Computer-supported Active Transparency for Strategic Open Innovation

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Abstract: Aiming at facilitating the design and deployment of information systems to support Open Innovation with a potential of providing sustainable competitive advantage, we rely on the micro-foundations of dynamic capabilities, namely on the concepts of framing and abduction that are considered as the main elements of generative sensing. We elaborate the concept of "active transparency" as a step for developing generative sensing through the implementation of computer-supported argumentation in an open innovation setting. In particular, we review the relationship between dynamic capabilities and strategic Open Innovation, we concentrate on active transparency surfacing the important role that argumentation plays in the deployment of this capability, and we discuss the ICT solutions that enable active transparency and open innovation for providing competitive advantage.

1 INTRODUCTION

Open Innovation (OI) is an established paradigm of innovation based on "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the market for external use of innovation, respectively" (Chesbrough, 2006). The adoption of OI by an organization implies that the innovation management process (Tidd and Bessant, 2014) becomes porous, and ideas, concepts, design, products, services etc. flow in and out of its boundaries. At the same time, different human and non-human knowledge sources associated with internal and external organization actors, such as managers, users/customers, employees, suppliers, competitors, researchers, regulators etc., become interconnected in many different ways, and information and knowledge items of different forms flow between them, and are transformed in many different ways. Clearly, in large complex organizations, or networks of organisations, this is accomplished in a complex web of social processes (Anderson and Hardwick, 2017), in which agents of different views, interests, cultures and power status (Mota Pedrosa et al., 2013), usually being situated geographically and contextually at a distance, are part of.

There are four models associated with Open Innovation (Möslein, 2013). In *innovation markets*, organizations and individuals act as *seekers* of innovation solutions and *solvers* of innovation problems. This model is usually implemented through intermediaries that facilitate the matching of problems to solutions. In the model of firm-sponsored *innovation communities*, agents of different size and complexity develop ideas, discuss concepts and promote innovation. Crowdsourcing is a particular strategy in the framework of this model, also associated with *innovation contests* where a firm gets ideas for products, services, solutions, or even business models from different sources (customers, suppliers, etc.), which are also involved in their evaluation and selection. When *innovation toolkits* are used, users develop solutions in prescribed steps, sometimes using standard components and modules in a predefined solution space, interacting with the company to get feedback. Innovation markets and the related social product development forums, as well as the ideas/innovation contests, provide solution spaces with a high number of degrees of freedom, whereas innovation and co-design toolkits and innovation communities, through predefined procedures, restrict the solution space and processes (Piller and Ihl, 2013).

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In this paper, we focus on the model of *innovation contest* for providing strategic advantage, i.e. the use of OI for obtaining ideas and solutions to problems set collaboratively by the focal company and its partners and customers, with a potential of gaining competitive advantage (Malhotra and Majchrzak, 2016; Tavakoli et al., 2017). It has been argued that to exploit the strategic potential of such innovation models, the firm should install mechanisms for integrating the knowledge provided by external sources with that held internally. There have been proposed different mechanisms and model processes for knowledge integration in strategic organisational processes (e.g. Nonaka and Takeuchi, 1995; Malhotra and Majchrzak, 2016) associated with the development of (dynamic) capabilities (Adamides and Karacapilidis, 2018). Most of them, however, are at a macro or meso level of analysis and hence are not suitable for providing insights and guidelines for the design of information systems (IT platforms) that support the operation of such OI models.

To facilitate the design and deployment of information systems to support OI with a potential of providing competitive advantage, in this paper, we rely on the micro-foundations of dynamic capabilities, namely the concepts of *framing* and *abduction* (Dong et al., 2016), which are considered the main elements of *generative sensing*. We elaborate the concept of *"active transparency"* (Adamides and Karacapilidis, 2018) as a step for implementing generative sensing through the implementation of computer-supported argumentation in an open innovation setting. We provide design specifications for such a system and an example of its potential use. Following in Section 2, we review the relationship between dynamic capabilities and OI for competitive advantage. Then, we concentrate on active transparency surfacing the important role that argumentation plays in the deployment of this capability. In Section 4, we discuss the ICT solutions that enable active transparency and open innovation for providing competitive advantage. Finally, in Section 5, we draw the conclusions.

2 DYNAMIC CAPABILITIES AND STRATEGIC OPEN INNOVATION

It has been argued that organizations that aim at strategic OI need to develop a set of capabilities for absorbing and assimilating knowledge from different sources in an efficient and effective manner (Hosseini et al., 2017). These capabilities are associated to the organisation's absorptive capacity and the development of an infrastructure for cooperative learning. In general, capabilities are constituted by assets/resources, such as ICT artefacts, and routines/processes for deploying these assets (Amit and Schoemaker, 1993). OI-based strategic capabilities are linked to the notion of *dynamic capabilities* (Teece et al., 2016), i.e. to the ability to select or change operational/ordinary capabilities and switch strategies between breadth (diversity) and depth (intensity) in the effective use of internal and external knowledge sources about products, services, business models, etc. In more practical terms, they are linked to an organization's ability to innovate through the appropriation of the right knowledge by *sensing* the environment, *seizing* opportunities and *transforming* its innovation process(es) and value offerings. Sensing is associated with exploration, whereas seizing with both exploitation of the internalized environmental signals, ideas, concepts, technologies etc., as well as with the exploration of the external environment for gaining economic value from the innovative products and/or services developed through transforming activities. External knowledge integration and learning are products of the execution of these activities, which in the inbound OI approach exhibit a certain degree of openness (Tavakoli et al., 2017), while their effectiveness depends on the organization's level of *absorptive capacity* (ACAP) (Cohen and Levinthal, 1990), as well as on its degree of *"active transparency"*, which may be defined as a form of *generative sensing* (Cui et al., 2015; Dong et al., 2016).

Active transparency allows an organisation to control proactively and effectively its interface with the external environment, as far as knowledge inflows and outflows are concerned. Active transparency refers to an active organisational interface that filters and distils internal and/or external knowledge before it is integrated. In this line, it supports the collective development of hypotheses about problems and their innovative solutions – in general, hypotheses about the possible use and effects of incoming and outgoing knowledge items – as well as the testing for their validity. In effect, active transparency is a capability that is constituted by the capabilities of generative sensing and argumentation. *Generative sensing*, in turn, is a component of dynamic capabilities founded on the micro-capabilities of *framing* problems/issues and selecting/inferring their solutions using an *abductive logic* (abduction) (Dong et al., 2016). *Argumentation* refers to the use of formal schemata to collectively – in an OI fashion – set propositions and

collectively decide on the validity of propositions. Formal argumentation schemata control the proposition-setting and decision-making processes by regulating the relative power (positional and rhetoric) of participants and their arguments (dominant argumentation logic/repertoire).

Absorptive capacity also contributes to an organization's capability/readiness of recognizing the value of new external information, but also to assimilating it, and applying it to commercial ends (Cohen and Levinthal, 1990). Recent research directly associates absorptive capacity to the dynamic capabilities framework and stresses its importance as a degrees-of-freedom provider towards innovation and change (Zahra and George, 2002; Teece et al., 2016). Absorptive capacity is a function of the richness/diversity of the pre-existing knowledge structure, both personalized (tacit) and impersonalized (codified). Hence, although many consider ACAP as a dynamic capability (e.g. Lichtenthaler and Lichtenthaler, 2009), it is better to consider it as an intangible, accumulating and depleting strategic asset used in organisational processes/routines. Obviously, both the active transparency and ACAP of an organisation depend on the corresponding qualities of its individual members.

The very processes of knowledge creation and integration are largely associated with interaction and socialisation (Nonaka and Takeuchi, 1995). So, in OI settings (innovation contests and crowdsourcing), a knowledge management strategy that aims at the efficient and effective creation of strategically-useful knowledge from different intra- and inter-organizational sources, as well as at augmenting learning capacity, should be primarily targeted on the use of ICT for the development and use of social capital, rather than on the installation of technology systems for the storage, transformation and distribution of codified knowledge (Lichtenthaler and Lichtenthaler, 2009; Adamides and Karacapilidis, 2018). Towards this objective, and on the basis of the above discussion, methods and tools for supporting active transparency, as well as for supporting intra-organisational collaboration are required. Hence, the objective of OI contests for gaining competitive advantage suggests a *personalization* rather than a *codification* knowledge management *meta*-strategy (Scheepers et al., 2004), in which information and communication technology has an important role to play. There is a wide range of technologies that can be used for augmenting learning processes and building ACAP and active transparency, the most important of which are discussed in Section 4. Before that, however, we further elaborate on active transparency and the role of argumentation within it.

3 THE CONCEPT OF ACTIVE TRANSPARENCY FOR STRATEGIC INNOVATION

As it was indicated before, active transparency is an organizational capability directly related to *generative sensing*, which is a particular type of sensing capability, focused on generating and testing hypotheses about new technologies, new products and novel strategies (Dong et al., 2016). As such, active transparency controls the inflow and outflow of organizational knowledge (Karacapilidis et al., 2003), actively contributing into knowledge integration in both ways. Active transparency presupposes the capabilities of problem framing and abduction, which in OI settings are accomplished by a set of internal and external organizational actors in an argumentative fashion. In this way, it directly addresses the very definition of innovation as a "process where knowledgeable and creative people and organizations frame problems and select, integrate, and augment information to create understanding and answers" (Teece, 2001). As activities in all the phases of the innovation process constitute problem resolution tasks (Leonard and Sensiper, 2003), propositions and evaluation of propositions need to take place all along the innovation process. Obviously, innovation for sustainable competitive advantage means a move towards strategy innovation rather than incremental change and should be based on the refinement and integration of knowledge, and not on a number of discrete unfounded ideas. In fact, propositions for novel technologies, products or strategic initiatives to innovative business models are arguments/propositions with supporting evidence, which however have to be evaluated and accepted in a collective manner (Wright, 2012).

Truly innovative propositions are not based on existing technologies, products and strategies and are easily accepted in the initial format proposed. They are the result of argumentative discussions/negotiations between external and internal organizational actors. Argumentation contributes to the extraction/elicitation/filtering of knowledge from diverse sources (to support arguments) and to their integration (conflict resolution and agreement). Nevertheless, this process of convergence of perspectives and agreements does not take place in a political vacuum. Politics in the

change/innovation process is important and "creating affective change and adaptation within the organisation depends upon effective use of politics" (Eisenhardt and Zbaracki, 1992). Inevitably, this "political" perspective leads to one of the central issues of active transparency and its implementation, and consequently of open innovation, that of the relative distribution of power among all the agents participating in the contest/crowdsourcing, and the regulation of its influences on the outcome of the knowledge integration process through asymmetric forms of argumentation.

In general, the purpose of an argument is to show that a non-trivial assertion (a proposition whose validity is not obvious without further details and cannot proved or verified by evidence) may claim validity (von Werder, 1999). Argumentation is a context-based sense-making process, which varies according to (socially) constructed rules and (social) groups. According to Bloor (1980), characteristic forms of argument will emerge in a social setting, standing out by their frequency (e.g. seeking argument justification with reference to a specific report, or with reference to what the industry leaders do, etc.). Inevitably, this gives each social (organisational) structure its *dominant argumentation repertoire* of explicit legitimation, which solidifies and increasingly constrains social and organisational behaviour, and is used for characterising and evaluating actions, events and other organisational phenomena "which are often organised around specific metaphors and figures of speech" (Potter and Wetherell, 1987). As a result, institutionalised justifications exist as objective, widely available rules, and, directly or indirectly, tell organisation members how to argue (Sillince, 1999). Clearly, the institutionalization of an argumentation form is not a positional- and rhetorical-power-neutral process, neither a static one. In innovation propositions, organisation members with high positional power need not justify their arguments extensively, while those with rhetorical power (which is related to the positional power) may bias the organisation discourse, both in short and long term, towards specific forms that have more affinity with the institutionalised argumentation forms, undermining other forms which may include more substantive arguments. This is one of the drawbacks of "closed" innovation and at the same time a sign for caution for open innovation. Argumentation for postulating (innovative) propositions should encourage external actors to contribute giving them appropriate power to support their arguments by using a variety of justification/claim logics. ICT can contribute to this by sealing off these processes from their actual social/organisational context in a controlled manner (Kallinikos, 2011).

Many argumentation models (formalisms) have been proposed in the literature, especially in connection to computer-supported argumentation systems (Bentahar et al., 2010). Gürkan et al. (2010) integrated three such formalisms (IBIS, the Toulmin framework, and the concept of argument schemes of Walton) in an inclusive model, which consists of the *problem/issue* in hand, the *ideas/proposals/positions* for its solution, and *pro and contra arguments* related to proposals. Pro and contra arguments are justified by *claims* consisting of *grounds* and *warrants*. Pairs of grounds and warrants define four main *argument schemes* (which are related to the argumentation repertoires mentioned above), namely, arguments based on *expert opinion* (accept claim because someone is an expert), *popular opinion* (something is generally accepted as true because it is generally accepted as true), *analogy* (A works because it resembles B that have been proven to work in the past) and *causal associations* (A works because B works, and there is a positive correlation between the two). Clearly, all four schemes can be employed in an OI-based strategy.

The quality of propositions and the knowledge/insights produced is a function of the *argumentation rationality*, i.e. the thoroughness of the proposition preparation as revealed by the arguments put forward to support it (von Werder, 1999). In relation to the above argumentation models, abuse of *positional power* means that the proponent does not justify claims and/or pro/contra arguments, or does not justify the selection of a specific argumentation scheme, or does not justify the issue of specific rhetoric arguments, or even does not justify the truth of warrants. Similarly, the abuse of *rhetorical power* implies that the proponent knows how others react to rewards and practices rhetoric argumentation accordingly, giving little emphasis on the validity and truth of arguments and statements ("populist" behaviour). Such behaviours result in effectively weak arguments and shaky propositions distorted by power relations. So the result of the knowledge integration effort and innovation will not necessarily match the organisation's strategic needs.

In open innovation, once a proposition is framed collectively in an argumentative fashion, then its validity needs to be tested through abduction. Abduction is a microfoundation of generative sensing and active transparency. It is a form of logical reasoning in which hypotheses/propositions, which are intuitive "guesses" (and not necessarily logically

sound) are introduced and then tests are performed to validate them (Dong et al., 2016). The proposition is a hypothetical mechanism (the product of abduction), which, if it existed, would generate (would be responsible for) the observed phenomenon/problem, or a phenomenon different from what was normally expected (Papachristos and Adamides, 2016). The proposition may be the result of formal argumentation and thus logically sound as far as the collective process is concerned. However, most likely, it will be unfounded regarding its content, since most participants have limited, or no, knowledge of the specifics of the issue/problem and the context around the issue.

In *explanatory abduction*, the environment is scanned for truly surprising ideas and facts. Here the participation, collaboration and argumentation of external and internal agents follow initially a *dialogic* conversation model where the diversity of ideas and propositions is the principal objective (Karacapilidis et al., 1997; Sennett, 2012). This is followed by *dialectic* conversation to arrive at a single, or a small number of propositions. For instance, as a very simple example, consider a number of executives involved in a discussion about the causes and possible (innovative) solutions to the pollution problem of an industrial district. The argumentation of executives may result in a consensus that the main sources of pollution are the industrial waste of a paints-producing company. This forms the (unfounded) proposition to be validated by collecting data to construct the underlying mechanisms that when put in place – in reality or simulated – will (re)produce the phenomenon (pollution in our case), and hence support this claim and reject any alternative claims – for instance, a claim that a food processing company also situated in the district is the main pollutant. Once the alternative claims have been discarded, the hypothesis becomes a sort of conclusion to be used in (the next phase of) innovative abduction.

In *innovative abduction*, inferences are made about the strategic options/innovations and/or the initiatives that need to be accomplished for their implementation. Here, the premise is that the paints company is the main pollutant and the hypothesis to test is the (possible) use of specific chemical waste treatment technologies that will convert waste to energy source for the food processing company. The hypothesis will be validated by collecting data, consulting specialists, even performing simulation experiments. It is possible that this hypothesis will not be valid, so an alternative hypothesis, e.g. mixing with other chemical wastes and treatment to heat the nearby village, need to be tested. Once this proves to be possible, hypotheses about the implementation of the technological innovation will be set and tested. In this way, eventually, the industrial district will arrive collectively at an innovative solution (innovation) that provides competitive advantage to the participating companies through cost reduction and the construction of a green image.

4 THE PROPOSED TOOLSET

Open Innovation can be facilitated and significantly augmented through a diversity of software tools and associated technologies. In this section, we identify the main categories of these tools and comment on their capacity to support and enhance the explanatory and innovative abduction processes. Based on their main purpose, they can be classified into two broad categories: (i) tools that mainly serve the collection, integration and consolidation of underlying information, knowledge, opinions and values, thus supporting the collective development of hypotheses about problems and their innovative solutions, and (ii) tools that aid the analysis and validity testing of the components of the overall argumentation process and the assessment of stakeholders' attributes in terms of credibility and expertise. It is the former tool category that enables an organization to conduct a formal argumentation process towards framing the problem and postulating the related propositions, while the latter assists in performing experimentations with alternative mechanisms and approaches to reproduce or strengthen a proposition.

Collaboration Support. The emergence of the Web 2.0 era led to the introduction of a plethora of tools, which feature novel collaboration paradigms and enable users' engagement at a massive scale. These tools cover a broad spectrum of needs ranging from knowledge exchanging, sharing and tagging, to social networking, group authoring, mind mapping and discussing. For instance, *Facebook* (http://www.facebook.com) and *LinkedIn* (http://www.linkedin.com) are representative examples of social networking tools that facilitate the formation of online communities among people with similar interests; tools such as *MindMeister* (http://www.mindmeister.com) and *Mindomo* (http://www.mindomo.com) aim to collectively organize, visualize and structure concepts via maps to aid brainstorming and problem solving; *Debatepedia* (http://wiki.idebate.org) and *Cohere* (http://cohere.open.ac.uk) are typical tools aiming to

support online discussions over the Web; *phpBB* (http://www.phpbb.com) and *bbPress* (http://www.bbpress.org) are Web 2.0 applications enabling the exchange of opinions, focusing especially on the provision of an environment in which citizens can express their thoughts without paying much attention to the structure of the discussion. At the same time, there are tools enabling a more structured, and therefore more focused and effective consultation (Karacapilidis et al., 2009; Karacapilidis et al., 2004).

The abovementioned tools enable the massive and unconstrained collaboration of users engaged in discussions like the one sketched in the example given at the end of the previous section; however, the amount of information produced and exchanged (as well as the number of events generated) within these tools often exceeds by far the mental abilities of users to: (i) keep pace with the evolution of the collaboration in which they engage, and (ii) keep track of the outcome of past sessions. Current Web 2.0 collaboration tools exhibit two important shortcomings making them prone to the problems of information overload and cognitive complexity. First, Web 2.0 collaboration tools lack reasoning services, with which they could actively and meaningfully support a more productive collaboration. Second, these tools are "information islands", thus providing only limited support for interoperation, integration and synergy with third party tools. While some provide specialized APIs with which integration can be achieved, these are primarily aimed at developers and not end users.

Argumentation Support. As far as argumentation is concerned, various tools focusing on the sharing and exchange of arguments, diverse knowledge representation issues and visualization of argumentation have been developed. Tools such as *Araucaria* (http://araucaria.computing.dundee.ac.uk) and *Compendium* (http://compendium.open.ac.uk) allow users to create issues, take positions on these issues, and make pro and contra arguments. They can capture the key issues and ideas and create shared understanding in a knowledge team; in some cases, they can be used to gather a semantic group memory. In the example described in Section 3, such tools may facilitate the collection, structuring and visualization of alternative causes and solutions to the pollution problem (together with the propositions speaking in favour or against them). However, these argumentation support tools have the same problems with the Web 2.0 collaboration tools discussed above; they too are standalone applications, lacking support for interoperability and integration with other tools (e.g. with data mining services foraging the Web to discover interesting patterns or trends). They also cope poorly with voluminous and complex data as they provide only primitive reasoning services. This makes these tools also prone to the problem of information overload. Argumentation support services recently developed in the context of the *Dicode* project (Karacapilidis, 2014) address most of these issues through innovative virtual workspaces offering alternative visualization schemas that help stakeholders control the impact of voluminous and complex data, while also accommodating the outcomes of external web services, thus augmenting individual and collective sense-making.

In any case, argumentation support tools reveal additional shortcomings that prevent them from reaching a wider audience. In particular, their emphasis on providing fixed and prescribed ways of interaction within collaboration spaces make them difficult to use as they constrain the expressiveness of users, which in turn results in making these systems being used only in niche communities. Adopting the terminology used in the most common theoretical framework of situational awareness shaped by Endsley (1995), this category of tools only partially cover the needs of the three stages of situational awareness, namely *perception* (i.e. perceive the status, attributes, and dynamics of relevant elements in the setting under consideration), *comprehension* (i.e. perform a synthesis of disjointed elements of the previous stage through the processes of pattern recognition, interpretation, and evaluation), and *projection* (i.e. extrapolate information from previous stages to find out how it will affect future instances of the operational setting).

Social Media Monitoring. Social Media Monitoring and Analytics is an evolving marketing research field that refers to the tracking or crawling of various social media content as a way to determine the volume and sentiment of online conversation about a brand or topic (Bekkers et al., 2013). Their added value lies on the fact that such investigations can be performed at real time and in a highly scalable way. Well-known tools of this category include *Hootsuite* (https://hootsuite.com), *Trackur* (http://www.trackur.com), and *Sysomos* (https://sysomos.com). These tools can support the required "attention mediation" suggested by Klein and Convertino (2015), by providing a structured way to represent the "big picture". Disclosing the analytics and reports implies the provision of feedback to the involved population on how their input has been taken into account. In the example discussed in Section 3, a social media

monitoring tool may provide valuable feedback from the citizens affected by the pollution problem about the solutions being shaped.

Opinion Mining. Opinion mining tools employ natural language processing, machine learning, text analysis and computational linguistics to extract relevant information from the vast amounts of human textual communication over the Internet or from offline sources (Dhokrat et al., 2015). In fact, the propagation of opinionated textual data has caused the development of *Web Opinion Mining* (Taylor et al., 2013) as a new concept in Web Intelligence, which deals with the issue of extracting, analyzing and aggregating opinions from large quantities of textual data. The analysis of the sentiment of citizens' opinions, known as Sentiment Analysis, is significant for both the private and the public sector, because it allows determining how people feel about a product or service, or about a public issue under consideration. We can distinguish between two types of tools in this category; those that provide a framework for data mining algorithms (e.g. *Rapidminer* (https://rapidminer.com), *KNIME* (https://www.knime.org) and *WEKA* (http://www.cs.waikato.ac.nz/ml/weka)), and online platforms that can visualize opinion mining analytics on predefined Web 2.0 Sources (e.g. *sentiment viz* (https://www.csc2.ncsu.edu/faculty/healey/tweet_viz/tweet_app) and *Socialmention* (http://www.socialmention.com)). Opinion miming methods can be used in combination with the abovementioned engagement and collaboration tools as well as social media monitoring tools. In the example discussed at the end of Section 3, an opinion mining tool may systematically identify and extract affective states and subjective information about an alternative cause of (or solution to) the pollution problem, and reveal meaningful insights that may advance the related discussion.

Reputation Management. Reputation Management refers to the need to seek references for an individual or organization participating in social networks and communities regarding their intellection or influence (He et al., 2012). This need is partially addressed by existing online reputation management services, which monitor one's influence based on his/her activities in the social web, such as *Klout* (http://www.klout.com) and *Naymz* (http://www.naymz.com); or in the research domain measure one's scientific performance based on citation analysis, such as *Google Scholar* (http://scholar.google.com) and *Research Gate* (http://www.researchgate.net). Another stream of reputation management systems is using customer feedback to gain insight on suppliers and brands, or get early warning signals to reputation problems (e.g. eBay RMS). Current reputation assessment algorithms can assign a reputation score to individuals and enable the identification of experts. In any case, the identification of promising ideas and proposals from large corpuses demands contributors to be assessed against their expertise on specific topics related to the problem under investigation. By collecting data concerning the knowledge, credibility and expertise of individuals, reputation scores are calculated for each individual with respect to different thematic areas using a synthetic algorithm; based on these reputation scores, content generated by the most knowledgeable experts over the web can be shown first in users' searches, and this enables the identification of and the focus on the highest quality content that has been already generated in various electronic sources by experts ('passive expert-sourcing'; such an approach has been developed in the European project *EU-Community* (Androutsopoulou et al., 2016)). In the example sketched in Section 3, a reputation management tool may identify and assess the rhetorical and political power of stakeholders involved in the pollution problem under consideration.

Dynamic Simulation. Dynamic simulation environments (Agent-based, Discrete Event and System Dynamics) are used to model and simulate complex realities in various domains. In its conventional use, simulation allows for testing alternative solutions, as well as predicting and assessing the impact of prospective choices, reducing the associated uncertainty. In an abductive/retroductive mode, simulation modelling is used for representing and simulating underlying mechanisms/ hypotheses that are suspected to be responsible for phenomena observed (Papachristos and Adamides, 2016), or for testing the effectiveness of postulated unfounded solutions/innovations. In the example mentioned in Section 3, a system dynamics simulation model could be used to represent product, by-product and waste flows in an industrial district, and it could be used to test the hypothesis that the paint company is the main pollutant, as well as the hypothesis that waste can be treated and converted to energy source for the food processing company effectively. Well known examples of visual simulation environments include *ExtendSim* (https://www.extendsim.com/), *Vensim*

(http://www.vensim.com) and *Anylogic* (http://www.anylogic.com).

Decision Making Support. Data warehouses, online analytical processing, and data mining have been broadly recognized as technologies playing a prominent role in the development of current and future Decision Support Systems (Karacapilidis, 2006), in that they may aid users make better, faster and informed decisions. However, one critical point that is still missing is a holistic perspective on the issue of decision making. This originates out of the growing need to develop applications by following a more human-centric (and not problem-centric) view, in order to appropriately address the requirements of public sector stakeholders. Such requirements stem from the fact that decision making has also to be considered as a social process that principally involves human interaction (Smoliar, 2003). The structuring and management of this interaction requires the appropriate technological support and has to be explicitly embedded in the solutions offered for this purpose. The above requirements, together with the ones imposed by the way open innovation stakeholders work and collaborate today, delineate a set of challenges for further decision support technology development. Such challenges can be addressed by adopting a knowledge-based decision-making view, while also enabling the meaningful accommodation of the results of social knowledge mining processes (revealing the needs, perceptions, opinions of the general public). Knowledge management activities, such as open innovation related knowledge elicitation, representation and distribution influence the creation of the decision models to be adopted, thus enhancing the decision making process, while evaluation of contributions in the decision making process act as a reputation mechanism and provide incentives for engagement.

5 CONCLUSIONS

In this paper, we elaborated the concept of "active transparency" as a step for developing generative sensing through the implementation and deployment of computer-supported argumentation in a strategic Open Innovation setting. Aiming at developing an OI platform with a potential of providing sustainable competitive advantage, we reviewed the relationship between dynamic capabilities and strategic Open Innovation, we focused on active transparency stressing the important role that argumentation plays in the deployment of this capability, and we discussed the ICT solutions that enable active transparency and open innovation for providing competitive advantage.

In any case, we argue that the seamless interoperability and integration of these ICT solutions is a hard issue. An ideal OI platform should be able to loosely combine existing standalone tools and web services to provide an all-inclusive infrastructure for the effective and efficient support of diverse OI stakeholders. Such a solution will not only provide a working environment for hosting and indexing of OI-related services, and the required retrieval and meaningful analysis of large-scale data sets; it will also leverage existing technologies and social networking solutions to provide stakeholders with a simple and scalable solution for targeted collaboration, resource discovery and exploitation, in a way that facilitates and boosts OI activities (Adamides and Karacapilidis, 2018).

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