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## Regular article

## Complexity in project co-creation of knowledge for innovation

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## ABSTRACT

The European Union (EU) promotes collaboration across functions and borders in its funded innovation projects, which are seen as complex collaboration to co-create knowledge. This requires the engagement of multiple stakeholders throughout the duration of the project. To probe complexity in EU-funded innovation projects the research question is: How does complexity affect the co-creation of knowledge in innovation projects, according to project participants? The data for this study was collected from project experts in the form of short narratives, using a questionnaire based on the elements of complexity of Mitleton-Kelly (2003). The results indicate that complexity characterises the co-creation of knowledge in innovation projects in various ways. Most emphasis was put on the elements Self-organisation, Connectivity and interdependence, Co-evolution, and Creation of new order. Thus, although this study demonstrates that the elements of complexity can be used to gain insight into innovation projects, the results show that not all elements of complexity are equally important in this context and that they appear in a certain order. Moreover, understanding the complexity of collaboration for innovation in relation to the input-throughput-output model of organisational communication is a contribution to theory that may help future projects achieve faster innovation.

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### Introduction

The European Union (EU) promotes collaboration across functions and borders, and involving multiple authorities, academics, practitioners, and industry. The aim is to enhance innovation and thus, increase the competitive advantage of Europe (European Commission, 2016). For example, the Horizon 2020 program calls for European research and development initiatives that are expected to strengthen European collaboration for innovation (European Commission, 2019).

These EU-funded innovation projects can be seen as complex forms of cooperation aimed at the co-creation of knowledge, a process in which multiple stakeholders with diverse backgrounds participate (Ruoslahti, 2018). Aaltonen and Sanders (2005) note that complexity can be used as a framework of sense making. Systems emerge through interaction between its agents, the people, processes, technology, governance, etc. (Aaltonen & Sanders, 2005), however these emergent systems cannot be led by just one agent. This principle can be applied to innovation projects, which operate through collaboration “facilitating reciprocal learning and co-evolution between the partners” (Mitleton-Kelly, 2005, p. 38). In

projects, various partners try to make sense of challenges, including diverse input to co-create innovations. Diverse input can facilitate knowledge creation and innovation in complex problem-solving (Valkokari, Paasi, & Rantala, 2012).

EU-funded innovation projects often involve a high number of participants with very different backgrounds from industry, universities, governments, and civil society. They have, therefore, been characterized as complex. This may lead to a bureaucratic burden, but complexity can also be seen as a positive characteristic. Bassett-Jones (2005) for example, concludes that, diversity can enhance creativity and innovation, although when managed poorly, it can also be “a cause of misunderstanding, suspicion and conflict” (p. 169). Creativity, the source of new ideas and creative processes, “is a complex and diffuse construct”, write Alves, Marques, Saur, and Marques, 2007 (p. 28), and continue to note that “multidisciplinary and multisectoral networks can play important roles in members’ competitiveness” (p. 32), as diverse input helps facilitate innovation and complex problem-solving. Based on experiences of several EU-funded projects, this study aims to further

clarify how complexity affects the functioning of innovation projects and, in particular, time to innovation.

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## Innovation projects

This section looks at innovation networks, complex co-creation, innovation projects, and organisational communication in the context of EU-funded innovation.

### Multi-stakeholder projects

EU-funded innovation projects are multi-stakeholder projects. Franco and Pinho (2019) note that innovation needs research that creates technological advancements and new and improved products. These projects are required to include multiple actors representing e.g. end-user, industry, and academic organisations in their consortia (European Commission, 2019). When organisations come together, “there should be emphasis on post-merger relationships, and the development of an emergent culture to support the new organisational form” (Mitleton-Kelly, 2005, p. 39). Although her study focuses on mergers and acquisitions, the principle could be useful to apply also to forming project consortia. Thus, the innovation network stakeholders need to put enough emphasis on discussing what expectations they have for their relationships and the emergent culture during the innovation project. Projects may come with internal crises and, therefore, form a turbulent environment for several years in time, and “as many crises combine different kinds of threats, cooperation with other actors is needed for their mitigation” (Vos, 2017). Networks of relationships are sustained through communication, feedback, and inter-dependence. “When they meet a constraint they are able to explore the space of possibilities and find a different way of doing things, i.e. they are creative and innovative” (Mitleton-Kelly, 2005, p. 45).

Stakeholder management offers some systematic approaches to organise the relationship between organisations and the stakeholders involved (Roloff, 2008). Innovation projects can also be studied as systems; and systems cannot be understood by analysing their parts separately, write Aaltonen and Sanders (2005), their global features should be seen as a whole. Understanding knowledge co-creation is important, as innovation and creativity are sources of competitive advantage (Bagayogo, Lapointe, Ramaprasad, & Vedel, 2014). Organisations explore alternative ways of working toward their tasks (Mitleton-Kelly, 2005), and can identify opportunities for encounters that support the co-creation of value in business by mapping end-user processes and practices (Payne, Storbacka, & Frow, 2008).

Consequently, managing creative knowledge capital is about “providing the conditions and circumstances for creativity and innovativeness” (Wilenius, 2008, p. 66). To create new knowledge Nonaka and Takeuchi (1995) advocate dynamic interactions between stakeholders.

Multi-stakeholder networks are organisational structures, which allow collective innovation over organisational and national boundaries. Objectives and actions in multi-stakeholder networks become negotiated by the participants, as their participation is voluntary (Roloff, 2008).

Collaboration for co-creation of knowledge and innovation calls for a common problem, and ideally, also end-users are engaged to participate actively (Ruoslahti, 2018). The roles of the stakeholders may change over time. For example, end-users are often active in the beginning when project requirements are set, and they may also be involved in the development and testing of solutions. Managers predominantly see co-creation as a way to generate ideas for new products and services (Frow, Nenonen, Payne, & Storbacka, 2015). Organisations (e.g. projects) that aim at innovation benefit from networked environments that encourage and facilitate exploration of the space of possibilities

(Mitleton-Kelly, 2005, p. 50). To ensure open communication enabling co-creation of knowledge, an innovation network needs

to manage engaging its stakeholders throughout the project, and be aware that this takes both time and effort.

### Complexity of funded projects

Innovation projects are networks that aim at co-creative collaboration. They need facilitation and cooperation tools. When network stakeholders agree on common aims which also permit each stakeholder to reach individual goals, they are already co-creating. These common aims promote active stakeholder participation. This helps co-create knowledge and innovation. In turn, and collaboration is strengthened by bonds of trust within the value network (Ruoslahti, 2018).

Open innovation is based on voluntary collaboration and is, thus, self-organising (Leminen, Westerlund, & Nyström, 2012). EU-funded project consortia include collaboration between different types of partners: businesses, public authorities, universities, and end-users (Valkokari et al., 2012). While co-creation results from complex interactions between the various network actors, and even resource integration (Pinho, Beirão, Patrício, & Fisk, 2014), communication becomes co-constructed by multiple stakeholders, who have different interests and often many interdependencies (Vos, 2017). As knowledge co-creation is a main source of innovation and creativity in organisations (Bagayogo et al., 2014), co-creation to develop innovation can be promoted by organisational cultures that favour innovativeness and participation of end-users (Santos-Vijande, González-Mieres, & López-Sánchez, 2013). Responding to and influencing emerging events allows an organisation to influence its future (Aaltonen & Sanders, 2005), while Pirinen (2015) notes that knowledge is important for the competitive advantage of modern organisations. Knowledge strengthens the collective expertise needed in today's competitive global economy.

Criteria for innovation projects by the European Commission include the involvement if user communities, evidence of reduced time or costs to meet innovation purposes, and intensity of technology and information exchanges. Understanding the different ways of working and the motivation of the different partners is needed to understand collaboration between multiple actors in innovation networks (Valkokari et al., 2012). According to Mitleton-Kelly (2005) distributed leadership means that every participant feels responsibility to explore possibilities and take initiatives that fit the overall strategic direction. According to Aaltonen and Sanders (2005), in the currently fast changing environments organisations must understand their history and make sense of both future developments and how to influence these. Organisations make use of knowledge to anticipate future needs (Wilenius, 2008) and, similarly, innovation projects could act in a future-oriented way.

According to Poutanen, Siira, and Aula (2016) communication theories and complexity theory have common roots. Communication can be considered a central means to coordinate organisational activities, to achieve organisational goals, and support a process of organizing. Innovation projects as human systems are self-organising entities. This begins already at the project idea and proposal phases. People exchange ideas, ways of working and relating. Projects, as human systems, can co-evolve and co-create something that could possibly not have been predicted at the outset (Mitleton-Kelly, 2005).

Poutanen et al. (2016) find that many of the complexity-based studies that they examined, emphasize communication as information exchange that supports knowledge creation by networks of actors. Co-creative social interaction and knowledge sharing raise the need for new competencies for those experts and professionals sharing competences in networks (Pirinen, 2015). End-users should be active participants in value co-creation when designing products or services (Allen, Bailetti, & Tanev, 2009). The processes to build knowledge and innovation are “increasingly complex, multidisci-

plinary, trust-based, co-created, path-depended, and globalized” (Pirinen, 2015, p. 323). Co-creation of knowledge calls for group dynamics in collaboration. Understanding this is “of particular importance in this age where innovation and creativity have become a source of competitive advantage” (Bagayogo et al., 2014, p. 632). This also relates to having a clear purpose, roles and common ways of working in the project. Building trust among the stakeholders, with leadership, facilitation, and a back-up system for representatives enhance an open flow of communication (Rajamäki & Ruoslahti, 2018).

Project organisations need to be resilient for continuity also in case of disturbances (Rajamäki & Ruoslahti, 2018). Similar to a resilient organisation, the project organisation needs the ability “to accommodate several heterogeneous cultures, provided that there is overall coherence that provides unity of purpose and/or values” (Mitleton-Kelly, 2005, p. 47). Polyphony and diversity in organisations are highlighted in the complexity perspective. Continuous balancing of opposing tendencies and preservation of diversity require skills, write Poutanen et al. (2016). Mitleton-Kelly (2005) brings up the notion of co-evolutionary integration to explain that where organisations cooperate the new organisation inherits characteristics from each constituting entity. In innovation projects multiple stakeholders together try to make sense of challenges in business and society, sharing experiences to bring about innovations. These projects can be seen as complex evolving systems, a concept used by Mitleton-Kelly (2003) to describe organisations characterized by various elements of complexity including, for example, the level of interconnectedness of the parts of the system. Altogether, she mentions ten elements of complexity, discussed also by Aaltonen and Sanders (2005).

In this paper, the elements of complexity by Mitleton-Kelly (2003) are used to make sense of the complexity of innovation projects, where partners come together (*Connectivity and interdependence*), to agree on roles, goals, and ways of working (*Self-organisation*). All project partners bring their individual and common histories into the collaboration (*Historicity*), and together they explore possibilities to reach innovative results and create new knowledge (*Exploration-of-the-Space-of-Possibilities*). The project consortium makes decisions on which path to take, presented in the project proposal and further plans (*Path dependence*). Interaction is used to re-focus the project plans (*Feedback*), as the project will encounter changes, both, in its environment and among the partners (*Far-from-equilibrium*). The project partners continue working together and influencing each other (*Co-evolution*) and, consequently, new innovations can emerge from the workflow among the consortium partners (*Emergence*), while the knowledge gained is disseminated and new collaborative structures are created (*Creation of new order*). In this study the focus is on innovation projects with EU-funding.

#### Projects create knowledge for innovation

Research and development collaborations ultimately aim at creating knowledge (Matt, Robin, & Wolff, 2012). “Innovation is as an idea, practice, behaviour, or artefact that is perceived as being new by the adopting unit” (Eservel, 2014, 806). It is a competitive advantage (Bagayogo et al., 2014) that is increasingly important for researchers and practitioners (Eservel, 2014), as the EU calls for Europe-wide innovation by its current Horizon 2020 funding programme (European Commission, 2019). New opportunities for change are constantly emerging (Aaltonen & Sanders, 2005) for organisations and projects alike. “In turbulent, surprising, continuously evolving marketplace environments only flexible, agile, and relentlessly dynamic organisations will thrive” (Lengnick-Hall, Beck, & Lengnick-Hall, 2011, p. 243), as risks in network collabora-

tion cannot be avoided, only reduced. (Vos, 2017), while knowledge creation processes can be significantly impacted by disseminating knowledge through collaboration (Abubakar, Elrehail, Alatailat, & Elc, 2017).

EU-funded projects are co-creation networks formed by research and development consortia, and knowledge management in networked innovation calls for a strategic approach (Valkokari et al., 2012). However, “EU-funded projects are likely to involve a higher bureaucratic burden than spontaneous collaborations” (Matt et al., 2012, p. 900). Organisational innovativeness is supported by co-creation with customers (Luoma-aho et al., 2012), and, when developing services and processes networking is considered especially important (Tikanmäki, Tuohimaa, & Ruoslahti, 2012), as in co-creation “designers and users engage in mutual enabling roles” (Kummitha, 2019, p. 108). Similarly, in EU-projects the role of end-users is emphasised. Thus, ensuring that the consortium project fulfils end-user needs calls for active on-going end-user communication, co-creating products and services with end-users (Miettinen & Koivisto, 2009).

Major problems occur when organisations are put together, ignoring the diversity of people and cultures, for example, by a lack of communication with stakeholders, unclear roles and, responsibilities (Mitleton-Kelly, 2005). As diversity is also, according to Bassett-Jones (2005), “a recognizable source of creativity and innovation that can provide a basis for competitive advantage”, such issues need to be taken into account when creating innovation projects. To increase the impact of the project commitment and active participation, already in the early stage of the project implementation, by partners and end-users are key (Henriksson, Harri, & Hyttinen, 2018). EU-funded innovation projects bring together organisations and professionals who usually do not work together. In this way, they are according to Norvanto (2017), p. 78) a unique form of a knowledge community enabling the participants “to enter completely new domains while expanding their social networks and learning new practices”. Pirinen (2015) says that shared expertise is created, taking the form of a “body of knowledge in action” (p. 327).

Co-creating innovation requires dialogue for active learning processes in which the actors mutually affect each other (Santos-Vijande et al., 2013). Collaboration in EU-funded innovation projects may add to the competencies of organisations (Matt et al., 2012). Ruoslahti and Tikanmäki (2017) note a connection between the elements of complexity (Mitleton-Kelly, 2003) and the time that it takes to achieve co-created innovation: “Added complexity may greatly reduce the time to value creation and innovation” (p. 267). This may be a crucial success factor in funded innovation projects, as they have pre-determined periods in, which to achieve their results.

Vos and Schoemaker (2004) offer a process model that divides organisational communication into three phases: input, throughput and output. In the context of innovation projects, Input communication, for example, helps involve end-users to set requirements, Throughput communication facilitates close collaboration and knowledge co-creation for innovation, whereas Output communication includes disseminating project results to external stakeholders and user communities. Vos and Schoemaker (2004) note that communication contributes to value creation in an organisational context in ways, where these phases are not linear steps but rather cyclically interrelated activities in often chaotic environments. Distinguishing between these three types of communication phases can help understand collaboration within innovation projects. Most EU-funded projects can be understood as co-creation projects benefiting innovation networks, and as such are relatively complex and can be more or less diverse (Ruoslahti, 2018).



## Method

Based on experiences of several EU-funded projects, this study aims to further clarify what complexity means for innovation in EU-funded projects. Consequently, the research question of this study is: How does complexity affect the co-creation of knowledge in innovation projects, according to project participants?

The research focused on recent EU-funded innovation projects in the security area. The six projects that served as the context of this study are:

- 1 Airborne Information for Emergency Situation Awareness, AIR-BEAM, 2012–2015.
- 2 Automated Border Control Gates for Europe, ABC4EU, 2014–2018.
- 3 European Test Bed for the Maritime Common Information Sharing, EUCISE2020, 2014–2019.
- 4 Improving the Effectiveness of Capabilities in EU Conflict Prevention, IECEU, 2015–2018.
- 5 Gaming for Achieving Peace, GAP, 2016–2019.
- 6 Maritime Integrated Surveillance Awareness, MARISA, 2017–2019.

The data for this study was collected by expert consultation, as such a qualitative approach can provide richness and depth (Poutanen et al., 2016). Nine experts were selected, who all agreed to participate in this study. All had extensive project experience, including being work package and task coordinator in one or more of the EU-funded projects that provided the context for this study and are listed above. All project consortia consisted of various partners. The project experts were approached with direct requests to participate as respondents in this study. Eight respondents agreed to write short narratives while one of the experts preferred to be interviewed instead. In the latter case the researcher reported the answers in a similar way.

Informed consent was collected from each participant to meet with the principles of research ethics. To ensure the anonymity of the respondents, their comments are presented in a way that they cannot be attributed to or be interconnected for a particular respondent, not to reveal their identity and affiliation. The respondents were provided with a questionnaire consisting of 11 open questions. For each question they were asked to write a short narrative on their views related to the EU-funded innovation project they were part of. The questions were based on the ten elements of complexity by Mitleton-Kelly (2003).

The data was collected during the spring of 2019. The narratives were nicely on point, per question up to 230 words in length, and provided the insight to address the research questions. A first reading of the material showed that satisfaction level was reached. Next, the material was read again to arrange for analysis it in a Data Extraction Table (DET). This was an Excel sheet, where the rows were formed by the respondents and the columns addressed the elements of complexity as explained in section 2.2. The units of analysis were phenomena of cooperation that were identified from the narratives data. The analysis focused on identifying those phenomena that occurred more often in the data, marking citations that clearly illustrated what the elements of complexity meant in the context of innovation projects.

## Results

The structure of this Results section follows the elements of complexity (Mitleton-Kelly, 2003; Aaltonen & Sanders, 2005), including Connectivity and interdependence, Self-organisation, Historicity, Exploration-of-the-space-of-possibilities, Path depen-

dence, Feedback, Far-from-equilibrium, Co- evolution, Emergence, and Creation of new order. For each element, a short description is given based on the author's explanation but in this case applied to innovation projects, after which the findings are presented.

### *Connectivity & interdependence*

One of the elements of complexity concerns interrelations, in this case, among the project participants. The respondents stress that in order to create innovation value, project participants need to collaborate closely in the project to deliver output through joint activities for the planned work packages and tasks. Thus, partners share and combine their different areas of expertise when solving real case problems.

Project participants stimulate each other toward broader views. When working in parallel, partners depend on each other and their work is affected if they have to wait for results by others. The respondents, however, also note that some innovation project partners may compete within these projects. This may serve to blur the overall innovation goal, and even prevent the consortium proceeding towards it. Thus, some respondents noted that reaching innovations becomes difficult if the consortium includes companies that are direct competitors in the market, as they are unwilling to openly share with one another.

The respondents strongly feel that partners in innovation projects are connected and interdependent. One's performance has a direct effect on the ability of others to perform their tasks, as project output is compiled by combining the work of all consortium participants. Thus, the project performance of one partner may positively, but also negatively, influence other partners.

### *Self-organisation*

Self-organisation relates to spontaneous order. The results show that expert project partners are often intrinsically motivated to conduct well in the project, and by doing so also bring expected – and sometimes unexpected – results. “Well planned is almost done”, notes one respondent. A project can gain high-level results, when the project proposal is well planned in advance. In addition, partner motivation and expertise are important in gaining good results. Workshops, seminars, and questionnaires are proven ways of working together to identify how to solve issues, note the respondents. It shows self-organisation when partners come together to address issues at hand.

The project consortium has freedom in organising project work packages, tasks, and activities. When these are well described in the project proposal, the consortium has a better chance to deliver what has been agreed, once the project becomes funded. Respondents note that the level of self- organisation varies from project to project. One respondent commented that most projects have been “really well organized”. However, also, some have been organised poorly, one comment, for example notes that participant commitment may greatly differ: “Having worked in many international projects, there is the tendency that some partners in consortia can follow the general idea and plan quite well, then there are partners who need constant reminding of their duties, and there are partners who ignore any kind of reminding”.

The results emphasise that project work cannot be left to a few active partners, but that active collaboration is needed by all consortium partners to achieve optimal levels of self-organisation within project consortia. The ability for self-organisation thus, differs from consortium to consortium. It was noted that normally, a core group will develop the main idea and goals, and then also drive the work for innovation. Furthermore, “the coordinator is in

a very crucial position”, as one respondent wrote, and the funder may have strict guidance.

### *Historicity*

Complexity also relates to the different histories of the project consortium partners and other related stakeholders involved. Moreover, each individual involved brings one's own professional and educational background to the project while interacting with others. The respondents, thus, point out that these individual and organisational histories influence project consortia in many ways. On the one hand, partners who share a positive history often work well together, which may then cause that “some partners might feel left out”, as stated by a respondent. On the other hand, the fact that some partners have a bad shared history can exert a negative influence on the project as a whole. A related point of view brought up by a respondent was, that when partners do not know each other's histories, the lack of established reputations may lead to “unnecessary highlighting of what partners have done in the past”.

Respondents note that it is beneficial to include partners who know each other and have common experiences of earlier project work, but not to exclude partners who bring other beneficial knowledge and experience to the project consortium. Cultural backgrounds also influence the way in which partners work together, as this influences ways of working and communicating.

According to the respondents, motivated expert consortium partners help deliver the best results. However, expertise usually is needed in many different fields and, thus, all project partners are expected to bring in their specific expertise. Partnerships are then continued, in consequent projects, with those who are seen to be the most motivated experts. As stated by a respondent: “A member that has managed well in a previous project is a desired partner for new projects”.

### *Exploration-of-the-space-of-possibilities*

The space of possibilities relates to flexibility of working and, thus, space to find different solutions. A project's ability to explore the space of possibilities depends, as one respondent notes, on “the time available, meaning the extent of funding and people in the project”. The productivity and success of any project consortium are based on its people, their attitudes, and on how they approach the project work. One problem that was addressed by a respondent is, that after the proposal has been submitted and accepted, there “is little possibility to change the content of work packages”.

Project proposals are often made years in advance and require a high level of detail. Work in projects is expected to follow the planning upon which the decision to allocate funding was based. Adaptations have to be communicated or even negotiated with the funder, which may hinder the exploration of possibilities.

The respondents acknowledge that exploring possibilities must already be addressed during the project preparation phase, so it depends heavily on project planning and how it is documented. One respondent notes, about addressing a specific issue: “if this is embedded to the project then the result will be achieved at least in some level”. The funding instrument also affects the ability of a project to explore the space of possibilities. However, it was noted that an innovative group can, also during the project, think flexibly to find ways to arrange the content and events of the project.

### *Path dependence*

Path dependence concerns new opportunities being influenced by prior decisions. This path dependence is also visible in innovation projects. Filling niches that create new niches and opportunities are best achieved “via continuum of innovation pro-

jects”, as one respondent said. How project partners work and cooperate, their nationalities, and prior backgrounds impact the project's ability to identify opportunities. Results indicate that filling niches can create paths toward new opportunities. One respondent noted that: “All of the projects I have been involved in over last two years have created new opportunities – some of them are already implemented”, and another that “new partnerships are always built in consortiums.”

According to the respondents, partners often perform at different levels, which is also demonstrated in the relations between them. Some partners are active with their project tasks and their responsibilities, duly reacting to communication from work package and task coordinators. On the other hand, some partners perform slowly, only when reminded. Such partners who do not conform to the general flow of work disrupt the common working spirit: “Then there are partners who really annoy the rest of partners because they do not even pretend to be working”, according to a respondent. The level of activity will affect future project opportunities.

### *Feedback*

Feedback is a way to identify what changes should be made to how a project is conducted. In most cases, feedback was looked at in a positive way, and considered even “crucial”, as one respondent saw it, positive feedback “gives joy and builds trust”, while critique should be given “in a way that is no too harsh”.

When there are more partners, feedback can however, become a difficult issue. Some comments show that the role and effects of feedback can be twofold: “I have not experienced any ‘artificial’ need-to-be feedback in the recent projects” quoted one respondent, while another quote on the effects of feedback states: “Actually the role is big but the effects have been zero”, and a third wrote that: “Constructive feedback of end users help the development and innovation project”.

Results show that on-going analysis of project results are needed to engage expert partners and core stakeholders. Feedback whom e.g. the Commission of the European Union, stakeholders, coordinator, industry, and others is essential to an innovation project. However, project feedback processes are often seen as being too slow. Therefore, projects need to focus enough on collecting and responding to feedback, which is seen as a main way to engage partners and accomplish when needed a re-focus in project tasks.

### *Far-from-equilibrium*

In fast changing or extreme situations projects will need to make major adaptations. Even though carefully planned project proposals set the goals and direction for EU-funded innovation projects, they are often far from a state of equilibrium. As one of the respondents says: “Good projects follow the outside world continuously”. Even daily politics can affect a project. For example, changes in global politics can set back a lot of work, which happened in a regionally funded innovation project with Russian partners who could not proceed their work in the project, when Russia was sanctioned.

The many partners that act in parallel influence each other during an innovation project. Moreover, the project coordinator has a definite effect on how the consortium performs. If the project coordinator is weak, it is difficult to find consensus which can be problematic, according to a respondent, especially if the preparation phase involves too many partners to be effective. This would require coordination intervention. Some respondents experienced that a small core team can best plan the project proposal, making a project idea into a project proposal.

### Co-evolution

Co-evolution of partners is seen in partners finding mutual ways of working together, having positive relationships where they trust and appreciate each other to generate good results and new ideas. It was noted that disseminating project results can be challenging, despite advances in social media and other mediums of communication.

“When a project comes to an end, core members create a new project”, notes one respondent. Thus, a project continuum that builds on the success and results of earlier projects become possible. These partners co-evolve together, which promotes the emergence of new ideas and innovations.

The results indicate that projects identify new problems, find new important research questions, and even evolve to form new projects or even businesses. As, discussed earlier, the time available, the histories, attitudes and expertise of partners, and role of the coordinator are issues that can promote success or failure. Thus, it is important that project partners find ways to build trust and collaborative ways of working together toward the innovations promised in the project proposal.

### Emergence

The respondents view that new results in innovation projects emergence from a good workflow among active consortium partners. One project example was quoted, where they were able to create an analysis to crosscheck project results with the existing operational capabilities and legislation.

Many that influence each other can at times cause confusion and at other times develop something totally new.

When all consortium members have clear tasks, parallel work can considerably shorten the time needed for innovation. However, it was also noted that a very high number of partners in the consortium, may make it longer to reach innovations. Project consortia were perceived to undertake project activities quite well. Common ways of working strengthen trust between the actors, noted one respondent, and new persons bring new insights to projects.

End-user experiences are seen as especially important to project results, as is utilizing the extended networks that consortium partners each have of their own. Innovation partly depends on how active and how much partners want to share information, and how open they are to input from within and outside the consortium. Means for this may be e.g. public events, webinars, social media campaigns, communications and disseminations for large audiences.

In most projects, next to solving problems, one desired result is also to find new problems to further solve. One respondent even notes that university partners could help companies also in other innovation processes than the project.

### Creation of new order

Innovation projects aim at creating impact useful outside the project and thus, need input from outside the group of project partners involved. A consortium is influenced by the information that flows into the project consortium from the external environment. Information that is related to the ongoing project and its tasks is likely to influence project work, depending on the type of information and how it is related. In addition, it is crucial who are the project people that first receive the information and if they actively use it or pass it on.

Seminars, workshops, questionnaires, interviews, and conferences on project issues and its goals are, according to the respondents, useful ways of creating new order innovation. Thus, dissemination of project results aims to affect technologies and

processes by taking project recommendations into wider use. Therefore, new ways of disseminating project results, such as during the project creating and expanding end user communities, and organising intensive and digital workshops with them, have been utilized in the projects.

The respondents remind that many currently active pan-European networks and associations have been created in the course of funded projects. In addition, new businesses have been created based on project innovations. These examples demonstrate how EU-funded projects are intended to provide not only results in the form of new knowledge but also new order innovations.

Diverse enough input is needed for out of the box thinking and to push boundaries. Linking different sectors to solve very complex problems can help shorten the time needed to reach solutions and shorten time-to-innovation, which refers to the time from when the consortium partners come together to when the innovations resulting from the project are put to wider use. The respondents suggest that multi-stakeholder innovation projects can shorten the time needed to reach to innovations when multiple partners add insights, working closely together to generate new knowledge. Working together, face-to-face, in intensive workshops helps generate innovations, while working at a distance does not seem to provide the same results in the same time. One respondent said that “partners who work together generate new knowledge in addition to finished project tasks”. Partners may also come up with new project ideas to pursue.

The ability for projects to create new ways of organising, working and thinking, depends on the organisations, groups and individuals involved. “If the people have the drive, the flow, and can get

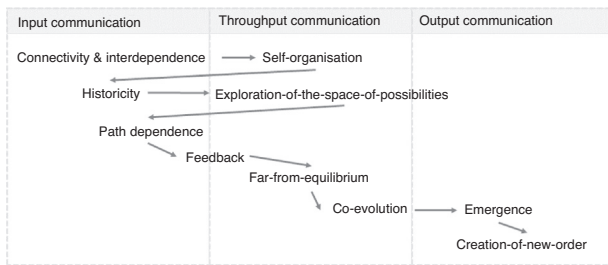
other people into this flow, the results have been great concerning the new organising, working and thinking”, comments one respondent. The partners involved explore new opportunities, for which the respondents promote using co-creative methods, collaboration technologies, shared documents, and feedback systems to ensure smooth collaboration towards solutions. Turbulent environments call for such dissipative structures and commitment to faster create innovations and new order.

### Discussion and conclusions

The views of project participants demonstrate how complexity characterizes co-creation of knowledge in innovation projects. The results show that all ten elements are visible but some more than others. Respondents clearly elaborated on the practical issue of how project partners work together, emphasising the element of *Self-organisation* as problems in this area directly affect everyone working in the project. There is a clear awareness of strong interrelations and a need for collaboration among project consortium partners, which concerns the elements of *Connectivity and interdependence* and *Co-evolution*. Moreover, projects have limited periods. For a project to be deemed successful, new knowledge and innovations must be reached fast. Similarly, new insights need to be disseminated timely to new groups of users and shared with wider audiences involved.

Time-to-innovation is emphasised by the respondents, which relates to *Creation of new order*.

This study showed that the elements of complexity by Mitleton-Kelly (2003) can be used to gain understanding of communication and collaboration in innovation projects, and that some elements of complexity may be more important than others. How many and which elements of complexity dominate may be different for the various types of innovation projects, and more research on this is recommended. As there is yet little empirical evidence on organisational communication in the literature on complexity



**Fig. 1.** Elements of complexity in relation to input, throughput and output communication in innovation projects.

(e.g. Poutanen et al., 2016), this study contributes some empirical evidence on organisational communication to the literature on complexity.

The results demonstrate that complexity in innovation projects is often experienced as challenging. The high level of *Connectivity and interdependence* characterizes the innovation projects, and this may form a burden when some partners are not willing to share information, for example, because of being competitors in the market. However, complexity can also be seen as a positive characteristic, when considering *Creation of new order*, as time-to-innovation can be faster if projects that aim at solving complex problems draw on multiple stakeholders that provide different types of input. This supports the way in which the EU promotes diversity in the project consortia that get funding for their project proposals, but also puts pressure on the consortia to select diverse partners that yet work well together.

Moreover, the results indicate that these ten elements, in the context of projects, show a certain order of appearance. *Creation-of-new-order*, for example, does not come first but rather appears among the last of these elements, etc. Project partners first come together and in close collaboration share their combined areas of expertise (*Connectivity & interdependence*) and are engaged in active collaboration to address issues (*Self-organisation*). These expert partners each bring their organisational and personal backgrounds, and experiences of good prior collaboration, into the project (*Historicity*) to find different solutions and explore opportunities (*Exploration-of-the-space-of-possibilities*), while co-creating a project plan or proposal. Choices made together (*Path dependence*) and feedback (*Feedback*) influence what adaptations are made to the work and which direction that project takes (*Far-from-equilibrium*), as well as how well the project partners work together and how much they trust each other (*Co-evolution*) to provide project results, new knowledge and innovation (*Emergence*) to create a meaningful impact that lasts even beyond the project life-cycle (*Creation-of-new-order*). This flow of relationships between the ten elements of complexity is visible below in Fig. 1.

The above Fig. 1 also shows how the flow of the elements of complexity, as mentioned by Mitleton-Kelly (2003) but now shown in the context of innovation projects, can be related to the earlier discussed input-throughput-output model of organisational communication (Vos & Schoemaker, 2004). The project partners are seen to first interact through two cycles of input-throughput communication, before focusing on throughput, and lastly moving towards output communication. This helps understand how the cyclicity of the communication activities and the order of the elements of complexity combine in the context of funded projects. This notion can form a basis for further research to clarify the process, and as such, is the main theoretical contribution of this study.

This approach can also provide a sort of guide map of facilitation (as suggested by e.g. Mitleton-Kelly, 2005; Valkokari et al., 2012) for co-creation processes and, thus, serve as a useful framework for innovation project practitioners (e.g. Norvanto, 2017; Pirinen,

2015) to focus on during the different stages of the project life-cycle, helping future projects achieve faster innovation.. Understanding the complexity of collaboration for innovation and the challenges posed by this collaboration can help future projects to function better and gain added flexibility to face the unexpected. The added knowledge may also benefit the EU when evaluating its funding models.

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