, however, not validated and, therefore, is not able to determine which criteria are more important or even if any are irrelevant.

Another work on knowledge-sharing in Online CoP is that by Cheung *et al.* (2013), who validated a theoretical model to explain how CoP members evaluate their knowledge-sharing experience and how the evaluation affects their decisions regarding continuance. The authors found that satisfaction, disconfirmation of reciprocity, disconfirmation of helping others and knowledge self-efficacy impact on the members' intention to continue sharing knowledge. The study did not consider other factors that could motivate knowledge-sharing, i.e., reputation, reward, trust and sense of belonging. As a further point, this model was tested on the users of an educational portal, which is one type of professional group, meaning that other types of professionals could evaluate the same criteria differently.

2.3 Studies on Managing CoPs

This third research stream considers studies that proposed models relating to the factors that should be paid attention to when managing a CoP. Differently from the other two streams, there are fewer works covering this approach.

One model that can be mentioned is that proposed by Chu and Khosla (2009) and Chu *et al.* (2012). These authors developed an evaluation model for CoP business strategies. They used a fuzzy multi-criteria decision-making method to analyse the CoP's priorities and preferences and then differentiated between the CoPs according to four business strategies – induce innovation and learning, promote responsiveness, increase core competency and enhance working efficiency – which were then used to analyse the differences between the groups.

Probst and Borzillo (2008) proposed another model where the focus is on management aspects. In their governance model, these authors addressed six key factors leading to the successful management of CoP: objectives, sponsorship, leadership, boundary-spanning, risk-free environment and measurement. The key factors were derived from ten governance mechanisms and five reasons for failure, discovered by the authors after an investigation within the CoP. This model, however, did not explore how information technologies are used as a key factor to improve communities, especially a VCoP. In addition, the model did not consider the level and quality of knowledge-sharing within a community.

In some models, the approach has been to focus on the management of a CoP following a “growing process” approach, looking at how growing or maturity stages can improve the communities. One such example comes from Gongla and Rizzuto (2001), who presented an evolutionary model based on a five-stage pattern of how communities should evolve, which are the potential, building, engaged, active and adaptive stages. The authors describe each stage in terms of the behaviour of people and organisations, the supporting processes and the factors enabling technology. The model does not contain aspects that are important for a CoP, such as the level and quality of knowledge-sharing, tools for assessment and sponsorship from upper management.

Another growing process model was presented by Loyarte and Rivera (2007), who created a cultivation model for CoP. This model includes four phases, the detection analysis of communities, their need for being organised, the choice of an appropriate community and an evaluation model for integrated communities of practice. The evaluation model detects whether the community has achieved its objectives or not. This cultivation model does not, however, specify the criteria for measuring and assessing the CoP, nor does it indicate the best practice for improving its work.

A final model belonging to the growing process approach was proposed by Lee et al. (2010), who identified four stages of maturity for a CoP, these being building, growth, adaptive and close. They defined the main features and activity at every stage and established the critical success factors linked to each stage. Even when this model includes several criteria and success factors, a number of aspects that could be relevant for assessing the communities, such as the level of knowledge-sharing, were not taken into account.

3. Research Method

Prior studies allowed us to identify several factors and properties that should be considered in order to provide a clear understanding of the strengths and weaknesses of a VCoP. These models present different perspectives, since some look at the VCoP assessment from the perspective of growth, while others examine the topic from the angle of indexes or factors to be implemented. These viewpoints helped us to build an assessment framework that can be used for benchmarking the performance of VCoPs in the oil and gas industry. We, therefore, separated the methodological approach into two main stages:

- The development of a maturity model for assessing the VCoP performance;
- The application of this model in various companies, to compare them and identify the network/community leaders and points for improvement (i.e. benchmarking studies).

In the first place, the maturity model was developed on the basis of our review of the international literature and analysis of implemented knowledge management systems and communities. Several features and best practice relating to CoPs were analysed, and are described in Sections 4.1 to 4.3. The references used to construct the model are summarised in Appendix A. We then developed a model to include the features for assessing CoP based on the main common issues mentioned in these works, to which we added complementary practices and features cited only in a few works.

The model uses eight elements to measure the company's organisational, managerial and technological maturity, in order to find a correlation between maturity and the performance and business impact of a VCoP. These eight elements are culture, sponsorship, architecture alignment, development, management, policy, technology and community assessment. The performance of the VCoP is instead evaluated according to the four main criteria of utility, trust, contribution and sense of belonging. In Section 4.1., we have discussed the proposed model, relating each proposed dimension to the prior works that were used as reference.

After developing the model, we applied the assessment model to a benchmarking study on how the CoP is managed in four leading oil and gas companies, British Petroleum, Chevron, Eni and Petrobras. The benchmarking panel included several major global companies of comparable size (number of employees) and level of internationalisation. The analysis focused on how knowledge and community management is used within these companies' exploration and production units. For reasons of confidentiality, we labelled the companies A, B C and D arbitrarily when presenting the results. For our empirical study, we focused our attention of the usefulness of the model, as well as on the main practices used in VCoP management within the entire oil and gas industry.

In the benchmarking study, we applied different strategies for collecting the data, involving (i) an online survey with 22 multiple-choice questions (Appendix A); (ii) a set of detailed interviews to validate the data collected; and (iii) a collection of documents and presentations.

With respect to the first data collection strategy, the online survey was sent to 14 network/community leaders – KM managers - (2 at Chevron, 5 at Eni, 4 at Petrobras and 3 at BP) who made up the knowledge management team in these four companies, with the aim of assessing the maturity level for the VCoP according to the above elements. These teams were in charge of collecting opinions in each company community (through an indirect data collection method). They then elaborated a mean to be used for assessing each item in the questionnaire based on the options given by the various community leaders. When we found very marked

differences in the responses given during the assessment, we asked the team to add this information as a comment to the questionnaire, so that these points could be clarified later during the interviews.

The second round consisted of a set of in-depth interviews to validate the data collected and identify the most pertinent initiatives supporting VCoP management. During these interviews, we first asked the knowledge management team to describe the VCoP management system, its characteristics and the difficulties faced. After that, we discussed the results of the questionnaire. When there were substantial differences in the responses given by the VCoP leaders, we asked the interviewees for their reasons and also to express their opinion on the final score allocated to the item. This meant that the central KM team had the final say in any differences of opinion, since we felt that they had a broader vision over the whole VCoP management system, which was our aim.

Finally, with regards to the collection of documents and presentations, we collected items that described the knowledge and community management systems for these companies, in order to help us understand the system in place within each company.

4. Results

This section is divided into two parts. First, we will describe the proposed model to assess and benchmark the VCoP management of companies and then we will present a benchmarking study of six global oil and gas companies where the model was applied.

4.1 A Model to Assess and Benchmark the Management of VCoPs

The proposed model (Figure 1) consists of assessing eight key enabling elements related to the company's organisational, managerial and technological dimensions, which can impact on four dimensions relating to the communities' performance, which were also evaluated. The summary of the detailed variables for these dimensions are presented in Table 1, and the questionnaire relating to this model is presented in Appendix A. The model was evaluated on a five-point Likert scale. The references for the criteria used in this assessment are also summarised in the table in Appendix A and discussed in the next sections.

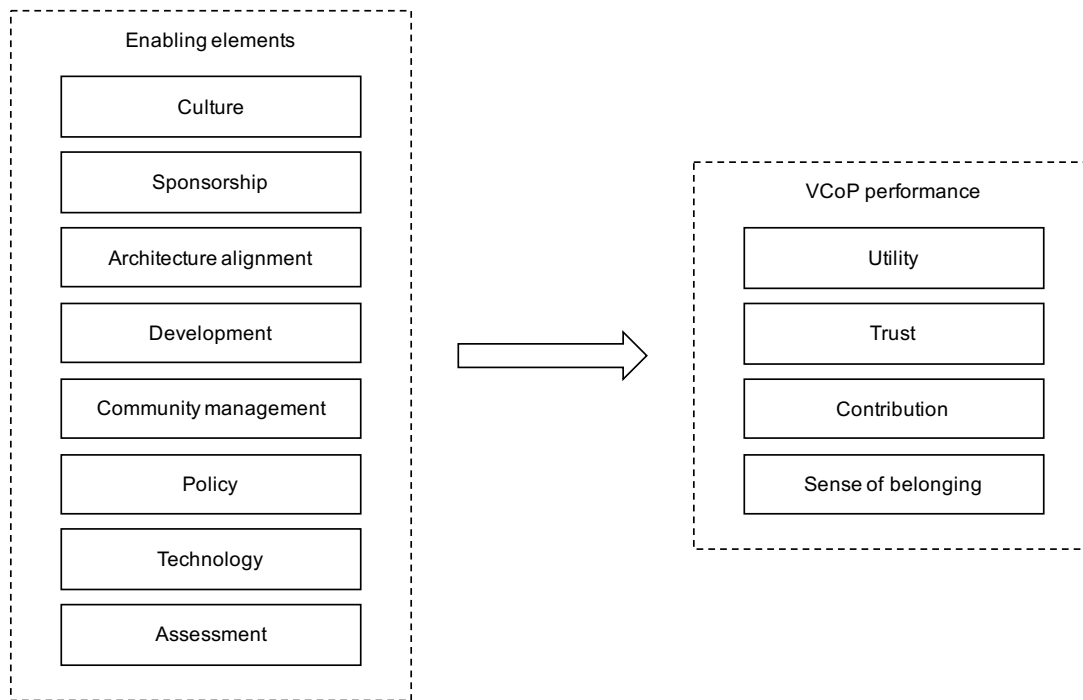


Figure 1 – VCoP assessment model

Table 1 – Dimensions and sub-dimensions of the assessment model

	Dimensions	Variables
VCoP Performance	Utility	Utility and effectiveness of the VCoP for the activities
	Trust	Sense of trust between the members of a VCoP
	Sense of belonging	Relationships and strong sense of belonging in the VCoP
	Contribution	Active participation and knowledge sharing in the VCoP
VCoP Organisational Levers	Culture	Emerging collaboration
		Openness to knowledge-sharing with actors
		Co-creation
		Sociality
		Climate
		Flexibility to change
	Sponsorship	Upper and Middle Management Involvement
		Upper and Middle Management Commitment
	Architecture Alignment	Target-needs alignment
		Business alignment
	Development	Open and cross-organisational participation
		Structured roles and activities
	Community Management	Incentive activities
		Structured roles and activities
	Policy	Accessibility
		Transparency
Technology	Social network and community	
	Unified communication and collaboration	
	Enterprise content management	
Assessment	Monitoring	
	Analysis of the benefits and business impact	

4.2 Assessment of VCoP Performance

The VCoP's performance was evaluated according to the four dimensions described as follows.

Utility. This dimension refers to the users' perception of the utility and effectiveness of the communities in terms of their own activities. This is because the level of knowledge-sharing and engagement in a VCoP is positively related to how useful the members perceive the VCoP activities to be for their own goals (Jeon *et al.*, 2011). The perception of utility is stronger when members feel that their own involvement in the VCoP will impact on their professional development and on their contact with other professionals (Lee *et al.*, 2015; Lev-on, 2015). Additionally, people are more satisfied with the VCoP when they realise that their personal contribution was useful in helping other members and they are then more likely to continue sharing new knowledge (Cheung *et al.*, 2013; Frank and Ribeiro, 2014).

Trust. This dimension refers to whether there is a strong sense of trust between the members of a community or not (Chrisentary and Barrett, 2015). Trust is considered an essential characteristic in any kind of knowledge-sharing or knowledge-transfer environment (Frank *et al.*, 2014; Usoro *et al.*, 2007). People need to trust in the solutions developed by others if they are to use them in their own operations. People also need to trust in the other members if they are to share their doubts and questions with the community (Sharratt and Usoro, 2003; Kim *et al.*, 2012; Bertone *et al.*, 2013; Bourhis and Dubé, 2010; Ardichvili *et al.*, 2003).

Sense of belonging. This dimension refers to whether members have offline relationships and connections among each other, as well as a strong sense of belonging to the community (Sharratt and Usoro, 2003; Kim *et al.*, 2012). This point is important because, in VCoPs especially, it is common to find passive members and members who take part only because someone else asked them to. These members may not really feel part of the community, and this can affect its performance. According to Lee *et al.* (2010), a critical success factor for a Community of Practice is that it acts as an extension to a human social network, especially by motivating members to establish relations outside the community. Along the same line, several studies on social network analysis have highlighted that a sense of belonging is a critical factor in maintaining any kind of network dynamically active, including a VCoP (Dubé *et al.*, 2006; Jay, 2009; Jeffries *et al.*, 2015; Wellman and Gulia, 1999). For instance, Lee *et al.* (2014a) indicate that relations among a community's members and the intensity of these relations, both measured through network analysis, are relevant for elaborating the risk of knowledge drain associated to a member leaving. In another paper, Lee *et al.* (2014b) also used social network analysis to diagnose knowledge-sharing actions and evaluate the structural health of communities of practice.

Contribution. This last dimension of the VCoP performance refers to whether members participate actively in the community, i.e. in a continuous and systematic manner, and contribute by

providing new content (Barker, 2015). According to this dimension, the higher the level of knowledge-sharing, the greater are the positive consequences perceived by members, in terms of both personal and organisational development, and the more satisfied users become with the VCoP (Jeon *et al.*, 2011; Zarco *et al.*, 2015). Passive members (those who are merely consumers of content) are a common negative feature in any VCoP, because there is no face-to-face interaction and people may not feel obliged to contribute. In order to maintain high levels of knowledge-sharing within VCoPs, it is important to increase the number of active members, i.e. members who are engaged in the community, participate actively and perceive its importance to the organisation (Corso *et al.*, 2009).

4.3 Assessment of VCoP Levers

The proposed VCoP assessment model involves eight key elements, described as follows.

4.3.1 CULTURE

The analysis of culture evaluates the attitude of upper management, middle management and other employees towards organisational behaviour to support the management of VCoP, as follows.

Emerging collaboration. This relates to whether the organisational culture is flexible in terms of cross-functional interaction, independently of the existing hierarchies between people and internal experts. According to knowledge-management literature, and VCoP literature in particular, for a VCoP to be successful, the social network must be stronger than its own hierarchy for collaboration among members and company experts to emerge (Chang and Lin, 2015; Lee *et al.*, 2010; Probst and Borzillo, 2008; Hung *et al.*, 2008; Huang and Huang, 2007; Cavaliere *et al.*, 2015). Since this aspect is part of a company's own culture, we have included it.

Openness to knowledge-sharing with actors in the company's extended network (customers, partners, suppliers, consultants, etc.). The more hesitant the company's culture is about sharing knowledge with other stakeholders, the more difficult it is to improve social interaction and capitalise on community knowledge (Frank *et al.*, 2014; Watson and Hewett, 2006; Hutzschenreuter and Horstkotte, 2010).

Co-creation: VCoP can be only successful if the company has a culture strongly focused on innovation and co-creation, since this forces the need for sharing knowledge among dispersed members. This item looks at whether people create broad participatory content and knowledge and so encourage widespread innovation (Lee *et al.*, 2010; Hung *et al.*, 2008).

Sociality. This item relates to whether the company's culture encourages interpersonal relationships and stimulates the creation and management of extended contact networks, which may be essential for outputs such as trust and sense of belonging (Lee *et al.*, 2010; Kim *et al.*, 2012; Huang and Huang, 2007; Chrisentary and Barrett, 2015);

Climate. This item reflects the organisational climate and the members' attitude towards social relationships and communication with others. This is because a culture that rewards a healthy organisational climate and transparent relationships can help to build up trust and a sense of belonging to the CoP (Frank *et al.*, 2014; Lin and Lee, 2006; Sharratt and Usoro, 2003).

Flexibility to change. This last item relates to the capacity for change and speed of the process in response to shifts in business needs and context. This is because the CoP must evolve rapidly according to business needs. As a consequence, this also relates to market change, since the CoP must act as a support tool to deal with such changes. Therefore, if the company's internal structure is unduly closed to adaptation and the creation of new communities, this can be a barrier to the successful implementation of any such managerial approach (Pan and Leidner, 2003).

The items mentioned above form the culture dimension of the assessment model. It must be noted that this dimension has a strong impact on the human aspects involved in VCoP performance, which are represented by the two measures of trust and sense of belonging. However, culture can also help with the other two performance metrics, but to a lesser degree.

4.3.2 SPONSORSHIP

The sponsorship of the different hierarchical levels within the company is an essential part of any initiative for improvement, especially those based on knowledge management (Söderquist, 2006). This need is stronger when the associated actions are performed virtually, as in a VCoP where the community members are from different functional areas and countries (Bourhis *et al.*, 2005; Bourhis and Dubé, 2010). Moreover, for VCoP members to be truly committed, there is the need for more than simple leadership encouragement; members need to really participate and get involved, including by sharing their knowledge with the network (Probst and Borzillo, 2008). Therefore, we have, therefore, proposed two main items:

Upper and Middle Management Involvement., i.e. sponsoring the development and use of communities;

Upper and Middle Management Commitment in Communities, i.e. whether or not managers take part in the launch, promotion and initiatives for managing change and to what degree; and whether they contribute to the community.

4.3.3 ARCHITECTURE ALIGNMENT

There is a vast literature on organisational development and information systems concerned with organisational alignment and architecture alignment (e.g. Reich and Benbasat, 1996; Sabherwal and Chan, 2001; King, 1988; Henderson and Venkatraman, 1993; Luftman, 2000). As a general understanding, this literature recognises that each process, activity and subsystem within an organisation should be aligned with the main organisational goals, so that all parts of that complex system called enterprise can flow to the same direction with the same end purposes. This aspect is also recognised in the information system literature, where authors such as Reich and Benbasat (1996) and Sabherwal and Chan (2001) have studied the alignment between information systems and organisational goals. In this sense, a VCoP is both a managerial architecture and an information system platform and, in both cases, it must be aligned to what the company pursues as a whole (Wenger, 2000). Therefore, the analysis in this category considers two different dimensions:

Target-needs alignment, which relates to the VCoP domain (e.g. common themes and problems, expertise of potential members, tools and language to be used, etc.), the needs of the target users, the methods of interaction and the informal networks of target users (e.g. organisational network analysis), the company objectives and the needs of community members, in order to identify shared goals. (Bourhis and Dubé, 2010; Chu *et al.*, 2014; Luo *et al.*, 2013; Yamklin and Igel, 2012).

Business alignment, i.e. long term development plans with objectives that are aligned with the corporate strategy; a clearly defined and communicated mission for each community (e.g. technical improvement, process innovation, training, etc.); upper and middle management involvement in the definition of community concepts (goals, scope, domain, etc.) (Dubé *et al.*, 2006; Probst and Borzillo, 2008; Chu *et al.*, 2014; Yamklin and Igel, 2012).

4.3.4 DEVELOPMENT

This key element of the assessment model looks at how a VCoP is developed. The development process runs from when the VCoP objective is defined until the VCoP become operative. It includes properties such as the design of activities, roles, the involvement of people and countries, the launch of initiatives and the management of change. VCoP development is, therefore, a development project like any other team design project and must be managed accordingly. With respect to this key element, our model considers two different dimensions.

Open and cross-organisational participation. As in other actions for organisational change, there is the need for open and cross-organisational participation in the community design.

When only a few people are involved during the development phase, there is a high risk of rejection and distrust in the VCoP's effectiveness (Wenger, 2000). Therefore, points to be considered are whether internal "champions" are both identified and involved in the community developmental phase (these are users with some experience in the use of community tools and promoters of change); whether the employees' independent initiatives/suggestions during the creation of new community are collated and accepted; and whether the various countries are involved in the definition and design of the community (Yamklin and Igel, 2012);

Structured roles and activities. Bertone *et al.* (2013) suggested that it is important to define a core group which is responsible for maintaining the community's focus and establishing strategic objectives and activities. Thus, this item relates to whether there is a team dedicated to the technical development of the community's tools, its launch and plans for managing change within each community that has been established. Moreover, according to Chrisentary and Barrett (2015), there is also the need to define a leadership role in the VCoP core group based on a model of leadership development. This may help to maintain continuity regarding the communities' engagement and alignment with the organisational objectives of the community (Cavaliere *et al.*, 2015). The leadership development is also the basis for all the other dimensions considered in this assessment model.

4.3.5 COMMUNITY MANAGEMENT

Community management relates to the level of activities carried out in the company to maintain the VCoP in operation and encourage its growth. For this, our model considers two different dimensions.

Incentive activities. This item looks at whether there are strategies to promote the community (promotional videos, communication campaigns), initiatives to involve the community members and to stimulate their contribution (editorial plans, contests) (Jeon *et al.*, 2011), specific communication and engagement actions for each country, offline meetings and events organised for community members (workshops, conventions, etc.) (Lee *et al.*, 2010; Bertone *et al.*, 2013; Kim *et al.*, 2012). This feature also looks at whether there are open and free policies of use (free access to community, contributions without moderation, etc.), training and support in community tools, economic incentives tied to user participation and contribution to the communities (e.g. bonuses, benefits, MBO) (Jeon *et al.*, 2011), formal recognition of participation and contribution to the communities (e.g. awards, contests, visibility in the community, etc.) (Sharratt and Usoro, 2003) and organisational policies and procedures to increase user participation (e.g. evaluation of business applications work-flow, requests) (Lee *et al.*, 2015).

Structured roles and activities. This second item is concerned with whether there are defined (i.e. formal) roles and actions in place throughout the community's operation, such as community leaders, managers and/or a central team to coordinate the various initiatives (Christentary and Barrett, 2015). This feature is also concerned with the roles and coordination mechanisms regulating community management (e.g. community leaders, facilitators, process owners, knowledge management champions and area experts), with adequate training and enough time dedicated to VCoP management operations, the use of tools and initiatives for sharing best practice among the people who manage the communities, and with monitoring the evolution of the community over time (Jeon *et al.*, 2011; Lee *et al.*, 2015; Lee *et al.*, 2010; Bertone *et al.*, 2013; Probst and Borzillo, 2008).

4.3.6 POLICY

This dimension is concerned with whether there is a clear policy regarding VCoP operation and participation. It deals with the boundaries of the VCoP in terms of its scope as well as the features and regulation of content during the processes of sharing knowledge and information. We looked at two items in this dimension.

Accessibility: This item relates to the ease of access to a community and to become part of it. With regards to access, some communities are relatively closed and joining involves too much bureaucracy, making them less flexible or dynamic. Having said this, even if greater openness is a desired feature in communities, there is also the need to safeguard the community's information and knowledge; an accessibility policy is therefore generally required (Bourhis and Dubé, 2010; Dubé *et al.*, 2006).

Transparency. This relates to whether users can express their opinions freely within the boundaries of corporate etiquette. When there are strong rules concerning personal expression, this can discourage people from taking part and sharing knowledge within the community (Probst and Borzillo, 2008; Bentley *et al.*, 2010). There is also the risk that members may not express their true options when sharing them with the community, but express what they think will please the community leaders or others in authority. This can happen above all when VCoP performance is evaluated.

4.3.7 TECHNOLOGY

VCoP could not be possible without the support of an information technology (IT) infrastructure in the company (Sharratt and Usoro, 2003; Bertone *et al.*, 2013). The IT platform is essential to any kind of virtual team, such as a VCoP, and these teams must be able to access different kinds of tools for the purpose of communicating in real-time or to share and store infor-

mation, among other requirements (Barker, 2015; Montoya *et al.*, 2009; Sarker *et al.*, 2005; Al-Ghamdi and Al-Ghamdi, 2015, Cavaliere *et al.*, 2015). Depending on the VCoP and the organisation, these tools can concentrate on formal or informal interaction between the VCoP members. We can consider three main kinds of IT tools that are commonly used for this purpose.

Social network and community. These IT tools support the creation and management of relationships between individuals, with tools that promote discussion, the exchange of ideas and involvement in networks, including those beyond company borders (blogs, fora, social network tools, expert research, advanced user profiles, etc.);

Unified communication and collaboration. These tools help in the process of managing any type of communication and collaboration, both within and without the company, in a standard way and independently of the medium used for transmission (web, landlines, mobile devices, TV) and the specific infrastructure and tools involved (audio/web/videoconferencing, instant messaging, VoIP, etc.);

Enterprise content management. This consists of the tools to provide support for managing contents and documents within and without an organisation, helping to improve accuracy, accessibility and integrity.

4.3.8 ASSESSMENT

A final dimension of the managerial aspects of a VCoP is the need to assess whether the VCoPs are evolving over time (Lee *et al.*, 2014a; Lee *et al.*, 2014b; Bertone *et al.*, 2013). In fact, the models discussed in our theoretical background are models for assessing communities, and a company can put in place strategies and indicators to help them evaluate either several specific aspects or the entire management system for a community. Therefore, we propose two main dimensions to be considered.

Monitoring, which involves using a measurement system that can be accessed and used by the community (Bourhis and Dubé, 2010). This includes, among the functions on offer, appropriate key performance indicators (KPIs) and success metrics; executive reports carried out in a systematic manner; and a strategic analysis of the development of the communities.

Analysis of the benefits and business impact, which looks at the organisational tools and mechanisms used to identify the benefits and the business impact or value of the community system (Lee *et al.*, 2010). These tools can be qualitative (e.g. qualitative descriptions, storytelling of success cases, problem cases, etc.) or quantitative/economic (e.g. time/cost reduction, increased quality, increased production, etc.) (Probst and Borzillo, 2008).

4.4 Application of the Model to a Benchmarking Study

Four global companies participated in this benchmarking study on the oil and gas industry: British Petroleum (UK), Chevron (USA), Eni (Italy), Petrobras (Brazil) and Shell (Netherlands). In all four cases, we first collected quantitative data and afterwards verified the information provided through a personnel interview with the key-respondents. Table 2 summarises the VCoP concept for each company, as well as the number of VCoPs that are managed and the total number of members involved in VCoP activities (members of at least one community).

Table 2 – Description of the VCoP properties of the studied companies

Company	VCoP Concept	No. of VCoPs	Approx. no. of members
British Petroleum	VCoP only for the senior experts. Other employees can send questions and receive information in a specific area. There are two main types of communities: (i) for all technical matters and business functions; (ii) with a transversal focus (e.g. process engineer network). They have their own technological platform.	20	600
Eni	VCoP for all employees in the exploration and production business unit. The VCoP is managed by an enabling team closely connected to upper management and which focuses on gathering the requirements for the technological and organisational development of the VCoP as well as for continuous improvement and benchmarking.	17	1,600
Chevron	They have two different kinds of VCoP: (i) Technical Network for problem solving; (ii) Community of Practice, for developing standards and best practice. SharePoint is their main platform, but they also use Yammer in some technical networks.	60	30,000
Petrobras	The communities cover several business areas and technical aspects within the company. Each VCoP has its own space in the online platform (developed specially for the company). This online platform allows members to share lessons learned, best practice and forum discussions, as well as sharing files.	16	11,526

Figure 2 presents the assessment results of the VCoP performance within the four oil and gas companies. The radar chart presented in Figure 2 shows how these companies stand in relation to the four dimensions being evaluated (utility, trust, sense of belonging and contribution) according to the answers given in an electronic survey confirmed at the time and then afterwards in the interviews. Figure 2 shows that Company B is the best performer, while companies A and C are the most critical. It is worth noting that all companies scored highest for *utility* of and *sense of belonging* to the VCoP, and that the most crucial problems associated to VCoP performance were related to the lack of *contribution* from the members and the lack of *trust* among community members (Figure 2).

An interesting point is observed in Company C, where both *trust* and *contribution* were given low performance scores, while *utility* and *sense of belonging* performed well. According to the interviews, this means that, in general, VCoP members perceive the relevance of the community and feel part of it, while also concluding that the community can improve their own work. However, they have not contributed in the way that had been expected, as the company has not invested sufficiently, above all in the aspect of socialisation among members. This means that members do not know the other members personally and do not feel comfortable about asking for solutions or help in solving a problem. This aspect is reinforced when analysing Figure 3, and will be discussed in greater detail below. Technology in this company performed badly, meaning that, according to the interviewee, the VCoP platform is not closing distances between members and is acting only as a file and content repository for the community.

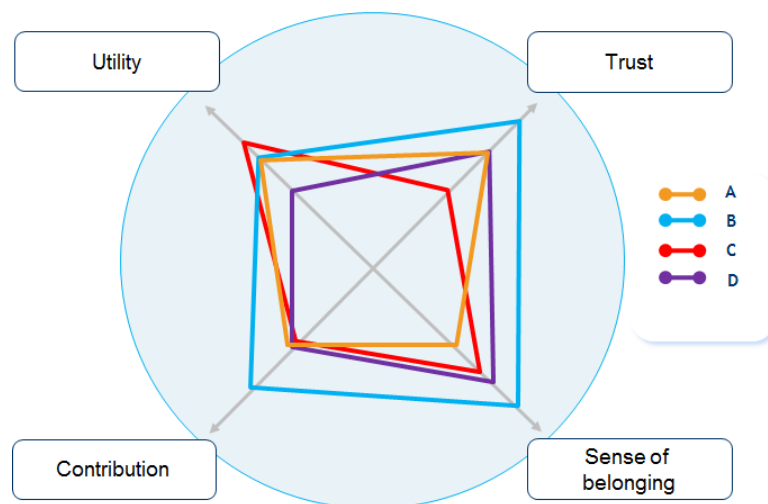


Figure 2 – Assessment of VCoP performance

After evaluating VCoP performance, the eight VCoP management levers were also assessed. Figure 3 shows the main results for these levers. As expected, the company with the best performance results in Figure 2 (Company B) also performed best for the levers of maturity in Figure 3. This was equally replicated for the company with the worst VCoP performance in Figure 2 (Company C), which is also the company with the lowest maturity for all the levers evaluated (Figure 3), especially in policy, technology and assessment monitoring.

Taking Company A, in Figure 2, we can see that it scored badly for its performance in *contribution* and *sense of belonging*, and better in *utility* and *trust*. It follows that these outputs can be compared with the performance of the levers in Figure 3 to see which dimensions are helping

and which are instead hindering this output. According to Figure 3, aspects such as *utility* and *trust* (see Figure 2) could be result of clearly defined VCoP goals (architecture alignment) and policies on the use of the VCoP. On the other hand, the low performance of *contribution* and *sense of belonging* (again, see Figure 2) could depend on poor technological infrastructure (especially for contribution) and a lack of suitable development strategies and sponsorship (especially for sense of belonging).

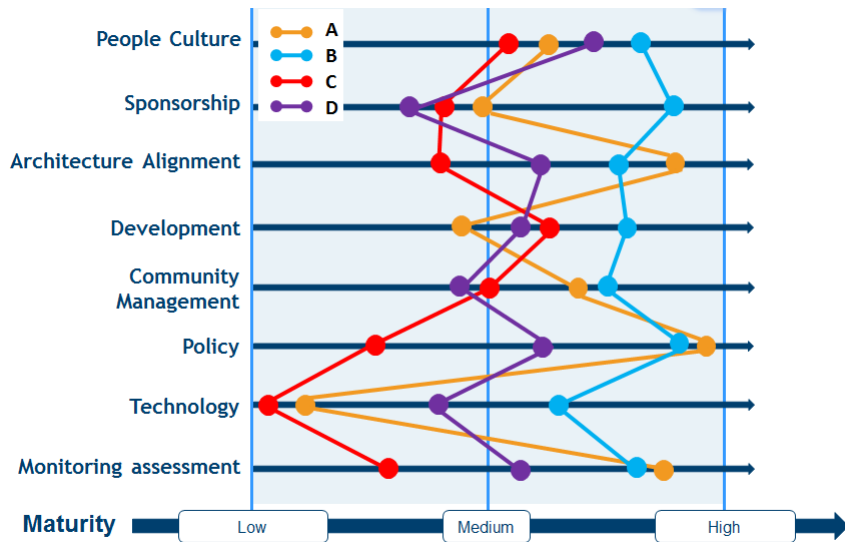


Figure 3 – Assessment of VCoP levers of maturity

Additionally, even when our application focused on the principle aspects of the assessment model, it is important to highlight that each of the above dimensions relating to the VCoP levers can be deployed at disaggregated levels of analysis, as explained in Section 4.3. For example, Figure 4 shows a detailed disaggregation of the community management assessment, which is deployed across several competences and skills that are used for managing a VCoP. The average of all the scores obtained by each company for each element, presented in this figure, gives the composite value presented previously in Figure 3 for community management.

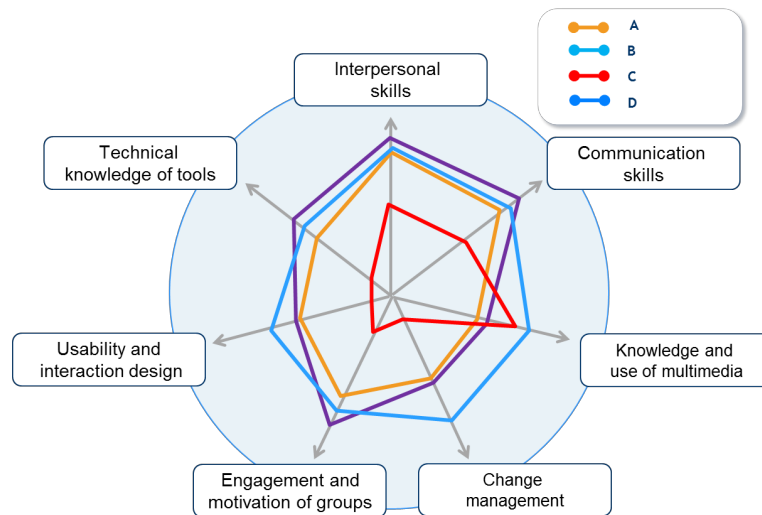
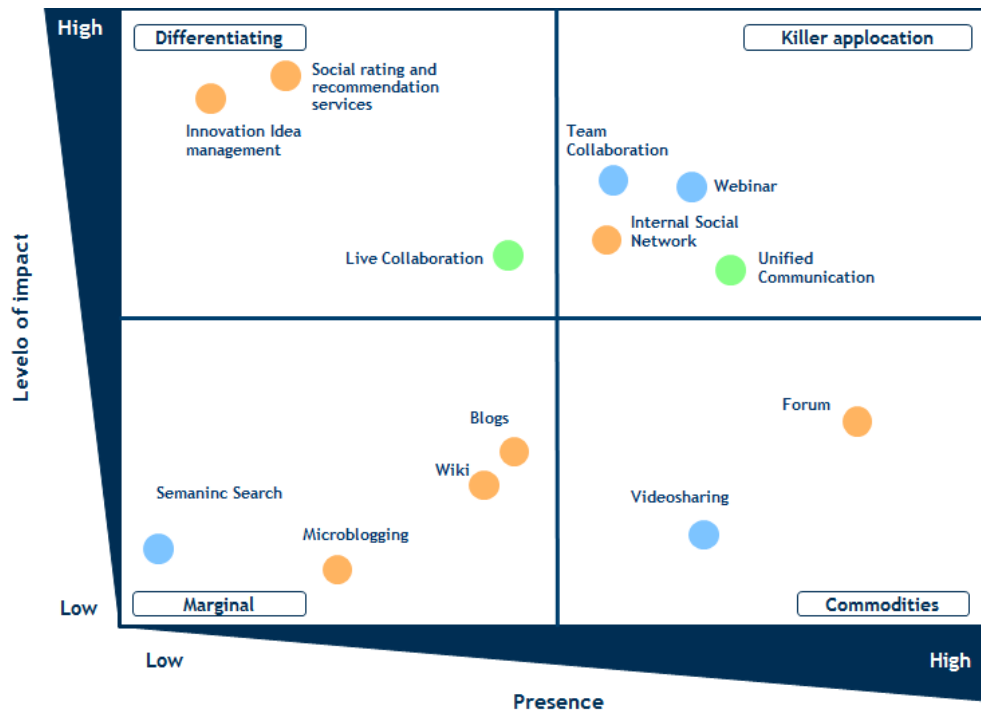


Figure 4 – Detailed evaluation of the community management dimension

As mentioned previously, according to Figure 3, technology is the most critical lever and is the one where VCoPs are still very much at a low stage of maturity. On this point, we collected information about the technologies used in VCoPs that are the most promising and commonly used within the companies analysed, obtaining this information from the key knowledge management (KM) managers during their interviews. Figure 5 presents these results, where the VCoP technologies were classified along two axes. The x-axis shows the average level of use of a specific technology in all the VCoPs being studied. The y-axis shows the average level of contribution (impact) of such a technology for managing the VCoP within the oil and gas companies being studied. We classified these technologies according to the two axes into four quadrants: marginal, commodities, differentiating and killer applications. The technologies in blue relate to enterprise content management, those in orange to social networks, and in green to unified communication and collaboration processes.

The first bottom two quadrants in Figure 5 show the technologies with low impact on VCoPs, according to the interviewees. While the bottom left quadrant gives technologies used sparingly, the bottom right quadrant indicates those used very frequently in the communities. This group of technologies includes tools such as video-sharing and fora for VCoP members. The differentiating and killer applications – both upper quadrants in Figure 5 – are the most powerful technological tools for VCoPs in this industrial sector. Some of the tools, like webinars and internal social networks, and others shown in this figure, are, according to the companies under study, very effective tools, and are being used more and more within these companies' VCoPs. Other tools described in this figure were seen as effective, but still at the initial stages of application.



Note: Blue: technologies related to enterprise content management; orange: technologies related to social network; green: technologies related to unified communication and collaboration.

Figure 5 – Technological tools used in the VCoP in the oil and gas industry

It is equally the case that best practice, as well as the levels of presence and contribution, can be identified for each dimension considered in Figure 3. These details depend on whether the company is interested in understanding specific tools and practices for a specific dimension.

5. Conclusions

This paper presented a model to measure the level of maturity of a company's organisational, managerial and technological levers for their virtual communities of practices (VCoPs). The proposed model can be used as a benchmarking tool to analyse how an industry sector performs with respect to managing its VCoP operations. The main contribution of this paper is that an assessment carried out through the proposed model provides an overview of the strengths and weaknesses of the VCoP management system, and is the opportunity for making a comparison with other organisations. The assessment can also be used to identify a series of potential actions that can be undertaken to improve the current status of a company's virtual communities. The assessment also helped us to identify best practice to be shared which can

improve the overall use of VCoPs within the oil and gas industry. Based on this, we will present the theoretical and managerial implications of this work.

Theoretical implications and future research

By building the proposed assessment model, we have identified a set of socio-technical practices and tools that can impact on VCoP performance. We also defined the performance metrics that should be considered for VCoP management. In other words, this model provides a theoretical framework for future quantitative survey studies that can evaluate the general contribution of all these practices and tools to VCoP performance. Another contribution is that our empirical data analysis highlighted different degrees of adoption and efficacy (impact) for IT tools in VCoP management. This analysis can open a research opportunity to gain a greater understanding of how these tools can be used to manage VCoP more effectively.

One limitation of this study relates to the data collection for comparative purposes among the companies. The fact that we collected data only from a few key-respondents in each company can be a limitation, because of the lack of reliability. However, as a benchmarking tool, this model has a more practice-oriented contribution, since it helps companies to understand which dimensions they should analyse and compare when they want to improve their VCoP management. As mentioned previously, this tool can act as a theoretical framework for other future studies based on quantitative survey research. This is particularly the case when wishing to understand the correlation existing between each proposed lever and the proposed VCoP performance output.

Managerial implications

Managers can use the proposed model as a tool to assess their own VCoP management system. The model provides a clear structure for organising a set of practices that managers can use as well as verifying how these practices are applied in their company. Furthermore, this model can become a powerful tool when industrial associations use it to carry out benchmarking analyses among several companies, which is the process we followed in our empirical application. In these cases, managers can see how their VCoP management compares with the performance of market leaders and identify any potential improvements based upon these comparisons.

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Appendix A – VCoP assessment structure

Note: the complete online form presented a short explanation for each variable according to the explanations presented in Sections 4.2 and 4.3.

Performance Dimensions	Variables Level of performance (scale: 1-low to 5- high)	References
Utility	Utility and effectiveness of the VCoP for the activities	[7][12][19][24]
Trust	Sense of trust between the members of a VCoP	[8][20][31][33]
Sense of belonging	Relationships and strong sense of belonging in the VCoP	[11] [17] [18][20][31]
Contribution	Active participation and knowledge sharing in the VCoP	[1][10][19]
VCoP Levers Dimension	Variables Level of presence (scale: 1-low to 5- high)	References
Culture	Emerging collaboration	[6][14][21][15][29]
Culture	Openness to knowledge-sharing with actors	[13][16][34]
Culture	Co-creation	[15][21]
Culture	Sociality	[14][20][21]
Culture	Climate	[13][25][31]
Culture	Flexibility to change	[28]
Sponsorship	Upper and Middle Management Involvement	[4][5][29][32]
Sponsorship	Upper and Middle Management Commitment	[4][5][29][32]
Architecture Alignment	Target-needs alignment	[4][9][26][36]
Architecture Alignment	Business alignment	[9][11][29][36]
Development	Open and cross-organisational participation	[35][36]
Development	Structured roles and activities	[3][8]
Management	Incentive activities	[3][19][20][21][24][31]
Management	Structured roles and activities	[3][8][19][21][24][29]
Policy	Accessibility	[4][11]
Policy	Transparency	[2][29]
Technology	Social network and community	[1][3][27][30][31]
Technology	Unified communication and collaboration	[1][3][27][30][31]
Technology	Enterprise content management	[1][3][27][30][31]
Assessment	Monitoring	[3][4][22][23]
Assessment	Analysis of the benefits and business impact	[3][22][23][29]
Notes: [1] Barker (2015); [2] Bentley et al. (2010); [3] Bertone et al. (2013); [4] Bourhis and Dubé (2010); [5] Bourhis et al. (2005); [6] Chang and Lin (2015); [7] Cheung et al. (2013); [8] Chrisentary and Barrett (2015); [9] Chu et al. (2014); [10] Corso et al. (2009); [11] Dubé et al. (2006); [12] Frank and Ribeiro (2014); [13] Frank et al. (2014); [14] Huang and Huang (2007); [15] Hung et al. (2008); [16] Hutzschenreuter and Horstkotte (2010); [17] Jay (2009); [18] Jeffries et al. (2015); [19] Jeon et al. (2011); [20] Kim et al. (2012); [21] Lee et al. (2010); [22] Lee et al. (2014a); [23] Lee et al. (2014b); [24] Lee et al. (2015); [25] Lin and Lee (2006); [26] Luo et al. (2013); [27] Montoya et al. (2009); [28] Pan and Leidner (2003); [29] Probst and Borzillo (2008); [30] Sarker et al. (2005); [31] Sharratt and Usoro (2003); [32] Söderquist (2006); [33] Usoro et al. (2007); [34] Watson and Hewett (2006); [35] Wenger (2000); [36] Yamklin and Igel (2012).		