HOW DOES A PROJECT-BASED ORGANIZATION AFFECT THE SMART FACTORY'S DEVELOPMENT? ACHIEVING "SMARTNESS" THROUGH A "FLUID MOSAIC" ORGANIZATION

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Abstract

Recently governments promoted the development of the smart factory paradigm in several ways, i.e. by supporting collaborations between universities and firms throughout the development of ad hoc organizations. Our research focuses on three projects-based organizations involved in a governmental plan in order to answer this research question: how research and industry coordinate in a temporary project-based organization? What kinds of project-based organization can better stimulate collaboration and innovation among research and industry towards the effective smart factory's development? Data have been collected from multiple sources: documents, interviews and participant observation. First results shows that when coordination is strongly based on hierarchy, it is hard to transfer knowledge, making tricky the innovation development. Instead, when coordination is based on mutual adjustments between partners, the information flow is natural, as well as the knowledge transfer, leading to more flowing processes. However, all these mechanisms are strictly linked and depend also on the cognitive distance between the partners. Particularly, when the distance is low, the leadership style is democratic and coordination is firstly based on mutual adjustment and then standardization, the resulting smart organization takes the form of what we call a "fluid mosaic" drawing on the fluid mosaic concept developed in biology.

Keywords: project-based organization, fluid mosaic, smart factory, cognitive distance, smart organizing

1 Introduction

Biologists refer to a "fluid mosaic model" when the organization of cells and membranes is not solid or fixed but elastic and adaptable to changing needs (Singer and Nicolson, 1972). In this contribution we argue that fluid mosaic organizations are in the need when it comes to develop innovation in a smart environment. Indeed we propose the fluid mosaic organization as a way of smart organizing.
Framed within the Fourth Industrial Revolution, the smart factory is related to an emerging industrial paradigm where extant literature talks about a revolution because there is not a single revolutionary enabling technology but rather a set of enabling technologies coming together thanks to the Internet of things in a systemic way. In the smart factory, all the production phases are connected and influenced by the information collected, accumulated and communicated throughout the design, the assembly line up to the post-sale, thus leading to a continuous collection of information. According to Almada-Lobo (2015), the smart factory concept bases on the Cyber-Physical Systems concept (a fusion of the physical and virtual worlds), the Internet of Things and the Internet of Services.
However, as suggested by Pisano et al. (2017), developments in the smart factory production system have tended to be characterised by bottom-up approaches where single companies looked for answers

to specific production problems, leading to solutions which are difficult for other firms to replicate. This means that at the beginning there was a lack of top-down, systemic initiatives for facilitating a large scale redesign of the sector in order to make a relevant contribution to the creation of value for all those involved. In the attempt to solve this problem, in recent years, governments promoted the development of this paradigm in several ways, i.e. by supporting collaborations between universities and firms throughout the development of project-based organizations. Nevertheless, cooperation among different actors is not an easy task, and for these reasons the project-based organization could obstacle the purpose of the project itself and limit the innovation process (Gann, 2000). Furthermore, the systems integration - a firm's capability to combine different knowledges and physical components into functioning systems - is fundamental for developing innovation in complex production systems and has relevant implications for project-based organizing (Davies et al., 2011).
To our knowledge, while the main contributions from the scholars underline the importance of new technology and their intrinsic characteristics in the paradigm of smart manufacturing, scarce relevance has been attributed to the organizational factors, that is instead the focus of this contribution. Our research focuses on a plan promoted by a regional government in Italy. The plan involved eight projects-based organizations, and this contribution presents three of them. The aim is to answer the following research question: *how universities, research centres and industry partners coordinate in a temporary project-based organization? What kinds of project-based organization can better stimulate collaboration and innovation among research and industry towards the effective smart factory's development?*
First empirical results suggest that elastic and fluid organizations may better support the process of innovation by fostering smartness. This research sheds light on the industry-university collaboration and related efforts of achieving innovation in an increasingly dynamic smart environment. Through the "fluid mosaic" concept, it finally presents an ideal type of smart organizing for better supporting that collaboration.
The remainder of the paper is structured as follows. Section 2 highlights the theoretical background concerning project-based organizations (PBOs). Section 3 provides the details of the methodology. Section 4 illustrates the findings, while Section 5 discusses the results and some implications for policy and organizational design. Section 6 ends the paper with conclusions and limitations drawn.

2 Literature review

2.1 The project-based organization

One of the most profound changes of the last decade in organizations is the flattening of vertical bureaucracies in favor of teams and team-based arrangements and network organization (e.g., Daft and Lewin, 1993; Child and Rodrigues, 2003). In this vein, the project-based organization could either establish inside a single organization or among multi-organization consortiums or networks (Hobday, 2008). An organization can be defined as project-based when "the project is the primary business mechanism for coordinating […] the main business functions [with] no formal functional coordination across project lines" (Hobday, 2000: 874). Temporality is an essential feature of these kinds of organizations (De Fillippi and Arthur, 1998).
Network organizations and flexible project-based organizations (PBOs) are proposed to be ideal for managing technological uncertainty and technology change for more than one reason (Hobday, 2000). First, since PBOs are short-lived phenomena, they promote organizational change and innovation. Second, PBOs do not need uses of irreversible resources commitments of fixed cost, and public actors could finance them. For these reasons companies, universities and other stakeholders may promote a variety of initiatives, and may end unsuccessfully without paying too much disturbance and cost (Sydow et al., 2004). Third, a highly autonomous multifunctional or multidisciplinary team should be a favorable environment for innovation and may generate new knowledge (*ibidem*).
However, scholars suggest also that a PBO could obstacle the purpose of the project itself and limit the innovative potential (Gann, 2000). Indeed, as pointed out by Boschma (2005), innovative processes

can be hindered by excessive proximity or distance of the actors involved in this type of organization. Accordingly, excessive proximity can generate blocking effects because it creates a lack in the variety of resources available to the organization. At the same time, excessive distance risks to create trust problems, with consequent difficulties in sharing work practices and procedures. According to the author, proximity (or relative distance) can be expressed as follows:

- Cognitive distance/proximity, that relates to the different knowledge held by the actors involved.
- Geographic distance/proximity, with respect to the spatial distance between the actors.
- Organizational distance/proximity, that relates to the different solutions prepared for cooperation between one or more organizations.
- Social distance/proximity, with respect to ties and interpersonal relationships.
- Institutional distance/proximity, that refers to the institutions in charge of defining procedures and rules to be followed.

The problem of distance and proximity rises dramatically when universities are involved in a PBO along with firms. Indeed, many difficulties arise when universities and companies collaborate in developing innovation and knowledge transferring, particularly when such a collaboration involves generalist universities and their humanistic departments (Corazza, Truant, and Tirabeni, 2019). As Zucker (2007) suggests, scientific knowledge does not flow smoothly between subjects nor can be transferred. Knowledge is a social fact, the result of the interaction of individuals located in sometimes distant organizational fields, and influenced by both the characteristics of the agents who take part in the exchange and the organizational culture in which they are rooted (Polany, 1966 cited in Gherardini and Nucciotti, 2017). There is, therefore, a social filter which prevents the direct transfer of knowledge between universities and firms. These social filters affect the process of innovation (Gherardini and Nucciotti, 2017). Other research underlines the so-called boundary object's dilemmas (Sapsed and Salter, 2004). Boundary objects have been applied as management tools for supporting the diffusion of knowledge among different groups. However the authors suggest that in a PBO with geographical distance and scarce face to face interactions the boundary object may become a tool for negotiating power relations which could facilitate or obstacle the process of innovation.

Further, fixed and pre-existent organizational structures influence the process of innovation and knowledge transfer, as well as governance and coordination mechanisms while project-based organizational structures – that are agile and changeable by definition - may facilitate knowledge creation while at the same time hinder knowledge transfer without suitable governance mechanisms. As many scholars underlined (Grandori, 2001; Nickerson and Zenger, 2004), project-based structures should be aligned with proper coordination mechanisms to maximize the benefits of knowledge processes. Since this kind of organization may assume different forms of informal organizations - from flatter/a-hierarchical to more centralized and hierarchic ones - and different leadership styles – from bureaucratic to more democratic ones - it could be very relevant to explore what specific coordination mechanisms of project-based organizing could foster innovation and collaboration.

From many different points of view, the smart factory is still a new topic, particularly when it comes to investigate the organizational features (Tirabeni, 2019) and related factors enabling innovation. To our knowledge, there are still no studies focusing on how and what specific types of coordination in PBOs may positively affect innovation processes and collaborations between universities, research centers and enterprises in a smart factory environment. Our research seeks precisely to fill this gap as it investigates the different forms a PBO may assume when developing smart factories' projects. It analyzes the most effective coordination mechanisms for designing and supporting innovation in the smart factory depending on the cognitive distance between the partners involved in the project.

3 Methodology

This paper focuses on an Italian regional plan aimed at developing smart factory's initiatives through *ad hoc* collaborations between universities, private and public research centers, SMEs and big companies. Our research adopts a mixed method approach (Johnson, Onwuegbuzie, and Turner, 2007) main-

ly based on in-depth interviews, active participant observation, and secondary data analysis encapsulated within an action research frame (Altrichter et al., 2009; Coghlan and Brannick, 2014; Sein et al., 2011). Data have been collected from multiple sources: regional and internal documents, interviews with the projects' organizational stakeholders, participant observation.
One hundred-twenty firms, three universities, and four research centers are involved in the above mentioned plan leading to 8 project-based organizations. From one hand, regional documents allowed to achieve descriptive information on the total number of firms, universities and research centers involved, the public funding received by each organization, the aim of each project. Moreover, those documents provide details about the specific technology that each project is developing. From the other, in-depth interviews and participant observation helped to understand the "how", namely the process through which the collaboration between the different stakeholders evolved in time thus enabling a first picture of the different emerging types of PBOs, along with their coordination mechanisms, leadership styles, and related proximity/distance between the actors involved.
As said, the plan gave birth to 8 ad hoc project-based organizations. Each organization has its own heterogeneous partners (private and public, firms as well as research centers and universities) and adopted a specific structure with very different coordination mechanisms and leadership styles with different degrees of hierarchy - in a continuum, ranging from a very low level to a very high one - different cultures, etc. Each organization has a big company as leader in charge of coordinating the execution of each project. See table 1 for an overview of our empirical data.

Empirical material	*Data collection period*	*Documents (N)*
Interviews	Feb 2019 – July 2019	14
Ethnographic diary	March 2018 – July 2019	2
Meetings with policy makers	May 2018 – July 2019	2
Regional Documents	_____	5

Table 1. The empirical data.

At present, we interviewed 14 individuals following a snowball sampling logic, and precisely: 4 professors, 6 researchers, 1 technician, 3 project managers, 1 company's CEO. We further analyzed available regional documents, made two separate ethnographic diaries, and had two meetings with policy makers in order to triangulate our data. We focused our analysis on three out of 8 organizations.
Data was collected between 2018, March and 2019, July. We refer to an interpretivist epistemology and our analysis is inductively oriented. The analysis followed recognized open and axial coding techniques (Corbin and Strauss, 2008) in order to identify and link the data collected to the research question. Attention was paid to coding the categories of objective descriptive data separately on the one hand, and the interpretative data based on perceptions on the other. More precisely, during the open coding, the data was first broken down by taking apart a sentence or a paragraph and giving a conceptual label to each separate idea, concept or event. The ideas were then re-grouped into categories, pulling together around them groups of ideas as sub categories. Then, during the axial coding, the concepts were structured into sub-categories and finally grouped into coherent and integrated conceptual categories. As a final stage, the sub categories were linked within and between each other. Then, the conceptual categories were linked in a coherent explanatory pattern. Importantly, as all the actors involved in this research take part in the same regional program which imposes same rules and values and requires all the actors to be located in the same geographical area we do not take into consideration institutional and geographical distance. Thus in the data analysis we precisely focus on cognitive distance. However, other further data are going to be collected in the next months. In the following we present some preliminary results.

4 Analysis and first results

Through this plan, the regional government aimed at fostering industrial research and experimental development projects on the smart factory topic. The initiative has been supported with a non-repayable loan and subsidized credit. It aimed at groups of SMEs, large companies and research organizations that intended to develop industrial research and experimental development projects in the Italian region of reference. According to the regional documents, the plan aimed at "supporting industrial research and innovation in technologies enabling and spreading the smart manufacturing of the future; fostering collaboration between companies and the research system in order to develop projects that respond to the need for innovation and competitiveness in intelligent factory's technologies".
The above points have important consequences for project-based organizing. First, there is a clear imbalance of power as the company owns always the formal legitimacy to coordinate the project; consequently, the aim of each PBO is always company-driven, and the knowledge production becomes a secondary goal. However, beyond the ways through which the plan has been designed that obviously influence power dynamics within every single project, each PBO was free to modulate its internal organization in terms of management and leadership styles as well as coordination mechanisms in order to fully achieve the project objective. Although each project has a formal leader – namely a big firm – each organization indeed adopted different forms that in turn enabled or hindered innovation and the whole "smartness" of the project. In the following we will describe three out of 8 PBOs, namely PBO 1, PBO 2, and PBO 3.

4.1 Project-based organizing for smartness: coordination, leadership and cognitive distance

PBO 1, PBO 2 and PBO 3 developed different forms of coordination and leadership, and own different levels of distance/proximity, according to the different kinds of involved actors. See table 2 for a detailed description of each PBO.

PBO	*Objective/Aim*	*Partnership*
1	Developing prototype infrastructures as edge computing network nodes, intelligent gateways for the cyber-physical system	- 19 firms - 5 research organizations (including 1 Polytechnic and the Social Science Department)
2	Developing sensors placed both on equipment and on operators such as exoskeletons and wearable robotics	- 15 firms - 5 research organizations (including 1 Polytechnic and the Psychology Department)
3	Fostering an integrated production process based on the use of technical polymers	- 18 firms - 6 research organizations (including 1 Polytechnic)

Table 2. Description of each project-based organization.

Project-based organization 1. PBO 1 aims at developing the following prototype infrastructures: edge computing network nodes, intelligent gateways for the cyber-physical system, wearable technologies. The organization includes only one humanistic department, and for this reason the cognitive distance is particularly high and creates trust issues. For example, as social scientists have to collect sensitive data, companies clearly worry about data protection. The PBO overcame the problem through standardized coordination mechanisms, such as rigid norms, strict rules, and fixed routines, along with the adoption of a bureaucratic leadership style. For example, the academic and research partners of the project had to sign a non disclosure agreement (NDA) in order to protect the company privacy, but this agreement is obviously in conflict with the aim and mission of academia and research in general, as this quotations clearly show:

"It is unbelievable that the company impose us to sign an NDA like that. The role of the university is to publish articles and produce knowledge. With this formal control, we cannot do our job. We do not have stimuli. Why should I do that if I cannot publish anything? It is a waste of time" (*Interview 1*)

"I was so excited about the project, but the coordinator made the job hard, and did not trust us. First, I had to sign a stringently NDA, and I cannot publish anything for ten years without the permission of the coordinator. Second, I had to write a protocol of 50 pages, where I had to detail every single action. We lost 6 months discussing protocols! How is it possible? Research is not a standard procedure. Research needs flexibility" (*Interview 2*)

The coordination between the actors has been extremely tiring, required long times, and finally hindered the university's work. These coordination's mechanisms fit perfectly with a bureaucratic and control-oriented leadership style, as these quotations show:

"There is a problem of coordination, but also a problem of too much control in the sense that if I want to go to another company and tell them: "you can use what we do", I could not, as I must always ask for a formal authorization to the coordinator. Then, one thing that bothers me personally is that when we do the operative meetings between the partners, there must be always someone from the third party who controls us, which is a little bit ... I mean, it seems to me that this limits us in freedom. I have never seen such widespread control over the partners in other projects" (*Interview 2*)

"We cannot work with this coordinator … They control everything! Last month I informally met one partner in order to understand their needs and organize some activities. The project manager called me and said I cannot organize a meeting without the permission of the coordinator, so the next time I must send a formal request" (*Interview 1*)

"What I perceive in this project is that if one leaves the borders, the coordinator is not happy, that is a bit constraining, because when a project is written and then when it is done, months have passed, and technology and research have changed, so it is absolutely normal that you want to evolve and certain limits are a constrain for research" (*Interview 4*)

"They do not let me work! Instead, in the other project [project 2][1] we are free to develop our ideas, as the coordinator leaves us to do whatever we like. That project is not a tayloristic industry [like this one]. We need freedom, and we must have the possibility to work freely" *(Interview 2*)

"Scientists cannot come here, in the company, and do what they want. There are rules to respect" (*company's comment, ethnographic note during a meeting*)

In PBO 1, the coordinator follows fixed and strict rules. This type of leadership does not favor the transfer of knowledge and innovation development because it sharply limits researchers' work. However, through a long and somewhat painful process, along with many meetings, the cognitive distance between companies and the university has been partially reduced.

"I had some problems with him [a company partner] because by human interaction design he means the interaction between machines. He has no idea that human-computer interaction means the interaction between the user and an interactive system. According to him, these interactions have to concern also the dialogue between machines and applications. That confusion went on for a long time, until we established that I would only deal with the interaction between man-machine, as I have no idea of what the interaction between machines is […]. Established that, then many meetings followed, and with the help of other academic colleagues, we finally designed the research activities we could carry out within the project" (*Interview 1*)

[1] University and companies can be involved in more than one project at the same time

In sum, in PBO 1 standardized coordination mechanisms along with a bureaucratic leadership limit the interaction among the partners and the fruitful contamination of resources and knowledge, while at the same time attempt to reduce cognitive distance between partners and solve trust issues.

Project-based organization 2. PBO 2 aims to achieve highly innovative technical solutions that allow performing highly complex operations through the safe and effective interaction between men, machines, and workstations, through sensors placed both on equipment and operators such as exoskeletons and wearable robotics. This project involves the university (Department of Psychology), the polytechnic, SMEs and big firms. As in PBO 1, the distance between partners is high since there is a humanistic department involved. This project is coordinated primarily through mutual adaptation mechanisms, where the actors informally coordinate themselves by freely sharing information and needs, according to the following quotations:

"In this project everything works very well. There are meetings with partners where we exchange ideas. In these meetings, namely plenary sessions, there is always the project's coordinator. However, the coordinator does not take part to the operative meetings. Usually, we are free to organize ourselves according to our necessities and goals. We meet and naturally adapt to the needs of all the partners" (*Interview 5*)

"We are free to meet whoever and carry forward ideas that were not foreseen in the initial project we are bringing with many exciting ideas […]. In this project, they [coordinator] expect new ideas from the university and are open to see how certain developments that had not previously been foreseen evolve. This project works well and quickly" (*Interview 6*)

In PBO 2 partners coordinate themselves by expressing needs and sharing information freely. Partners are free to meet without any formal request and novel ideas seem to circulate well. These coordination mechanisms are paired with a laissez-faire leadership style which, in turns, seems to work very well for those partners with a low cognitive distance. See the following quotations:

"In this project the leader is a very famous company that deals with transferring the robotic automation of assembly lines into Company X. He works closely with the Polytechnic because all the automation part of the project is done by the Polytechnic. But obviously, he does things for "Company Y". Therefore, it must automate and introduce robots for the Company X production line. This is the activity that is managed by Company Beta who leaves us free to work" (*Interview 7*)

"What came out of our collaboration is slightly different from what was originally written in the project. But the coordinator is very pleased with what we are doing and therefore they are giving us carte blanche, in the sense that one of the major innovative aspects concerns our activity together with others. The project manager is very happy that we are doing something different than the initial project, which is very innovative. I have already worked with most of the partners, and there is a good feeling and shared knowledge" (*Interview 5*)

"At the moment we have not written an article yet, but when we have a meeting and talk about this possibility, it seems there is no problem with this […] We already worked with most of the companies involved in the project and they know very well that academia needs to publish" (*Interview 6*)

Since most of the partners involved in the project have already been worked together, a laissez faire leadership style works well. Partners meet spontaneously and exchange ideas. The knowledge transfers fluidly and it seems that there is no trust issue. However, the problem raises when the cognitive distance increases, as in the case of the collaboration with the Department of Psychology. See the following quotation:

"It is very complicated. At the beginning we had to do focus groups and interviews to understand the implications of this new technology. But the most of other partners ignore us. There was no support. When we ask permission for doing focus groups and interviews, no one answers us. It seems they do not want to involve us in the activity. I also asked the project coordinator, but he said I had to find solutions with the other partners by myself" (*Interview 8*)

In sum, in PBO 2, with mutual adjustments and a laissez faire leadership, the knowledge flows fluently, but only when the cognitive distance is low. Instead, the knowledge transfer stops when the cognitive distance is high, leading to trust issues. In PBO 2 there are not mechanisms of compensation to overcome this issues, since the leader does not intervene to ask for collaboration among partners.

Project-based organization 3. PBO 3 aims to achieve an integrated production process based on the use of technical polymers, through the adoption of innovative additive manufacturing techniques, laser-assisted welding, and automatic testing machines. Unlike the other cases, in PBO 3 the cognitive distance is low as this organization does not involve any humanistic department. The project includes the polytechnic, the university, SMEs and big companies. At the beginning there was a coordination mainly based on mutual adaptation mechanisms, as shown in this quotation:

"Unfortunately, a long time has passed, and this first innovative idea has lost a bit of charge because the funding started late ... We did an internal brainstorming among all the partners to understand everyone's needs… So someone thought in a more appropriate way to the project to imagine an electronic object was an object that demonstrates the potential of the technique to build artifacts of this type. Others have said: I need this. Do this to me. Afterwards based on the needs of everyone we started working. All the members of the project are therefore proceeding in parallel according to their possibilities to contribute. So, everyone is involved but not all the demonstrators in equal measure. This is the right way to proceed in this type of project. Each component has a more important role in each phase of the project. So there are components in which the partner is more involved than others in which is less involved" (*Interview 10*)

Thanks to the mutual adaptation, each partner is concretely and effectively involved in the project, and different knowledge and competences flow brightly. The fluidity of this form allows to overcome the problem of delayed financing and reformulate the aim of the PBO itself. However, once the aims have been set, there is a strong – and more standardized - coordination through planning:

"We have a little time for the project. Therefore, we should go to forced stages, one meeting a week. Report one per month on each specific stage. Half a page. So, this electronic card is made up of ten parts. Each part has a manager who must achieve a certain result within a certain time, and each member must take part in two or three partners. Who does one thing and who does the other" (*Interview 11*)

The leadership of the project is democratic: the coordinator lets the teams work freely, but always asks for feedback and input in order to constantly monitor the work in progress:

"The coordinator organizes all the meetings, attends the meetings and organizes the bureaucratic issues. However, usually they let us work freely, and we are free to organize our work. As said, they ever ask for the report. Before taking a decision, they always ask the opinion of all the partners. This project is working very well because everyone is involved in the project aims. There is trust and understanding between the partners. The university has succeeded in making available its skills and the companies have put us able to work well and do innovation. We held the first conferences, and there are all the conditions for patents and publications" (*Interview 10*)

As this type of leadership promotes discussion and participation, it is an excellent style for effective innovation and knowledge transfer. It promotes trust and collaboration among members, and this lubricates the channels of knowledge transfer. See table 3 for a summary of the first results.

PBO	*Coordination*	*Leadership*	*Distance*	*Knowledge transfer/ Innovation development*
1	Standardization	Bureaucratic	High	Tiring
2	Mutual adaptation	Laissez-faire	High	Partial
3	Planning/Mutual adaptation	Democratic	Low	Fluid

Table 3. Coordination, leadership, and distance in each PBO.

5 Discussion. Achieving "smartness" through a "fluid mosaic" organization

Collaboration among universities and firms has been recognized as indispensable for economic development and technology advancement (Etzkowitz, 2000). However, as Boschma (2005) suggested, the innovation has been hampered by multiple factors such as excessive or scarce cognitive distance among the partners involved in the innovation process. In this vein, PBO has been considered a proper way for fostering innovation and knowledge transfer (Hobday, 2000).

Policy makers recently promoted the alliance among different actors in order to create temporary network organizations with the aim to increase technological advancements in the field of smart manufacturing. But different sub-types of PBOs could emerge whose specific characteristics – in terms of leadership styles, coordination mechanisms and cognitive distance between the involved actors - may affect the process of innovation and knowledge transfer.

From the data, it first emerges that when coordination mechanisms are strongly based on the hierarchy, it is very hard to share and transfer knowledge between partners, making tricky the innovation development itself. Instead, when coordination is based on a mutual adjustment between parties, the information flow is natural, as well as the knowledge transfer, leading to more flowing processes. However, and more importantly, we also discovered that these mechanisms can be strongly influenced by the cognitive distance between the partners. That distance is not negative *per se*, on the contrary a high distance can be a strategic advantage when developing innovation. But that distance must be smartly and properly managed as the main risk is the impossibility of a dialogue between partners.

From the moment when the project is designed to that in which it is realized it can pass a very long period of time. This means that, meanwhile, technology becomes obsolete. This is one fundamental reason for creating more flexible and fluid PBOs. Further, flexibility is needed to timely respond to the necessity of a single partner and enable all the actors to contribute to the project's goals.

Democratic leadership, especially when combined with mutual adjustment, creates favorable conditions for knowledge transfer and innovation. However, as PBOs are short terms organizations hence they need excellent planning to achieve set goals.

In PBOs, bureaucratic and laissez-faire leadership styles could obstacle the process of innovation. A bureaucratic leadership implies long times to organize the project activities and does not allow the partners to interact spontaneously. Also, it could be misleading in PBOs where the actors are organized in a short-term way. But a bureaucratic leadership could be useful if there are partners with high cognitive distance, since it may help in reducing uncertainties and risks, thus favouring a dialogue otherwise impossible. Laissez faire can be an effective leadership style when the distance among the partners is low, as well as when the partners have already been worked together. Instead, when there is

very high cognitive distance, as in PBO 2, it may create trust problems and scarce collaboration. The expertise offered by the "outsiders", such as an humanistic department, risks to be ignored as there is not a strong coordination able to push the partners to collaborate.
However, when the distance between the partners is low, the leadership style is democratic and coordination is firstly based on mutual adjustment and then on standardization, as in the case of PBO 3, the resulting organization takes the form of what we called a "fluid mosaic" drawing on the fluid mosaic concept developed in biology. By "fluid mosaic" we mean a smart, flexible, short-term organization, project-oriented, coordinated firstly through mutual adaptation and then planning, and managed with a democratic leadership style. Such as in biology, this type of smart organization adapts fluidly to the context in which it operates and fully exploits those resources made available by the actors who participate in the organization. Due to their characteristics, these kinds of organization naturally support cooperation, the exchange of competences and knowledge among different actors, and thus more easily lead to innovation in a smart factory environment.
The above considerations clearly arise a few implications for policy makers and organizational designers. Since innovation processes require different kinds of knowledge and expertise, the distance among the actors in PBOs is an essential feature especially in smart manufacturing, a field that naturally combines and requires highly differentiated competences. Hence, managing effectively the distance between the actors and coordinating them accordingly in ways that allow a fruitful dialogue without renouncing to the positive effects of being cognitively distant can be a crucial task. In this vein policy makers could take into account, when it comes to design similar programs and competitions, to include a temporary *super partes* office composed by experts in different fields (i.e. researchers, entrepreneurs, etc.). These experts could be recruited either for their competences, either for their previous participation and experience in similar programs. These experts could be in charge of specific tasks such as the management of conflicts among PBOs' actors and/or the arrangement of specific trainings for project managers and researchers too, so that they can get more familiar with project management tools. At the same time this may represent an opportunity for firms, universities and research centers to get acquainted in an unusual way. That may be particularly relevant when the cognitive distance among the actors is high, because it is essential, for example, that firms figure out the contribution each research center/university can bring to the project in order to manage the distance. Finally, concerning conflicts, these often imply a huge waste of time for PBOs. Since temporality is an essential feature of these organizations it is crucial to find fast solutions to problems. Such a *super partes* office may be a useful tool for managing and solving problems in a timely manner.

6 Conclusions, limitations and further research

Collaboration among different actors is assuming a more relevant role in innovation processes, particularly in the context of smart manufacturing where there is the need to integrate different disciplines. Hence it is essential to figure out the problem of coordination generated by the distance among the actors involved in the process. Our contribution provides an understanding of how and what types of project-based organizations can better stimulate collaboration among research and industry towards an effective smart factory's development. The objective is to achieve "smartness" in the broadest sense of this term.
Preliminary results suggested that PBOs with democratic leadership and coordination through mutual adaptation may better support the knowledge transfer since it leads to more fluid processes. Instead PBOs with laissez faire or bureaucratic leadership styles could limit the knowledge transfer. However, the main contribution of this research was to highlight the key role played by cognitive distance and its relationship with coordination mechanisms and leadership styles in PBOs focused on developing innovation within a smart factory environment. Our results could be employed by policymakers *as per* above in order to develop more effective programs and plans for better supporting future project-based organizations.

Finally, we are aware that a main limitation of this study is that we mainly interviewed individuals belonging to academia/research without giving a proper voice to SMEs as well as big enterprises. This limitation can lead to an obvious underestimation of relevant problems as perceived by companies. In order to overcome this limitation, our next steps will be to interview and gather data from other PBOs' stakeholders, and particularly small, medium and big firms. Starting from these preliminary results we will also further develop our framework.

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