Projects as temporary trading zones: a theoretical proposal and empirical illustration

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Abstract

This paper presents an outline of a theory of projects and project management. It engages in two of the most salient characteristics of projects, namely their interdisciplinary and unique nature. Based on the writings of Peter Galison and the notion of projects as temporary trading zones, we document the criticality of four elements of project organizing in answering five fundamental questions pertaining to why projects exist, how they differ, how they unfold, what the role of management is, and what determines the success and failure of projects. Our analysis specifically singles out the role of establishing an interlanguage facilitating the coordination of specialized experts in innovative projects. Moreover, we theoretically claim that projects as organizational devices, language creation, project management tools, and artefacts, are key elements in facilitating the creation of an interlanguage which seems critical for the success of coordination in interdisciplinary, innovative and unique kinds of projects. Our framework is illustrated with an empirical example taken from Galison's detailed studies of scientific laboratories.

Introduction

Projects play an important part in society, especially to drive and implement change and innovation. Projects are today one of the most popular forms of organizing and they play an important part for the coordination of diverse expertise. In these times of knowledge specialization, projects seem to play an ever more important role to provide integration of diverse knowledge and synchronized implementation. As a response, the scholarly literature investigating projects as organizational forms has expanded exponentially the past 20 years or so. The increasing proliferation of projects has also triggered various investigations into the specific nature of projects as organizational forms, discussing when projects should best be used, and the different modes of organizing projects. However, compared to other organizational forms, our understanding of projects is still rather undeveloped (Kellogg et al., 2006).

There is a growing body of research in the field of project management that discusses the ontology of projects (Cicmil & Hodgson, 2006) and the need for more elaborate theoretical approaches (Söderlund, 2011). This particular discourse raises the very issue of why projects exist and how we should address projects as social phenomena. This discourse also emphasizes the importance of pinpointing the very foundation of projects, in particular what differentiates projects from other kinds of organizations, what the unique characteristics of projects are, and what specific managerial challenges are faced when organizing projects (see for instance Morris et al., 2011; Söderlund and Tell, 2011; Lindgren and Packendorff, 2006). So far, scholars have argued that there is a lack of theoretical awareness and development in the field of project organizing and that that this situation has turned into a deadlock that has made it difficult for researchers to draw on each other's findings and accumulate knowledge through advancing theoretical conversations (Koskela and Ballard, 2006; Winch, 2006; Williams, 2005). Indeed, there are a number of reasons why the field has

developed in this direction and there are probably a number of paths ahead that one could take to amend the situation (Davies et al., 2011). In this paper, we will suggest one way forward – a suggestion that is based in two salient characteristics of projects that we believe have received limited interest, despite their importance to the practice of projects.

One possible route out of this seeming deadlock is to develop more advanced theoretical efforts based on the unique qualities of projects as organizational forms. In that respect, there is a need for more and complementary views on the theory of projects and temporary organizations (see for instance Lundin and Söderholm, 1995; Lindkvist et al., 1998; Söderlund, 2011). This is the overall and important aim of the present paper, namely to offer an example of how this kind of theoretical effort may look like and discuss the general insights that may result from such efforts. We suggest that the strategy of "borrowing theory" from neighboring disciplines, i.e. bringing ideas from one theoretical domain to address an issue to explain a phenomenon in another domain (Floyd, 2009), offers several possibilities. Such borrowing of theory must, however, rest on the understanding that the social context to which the theory is transferred to has unique characteristics that might be downplayed by the ignorant and blind transfer of theoretical ideas (Markoszy, 2009). Hence, borrowing should be done wisely and humbly with care taken to both the context in which the original theory was developed, and a thorough understanding of the context in which this theory is about to be tried out. This paper offers an example of how borrowing might be done, as well as how borrowing might contribute to the original theory by trying it out in related empirical settings. Important in this particular case is that borrowing is made with the explicit consideration of the salient characteristics of projects as organizational forms.

More specifically, the present paper seeks to take part in the development of new concepts and theories by offering a theoretical framework of projects as temporary trading zones (Galison, 1997) – a framing that is quite different from much of extant theorization in

the domain of project management and project organizing more generally. We believe this framing offers novel answers to fundamental theoretical questions, including why projects exist, why they differ, and how they behave – all fundamental and important questions for anyone interested in developing stronger theories of projects and the management of projects (Söderlund, 2004).

The paper is structured accordingly. Next we present the theoretical background to the paper and provide a historical exposé of the field of project organizing. Then follow a summary of the notion of projects as temporary trading zones, with a specific focus on Galison's writings. To offer empirical depth to our discussion, we then turn to an empirical illustration before moving on to a presentation of the key elements of our framework. We end the paper with conclusions and suggestions for future research.

Perspectives on projects and project processes

Indeed, the field of project management has long been dominated by a strongly rationalistic and instrumental approach (Lindgren et al., 2014; Packendorff, 1995). This is perhaps particularly obvious in normative writings on project management, which to a great extent is rooted in the growth of the practical application of decision sciences after World War II (see Erickson et al. 2013). This "Management Science" approach had a major impact, particularly in the practice of project management, namely how managers talked about project management and how people generally conceived of what project management really was. In this tradition of project management scholarship, project management is first and foremost seen as a scheduling problem of complex endeavors and projects are largely understood as a particular kind of complex tasks. This has also been seen in practice-oriented writings where prominent representatives of the field of project management have spoken about planning as the language of project management. The Polaris project became emblematic of the success of

this rational approach which gave birth to the “optimization school” of project management (Söderlund, 2011). In this perspective, projects represented an adept tool to solve a complex organizational problem to reach a well-defined goal within budget and time constraints. To a great extent, a defined toolbox existed to optimize the organizational effort, including work breakdown structures, critical path methods, risk analysis tools, and control instruments. This view is now widely criticized.

One of the most thorough and influential contributions criticizing the normative and instrumental tradition of project management writing is the recent work on critical studies of project management (see for instance the edited book by Hodgson and Cicmil, 2006). Scholars have analyzed the roots of the rationalistic model in a genealogical perspective and suggested a postmodern approach to projects. In this perspective projects are first and foremost conceived as processes. They are gradually constructed and re-constructed through social interaction, practices and language creation. Projects are framed as “emergent spaces” that become enacted through nested sensemaking processes. A parallel although somewhat different take has discussed the lack of relevance of the normative/instrumental tradition of project management. For instance, Hällgren et al. (2012) argue that « *the* [relevance] *problem occurs when simplified, rationalistic and deterministic models (or ontologies) are mistakenly considered to be accurate views of reality. (…) It could be argued, therefore, that PM research is not only an immature field of research, it is also unsubstantial in terms of understanding what is going on in projects* » (p. 462).

The present paper is in line with this novel framing of projects – both with regards to the processual as well as the practice-oriented view on projects. More specifically, we are interested in the exploration of the processes that are specific to projects. In that respect, we argue that there is a need to theorize about the very salient characteristics of projects. Indeed, with the exception of the earlier mentioned works, projects have been characterized mainly by

their temporariness (Lundin & Söderholm, 1990), their difference from operations (Declerck et al., 1983; Scranton, 2015) or routine activities (Obstfeld, 2012), and their goal-oriented/teleological nature (see for example Lindkvist et al., 1998; Morris, 2013). However, we still need to address what happens specifically within projects that are different from routine work (Kellogg et al., 2006), especially grasping the process characteristics of projects (Söderlund, 2013). We also need to improve our understanding of how projects unfold, how coordination emerges, and how knowledgeable work transcends disciplinary barriers in projects. Our take is primarily on what might be referred to as innovative projects (Davies and Brady, 2005), i.e. projects involving a high degree of uniqueness, specialized expertise, diverse knowledge, and creative problem solving, although we argue that much of the discussion holds for all organizations that are referred to as projects.

As pointed out above, we believe there is a need for a more elaborate theory of projects and project management. We also believe that theoretical attempts should be more common and make more use of writings in other areas within the broader realm of social science. In particular, we believe that theoretical attempts should make use of the salient characteristics of projects as social phenomena. The reason is that we believe that these salient characteristics also may offer the most promising alternative for producing knowledge of projects that also could influence management and organization studies in general. We also believe that such theories must acknowledge the dynamic and processual nature of projects, which has been emphasized by several others before us (Lundin and Söderholm, 1995; Lindkvist and Söderlund, 2002). We claim that the theoretical framework presented below to some extent does all this – it builds on extant research in social science, it draws on process theory, and it addresses several of the most salient characteristics of projects as social phenomena. Accordingly, this paper argues that research into projects need to become more interested in process and in the becoming elements of project management. Theoretical

attempts that fail to address the processual features of projects, as Söderlund (2013) points out, miss a great deal of the organizational challenges that contemporary projects are facing.

So far, process theorizations in projects have followed three primary paths. One relates to the framing of projects as punctuated processes (Gersick, 1989; Engwall and Westling, 2004) describing the project process as a sequence of punctuations between equilibria. In general, this process view has pointed out the fluctuating character of projects moving from open to closed stages. Another process view addresses the dynamic processes of projects as a set of sequences ranging from an entrepreneurial phase to a phase characterized by institutionalized termination. This framing is particularly apparent in the work on temporary organizations (Lundin and Söderholm, 1995). A third process framing relates to the dynamics of projects as problem-solving processes (Lindkvist and Söderlund, 2002) depicting the project process as a series of hypotheses and tests. The main point with the latter is that projects might be viewed as goal-oriented search processes where project management offers a specific tool for critical testing and reflection (Lindkvist et al., 1998).

These examples offer valuable and insightful interpretations and alternatives for how we should view projects as processes. However, they do not fully address the issue of projects as inter-disciplinary organizations. They do not explain how projects as multi-disciplinary interactions develop over time. In that respect, we believe that prior attempts primarily have investigated projects as temporary organizations, time-limited organizations, and goal-oriented organizations. Indeed, these are all properties that play a key role in projects and are characteristics quite unique for projects as organizational forms. However, the issue of inter-disciplinarily is perhaps even more fundamental to project organizing. Without the connection of disciplines and knowledge bases, then it becomes very difficult to set a project goal that might be achievable, to solve the technical problems necessary to reach the object, to understand how elements fit together, to make the temporary organization function, and so on.

This seems particularly important in contemporary projects where the increasing complexity of projects (Geraldi, 2009) and knowledge specialization (Brusoni et al., 2001) have called for yet more advanced project solutions, including agile principles and overlapping strategies (see for instance Grabher, 2004; Berggren et al., 2011; Lindkvist, 2011). In that respect, we believe there is a need for a theory that addresses how experts from different disciplines engage in each other's knowledge processes, learning processes, and thus learn enough to contribute jointly to developing a new system, product, technology (Gorman, 2002). This fundamental problem so common in many project settings has also been observed by others (Dougherty, 1992; Lindkvist, 2005) and researched by scholars from a wide range of disciplines (Kellogg et al., 2006). The latter has also clearly been pointed as critical in various studies of problems observed in innovative projects. For instance, Hoopes and Postrel (1999) address the criticality of "glitches" for explaining project failures – that actors involved in projects lacked a common understanding of very basic elements of the project which had detrimental consequences for the entire project. Others have pointed out the significance of various kinds of boundary-spanning mechanisms to facilitate cross-disciplinary coordination and thus successful project organizing (Ordanini et al., 2008).

The framework presented in this paper focuses on the coordination problem of projects (Söderlund, 2011) and it draws on the influential work by the historian and philosopher of science Peter Galison – a theoretical take that has been suggested in other studies on cross-boundary coordination (see for instance Kellogg et all, 2006). It should also be pointed out that our analysis draws on the idea that a theory of projects and project management need to respond to five key questions, namely: why projects exist, why projects differ, how projects behave, what the value is that the project management unit is adding, and, what determines the success and failure of projects (Söderlund, 2004). These overall questions are far from novel when it comes to the theorization of organizations and firms, however, they have

received surprisingly limited interest among project scholars. We believe this is fundamentally problematic, especially in times when scholars are calling for bolder theoretical attempts and stronger theoretical foundations for the further development of the field of project management (Lundin et al., 2015).

The ultimate goal addressed here is to build a more robust theoretical foundation to be able to describe and analyze the process of projects. To achieve this we begin by analyzing the rich literature on coordination and communication across boundaries in innovation management. We argue that this theoretical framing is relevant to understand several of the most salient process features of projects. We base our theory on the metaphor of the "trading zone" which was originally developed by Gallison in his book *Image & Logic* (1997). Indeed, we believe that the "trading zone" concept, with its emphasis on language creation as a condition for coordination offers an analytical platform to describe the nature of the processes inherent in many different kinds of projects.

The problem of coordination

In our view, we believe that the theory of project management must initially be made through a distinction between two kinds of organizational problems (see also Grant, 1996, and Söderlund, 2011, for a discussion in the context of projects). One relates to the cooperation problem, the other concerns the problem of coordination. The cooperation problem typically seeks to discuss how actors come to agree on a conflicting goal, how actors are able to reach agreement, how actors create a social exchange that works for all parties involved (Grant, 1996). Typically these kinds of theoretical attempts make use of stakeholder theory, economic theory, and goal setting theory (see Söderlund, 2013). However, as for the second problem – the coordination problem – other theories are relied upon. Here analysts are more interested in explaining how actors with diverse background come to integrate and unite their distinct

experience and their respective activities to reach a common goal. In that respect, the coordination problems may be unsurmountable even though the cooperation problems have been solved (Grant, 1996). Therefore, this paper is primarily interested in the coordination problems of projects and project management.

To arrive at an accurate conceptualization of the coordination problem, we have to rely on other literature than the conventional and narrow project management literature. This question is particularly significant for the management of innovation projects, as stated by Van de Ven (1986), "*managing part-whole relationships*" is a central problem in the management of innovation. In this perspective working across boundaries (internal and/or external) is a central concern (see Dougherty, 1992). Two research streams lead to important insights: the literature on integration and on boundary-spanning mechanisms.

One classical concept used in the literature is that of integration which was addressed in much early work on projects, for instance in Lawrence and Lorsch's (1967) landmark contribution. In this perspective, projects constitute an integrating mechanism that helps the different functions of the organization to work together in order to achieve complex tasks like new product development. However, Lawrence and Lorsch define integration very broadly as "*the process of achieving unity of effort among the various subsystem in the accomplishment of the organization's task*" (1967, p. 4). They do not offer a micro-oriented analysis of the ongoing processes within a specific project. A more sophisticated use of the concept of integration is provided by the Harvard studies on new product development projects (Clark & Fujimoto, 1991; Wheelwright & Clark, 1992; Iansiti & Clark, 1994). For them integration constitutes a dynamic capability. Its essence is "*the generation, fusion and accumulation of knowledge: the capacity to merge new knowledge about the impact of possibilities with deep accumulated knowledge of the complex existing capability base of the organization*" (Iansiti & Clark, p. 602). In this sense, they insist, integration is more than communication and

coordination across functional boundaries since it entails the "*proactive generation of new knowledge*" (ibid.). Their research provides an insightful description of internal and external integration mechanisms which corresponds *de facto* to the characteristics of heavyweight development teams that practices *integrated problem solving* (see Clark & Fujimoto, 1991). However, in our view, they did not provide a description of how integration unfolds within project teams, what are the practices associated with this integration process. As pointed out by Hoopes & Postrel (1999) what is produced during integration and how it influence project unfolding remains a bit mysterious.

Another and complementary line of literature focuses on coordination mechanism across boundaries in organization. This is a vast domain starting already with the work of Allen (1977) and our objective here is not to make a complete literature review. This might very well be needed but it is beyond the scope of this paper. We consider the work of Paul Carlile (2002; 2004) to be particularly representative for the more recent contributions in this stream of literature. Studying new product development effort, but not mentioning the term project or the project management literature per se, Carlile provides an in-depth study of the processes involved for managing knowledge across boundaries. He proposes an integrative framework which distinguishes three processes: transferring, translating and transforming. These processes correspond to increasingly complex situations in which novelty and diverging interests between actors complicate the coordination process. Kellogg et al. (2006) have added to this framework by an insightful in-depth study of the practices of cross-boundary coordination in the projects of a web agency. According to their findings, display (rendering work visible to others), representation (rendering work legible through use of power-point presentations or documents) and assembly (juxtaposing work through modification and recomposition) are the three main practices enabling cross-boundary coordination. In so doing, they provide an insightful description of the coordination processes

inherent in cross-disciplinary projects. However, and we claim this constitutes an important limitation of their analysis, they do not address the literature on project management, or the essential characteristics of project organizing, and the initiation of projects as significant modes of coordination.

These contributions provide important guidelines to our understanding of coordination processes in project teams involved in new product development. However, their explicit goal is not to develop a theory of what a project is and how a project unfolds, even if they describe some of the key processes at play. Thus, we think that we still miss an overarching framework that could integrate these works into an ontology of projects.

The ultimate concern here is to build a more robust theoretical foundation to be able to describe and analyze the process of projects, especially considering the interdisciplinary and unique nature of projects. To achieve this we begin by analyzing the rich literature on coordination and communication across boundaries in innovation management. We argue that this theoretical framing is relevant to understand several of two of the most salient, yet understudied, process features of projects. We base our theory on the metaphor of the "trading zone" which was originally developed by Galison in his book *Image & Logic* (1997). Indeed, we believe that the "trading zone" concept, with its emphasis on language creation as a condition for coordination is analytically powerful and fruitful to address the nature of the processes at stake in a number of different project contexts.

Galison's "trading zone"

In our quest for a relevant conceptualization of the processes of coordination inherent in projects we rely on the work of philosopher and historian of science Peter Galison. In *Image & Logic* (1997) Galison analyzes the evolution of the practices of scientists working in the

field of microphysics, more specifically atomic physics. He focuses on the question, central for the aim of our research, of coordination between the three cultures of physics: theorists, experimenters and instrument builders. *Image & Logic* is a fascinating description of the evolution of modern physics from a "workshop" type of science in early twentieth century to the huge post-1945 "factory of physics" which was developed at several prestigious institutes of technology, such as Stanford or the MIT. The increasing size and complexity of the experiments made the question of coordination increasingly important, yet challenging. To describe the processes of coordination Galison introduces the concept of the *trading zone* i.e. "*an intermediate domain in which procedures could be coordinated locally even when broader meaning clashed*" (p. 46). Indeed, as he demonstrates, there are often profound divergences (even paradigmatic ones) between the different cultures of physics or between scientist and engineers. However, he clearly shows how, despite these disagreements, "*there can be exchanges (coordination), worked out in exquisite local detail, without global agreement*" (p. 46). To build the notion of the trading zone, Galison relies on anthropological linguistic work showing how different groups representing radically different cultures and speaking different languages succeed in exchanging goods. According to Galison "*the work that goes into creating, contesting and sustaining local exchanges is (…) at the core of how local knowledge becomes widely accepted*" (p. 47). And, borrowing on linguistics, he insists on the process of language creation in the trading zone, contesting the notion of translation, so common in the sociology of science (Callon, 1986). Therefore "*rather than depicting the movement across boundaries as one of translation (from theory to experiment, from military to civilian science, or from one theory to another), it will prove useful to think of boundary work as the establishment of local languages – pidgin or creoles – that grow and sometimes dies in the interstices*" (p. 47). This emphasis on local language creation, referred to as "interlanguages", as the core element of coordination is, in our view, the fundamental

contribution of the trading zone. It is all the more relevant for our purpose that the notion of "language" is in fact kept broad in the framework presented by Galison. As he notes "*I intend the term "trading zone" to be taken seriously, as a social, material and intellectual mortar binding together the disunified traditions of experimenting, theorizing and instrument building*" (p. 803). Galison is very clear on this question in a subsequent reflection on the trading zone concept (Galison, 2010): "*the language of science does read, quite literally, as language: propositions, statements, observations, hypotheses and conditionals are all recognizably linguistic even if technical in scope. But at other times practices do not necessarily form linguistic objects, in a strict sense. Diagrams and symbols, for example, have their own combinatorial logic. (…) I'm interested in language in an expanded sense that would embrace such symbol language – whether computer codes, abstract algebra, formal logic, or the calculations of quantum physics. Each carries with it its own form of syntax, its own rules of simplification, generalization and composition. Similar (…) are languages formulated in ways that make use directly of spatial or topological relationships – electronic schematics, group-theoretical dynkin diagrams* [and so on]" (p. 43). It is also clear from Galison's writings that objects constitute a form of language. It leads Galison to speak of *wordless pidgin or wordless creole* to name "*material or symbolic objects [that] are also a form of language*" (p. 43-44). Therefore, as he explains, "*Images, symbol systems, calculational and diagrammatic schemes – even complex objects – could be part of a generalized notion of language that is far from "just words". Indeed, language, as I want to use it, is a regular yet flexible apparatus that may take many forms, from the recognized, everyday "natural world languages", to the myriad, systematic registers in which we communicate*" (p. 44). Thus Galison, even though criticizing the notion of "translation", recognizes his closeness with Star and Griesmer's research on "boundary objects" (1989).

As highlighted by Gorman et al., (2004: 64) the notion of the trading zone is more than a metaphor. For instance, engineers working with jet propulsion have used the term “trade” to refer to negotiations over design options (Lambert and Shaw, 2002). As these trades involve more than exchanges of information and perspectives, they are more than conventional trade-offs in projects. For instance, working on the Mars Rover project, engineers and scientists had to conduct a series of trades to arrive at a landing site that was satisfactory from a scientific standpoint and feasible form an engineering one (ibid). Gorman et al (2004) argue that for developments in many technology areas, the involved actors (such as engineers and scientists) will have to develop their own dialect which allows them to communicate and interact more effectively. For instance, nanotechnology trading zones can be multidisciplinary in which there is a division of labor between the groups and the groups develop a specialized dialect, a kind of ‘*nanocajun*’, to coordinate activities, or they can be genuinely inter-disciplinary with all participants engaging in discussions of all aspects of the research and development activities.

Indeed, the ultimate goal of the trading zone is the sharing of expertise and disciplinary knowledge. A key assumption in the literature on trading zones is that their members have to develop a creole and a shared meaning for common terms. In that respect, these ideas are generally in line with ideas associated with the knowledge-based theory of the firm (Grant, 1996), although the trading zone concept is more specific and related to a particular challenge that we believe is central to the organizing of projects. In that respect, the trading zone is a specific kind of knowledge organization (Lindkvist, 2005). Collins and Evans (2002) distinguish between three “levels of shared expertise”: None, Interactional, and Contributing depending on the degree of common knowledge and intensity of knowledge sharing in the trading zone. These levels might then be seen as stages in a project where members initially

have a limited shared expertise which then gradually develops through the development of a common language which becomes more interactional and contributory.

Inside the trading zone: an illustrative case

In order to understand what Galison means by the creation of a new language, a creole or pidgin, fostering coordination in the trading zone, it is useful to consider one case presented in *Image & Logic*: the MIT Rad Lab during World War II[1]. The Rad Lab was created at the end of 1940 to design radars that could be used in combat[2]. It operated under the leadership of Lee Alvin Dubridge until the end of 1945 and employed almost 4000 people at its peak. One of the main features of the Rad Lab was that it brought together, as other wartime endeavors like Los Alamos, scientists (theorists and experimenters) and engineers to design, under wartime pressure, highly innovative technical devices. In order to foster the coordination between scientists and engineers, the Rad Lab adopted a very original structure. It was not organized, as was usually the case, by technical expertise, but rather by components of the system (modulator, magnetron, antenna, receiver and indicator) and, after March 1942, by the logic of the end product (ground systems, ship system, etc., see figure 1). Therefore, as explained by Galison, *"the physical architecture [of the lab] closely matched the electronic architecture"* (p. 817 and Figure 1).

[1] The following section draws on section 9.7 (p. 816 and next) of Galison (1997).
[2] It is beyond the scope of this paper to make a complete history of the Radar Project at MIT which was based on the British discovery of the magnetron. Galison provides a good introduction in section 4.3.6 p. 288.

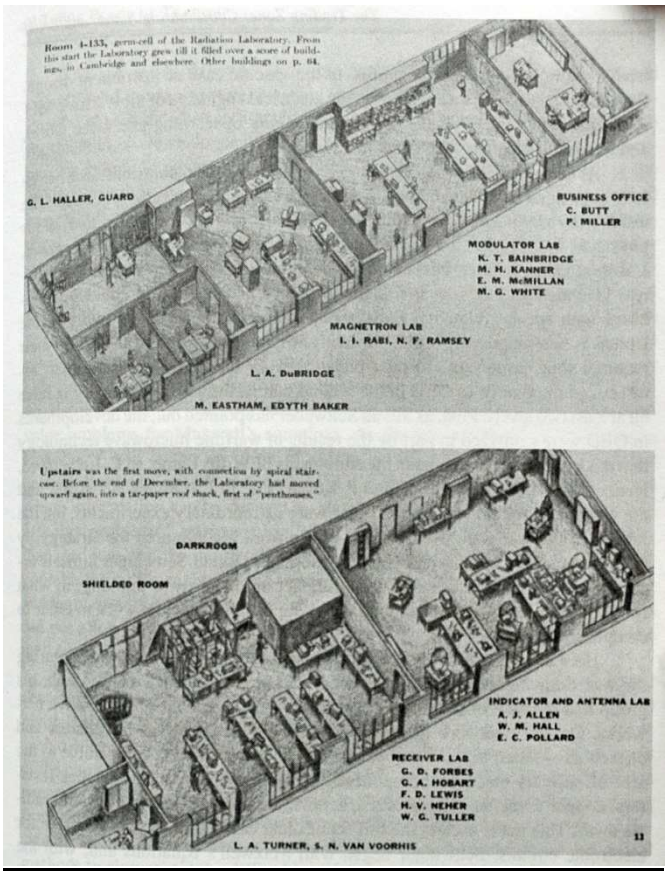

Figure 1. Physical architecture of the RadLab parallel electronic architecture (Galison, 1997, p. 819)

This, as he shows, "*did not respect the distinction between physicists and engineers. W. Turner, for example, was an electrical engineer with a desk adjacent to that of H. Neher, a physicist trained in experimental cosmic ray investigation. W. Hall, who had been an electrical engineer working for MGM doing sound recording, now shared the indicator corner with A.J. Allen, a physicist and electrical engineer, and E.C. Pollard, a physicist who (…) in 1940 was an assistant professor at Yale*" (ibid). This organization was designed to favor face-to-face communication between the experts involved in the project. It led to, Galison's argue, a new kind of trading among the different disciplines, i.e. one in which engineering was not merely the application of theory, but leads to the reconfiguration of both disciplines.

To demonstrate this point, Galison analyzes in detail the work of Julian Schwinger (who would later earn the Nobel Prize in physics in 1965) at the RadLab. Schwinger worked in the theoretical division of the lab and "*had the task of developing a usable, generable account of microwaves networks*" (p. 820), a critical question to design radar components. The problem was that ordinary network theory was useless for radar design. Therefore Schwinger "*began with Maxwell's equations and, with the help of his coworkers, derived a set of rules by which engineers and physicists could make practical network calculations*" (ibid.). However this first approach was too complex and "*as the war progressed and Schwinger assimilated more of the "good enough" and input-output culture of the Rad Lab, he began to abandon the physicist's abstract scattering theory of electromagnetism and to search for the microwave analogue of the electrical engineers' more practical representations: simple "equivalent circuits" that imitated just the relevant aspects of the components*" (p. 821). As Galison explains this was considered to be an old technique among electrical engineers "*who were used to treating certain systems, such as loud speakers, not according to their real electrical, mechanical, or electromechanical properties, but as if the loudspeaker were circuit of a purely electrical components.*" In other words, Galison points out, they more or less symbolically "*put the complicated physics of the loudspeaker's electromechanically generated sound into a "black box" and replaced it in their calculations with equivalent electrical components*" (ibid). By so doing, Schwinger allowed the engineers to make their calculations "*without entering each time into the details of complex boundary-value problems for Maxwell's equations*" (ibid.)

However, what was at stake in this process was much more than a simple translation of microwave physics into an "*engineering mold*". On the contrary, as Galison demonstrates, it was the creation of a true pidgin and the new language that facilitated the coordination

between physics and engineering. Indeed, one of the most difficult problems "*involves the determination of equivalent circuits for waveguides (long hollow metal boxes) involving discontinuities (protrusions, gaps, dividers, etc.)*" (p. 821 and figure 2). This was completely impossible with prewar physics methods. Instead, Schwinger devised "*theoretical methods to circumvent the difficulties of such geometries. Schwinger's solution was predicated on localizing the difficulty around the discontinuity and using variational methods to determine the equivalent circuit for that part of the waveguide. With this and other methods, Schwinger and his collaborators calculated example after example of equivalent circuits. Since equivalent circuits for continuous transmission lines were well known, it became a matter of routine algebra to combine equivalent circuits elements in the building of novel microwave circuits and to derive the practical quantities called for by the engineers: relations among input voltages, output voltages and current*" (p. 821-822).

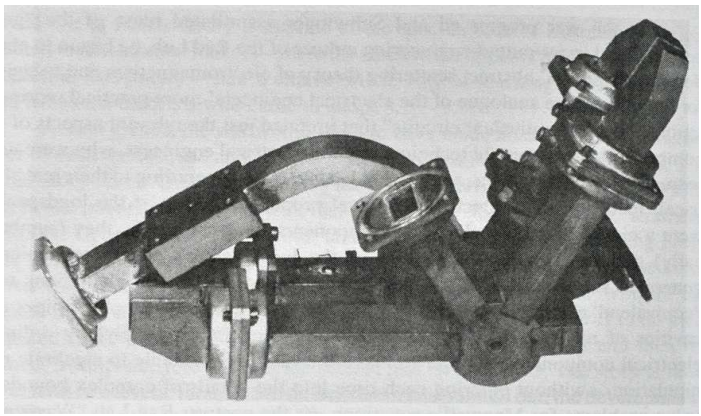

Figure 2. Complex waveguide (1945, from Galison, p. 822)

As a result Schwinger produced "*a kind of simplified jargon (or pidgin) binding elements of the language of field theory with elements of engineering equivalent circuit talks* (see figure 3 below). *(…)* [He] *had manufactured a meeting point that both physicists and engineers could understand and that both could link to their larger concerns – on one side to the concepts of*

Maxwellian field theory, on the other to the practices of radio engineering" (p. 822). What was fundamental here was that the "*glossary" was identifying newly calculated theoretical elements with recently fabricated fragments of microwave circuitry: neither was part of the prior practice of either the theorists or the radio engineers*" (p. 824, our emphasis). Thus, the constant interaction of physicists and engineers through the Radar Project paved the way for the creation of a new "*powerful, locally understood language*" (p. 833) that fostered the coordination between two distinct occupational groups. Indeed, this was something quite different from merely translating physics into engineering. And Galison insists on the fundamental role that co-localization (and wartime pressure) played in this process. "*Under the gun, the various subcultures coordinated their actions and representations in ways that seemed impossible in peacetime; thrown together they began to get on with the job of building radar*" (p. 827). In this perspective the MIT Radiation Laboratory "*offers us a picture of the trading zone as an epistemic matter and as a physical location. (…) The disposition of personnel indicates that engineers and physicists worked within sight of one another. (…) The success* [of MIT Rad Lab] *was directly related to the creation of such common domains in which action could proceed even though the physicist and engineers entered into the exchange with radically different understandings of the machinery and techniques involved*" (p. 830). In this perspective it is interesting to note that Galison provides examples in which the absence of such common space plagued the unfolding of the project. For instance, this was the case in the Time Projection Chamber (TPC) project conducted at Stanford between 1974 and 1985 (see Galison, chapter 7). In the TPC project, the scattering of experts in different locations prevented, or at least slowed down, the creation of an interlanguage and generated major coordination problems. This led the project manager, confronted to the slippage of the project, to urge in a memo "*next time to build a circus tent to house everyone*" (p. 619).

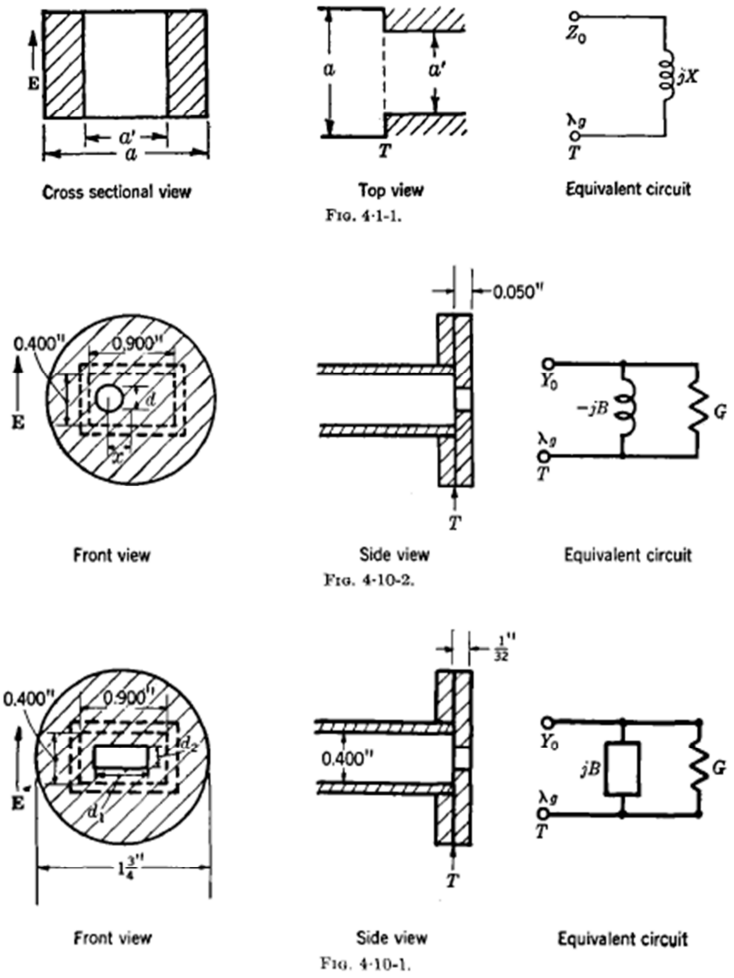

Figure 3: Physical waveguides and their equivalent circuits (from Galison, 1997, p. 823)[3]

Projects as temporary trading zones: a framework

Building on Galison's work, our principal argument is that a project might be viewed as a "trading zone" that facilitates the development of a language that works at the limits of knowledge boundaries. Actors from different firms, units, cultures, and disciplines have to coordinate their respective activities and knowledge processes under time and budget constraints to ensure that the project successfully comes to fruition. The basic coordination process is local language creation through words, symbols, and objects. Indeed, the

[3] Note: What is fascinating here is that this new language, created during the Radar project, later became institutionalized through textbooks. Indeed, these figures, shown in Galison (1997), were published in Marcuvitz's *Waveguide Handbooks*, first printed in 1951 as volume 10 of the MIT Radiation Laboratory Series.

fundamental question, which is often emphasized but little theorized in the project management literature, is how communication among people involved in a project unfolds, especially when the actors involved initially lack a common ground or a common understanding (Grant, 1996) and when the terminology and local languages differ considerably among the actors involved. The most frequent answers so far emphasize the role of team creation, co-location or the project manager function to foster coordination (e.g. Clark & Fujimoto, 1991); as well as the cross-boundary coordination processes occurring among people involved in the project (see for instance Carlile, 2002, and Kellogg et al., 2006). These earlier contributions facilitate an understanding of the role played by mechanisms and activities for facilitating coordination among different occupational groups and disciplinary experts. They also highlight how various kinds of knowledge complement each other to create new knowledge. However, prior research does not discuss the ontology of projects and therefore miss the question of local language *creation* as a central part of project organizing, which empirical studies has indicated is a central challenge in most non-routine, innovative and interdisciplinary projects. It also seems critical that we explicitly address the notion of the project into the analysis to be able to improve our understanding of how interlanguages are created. As highlighted in Galison's writings, the existence of the project as a particular kind of organization, the formalization of a project, co-location of members rather than the mere distant distribution and integration of activities, and a common authority all played key parts in the establishment and guidance of the process of developing an interlanguage. Accordingly, we thus believe that an improved understanding of the relationship between projects as facilitators for the creation of interlanguages may contribute to our general understanding of the development of such languages, and how they may be intentionally organized and promoted.

In this perspective it is also interesting to note the role played by various kinds of project management methods (organization as well as tools) in the fostering of trading zones between the different actors involved, especially scientists and engineers. It is evident from Galison's work that the major projects of the Second World War constitute a turning point. Indeed endeavors like the Radar Project and the Manhattan Project played a key role in the development of new collaborative practices, and of new forms of trading zones in which the creation of interlanguages were fostered by the emergence of "*new visible structural arrangements – both physical and social – in which action can proceed*" (Vaughan, 1999, p. 922). As we have seen earlier, Galison's analysis of the functioning of large projects and laboratories is crystal clear on this matter. What was new at the Rad Lab was precisely, contrary to its name, that it is not a traditional scientific laboratory but a project: it is oriented towards a very concrete and hands-on goal (building a radar), it had a clear and powerful managerial hierarchy, its structure organized the dialogue between disciplines through co-localization, and time was at the very essence of the entire process of organizing. Bringing scientists and engineers together under the same roof and the same authority led to new types of relations. It created a new kind of "*interactive zone*" (p. 830), which played a key role for expertise coordination. As shown, this impacted the physicists and engineers to create a new type of language to understand each other, a pidgin that was neither engineering nor physics yet facilitated the communication between expertise and the design process to unfold smoothly. This new language was not limited to the kind of formulas presented in figure 3. Indeed, other projects, such as the TPC project, demonstrates how in highly complex projects, project management methods like PERT[4], phased planning, task partitioning and the designation of system engineers and project managers, contributed to this new mode of communication and coordination.

[4] In the TPC case the PERT method was directly imported from Polaris since the military part of the Lawrence Berkeley Laboratory (named Lawrence Livermore Laboratory) designed the warhead of the Polaris missile (see Galison, p. 606).

The Rad Lab case and our condensed overview of the literature indicate that there are several interesting linkages between interlanguage creation and project organizing – linkages that have been pointed out as critical in studies of highly innovative and interdisciplinary projects, but so far have had little impact on the theoretical analysis of projects as organizational forms and the role of project organizing. We believe that this also underlines the value of better linking innovation management with project management – a link which has been essential in the past but which needs to be even more explicated (Davies, 2012). However, one problem is that the innovation management and boundary-spanning literature for the most part never talks about project management as a particular mechanism for the creation of interlanguage, and vice versa (see also Davies et al., 2013, for a detailed example) that project organizing rarely talks about interlanguage as a central concern for project organizing. We believe our discussion and the empirical account from Galison's research clearly point out the potential of these linkages for the furthering of the theory of projects and project management.

To lead the way for more interesting questions into the ontology and the processes of projects, we thus suggest a more elaborate use of the idea of projects as temporary trading zones. This leads us to the following basic proposition concerning the nature of projects and the processes involved: ***A project is a process that is enacting a temporary trading zone***. More precisely our hypothesis is the following: in large organizations, the setting up of a kind of "heavyweight" project organization allows the cross-disciplinary coordination processes of display, representation and assembly described by Kellogg's et al. (2006) to unfold. This enacts a trading zone which in turn leads to the creation of new interlanguages that foster the coordination between the different groups involved. This language has three components: linguistic representation, material representations (artefacts), and project management tools. Therefore theorizing about projects as temporary trading zones allows us to bring together the

contributions from two fields of inquiry: project organizing and innovation management. It should lead us to analyze carefully the three dimensions outlined above: organizational devices, coordination processes and the resulting new language. Since cross-boundary coordination processes have been described at length by Kellogg et al. we discuss the two other dimensions below.

Organizational devices. It is striking to note that the structuration of projects per se is almost rarely mentioned as an important element of coordination in the aforementioned literature on boundary-spanning and interdisciplinary coordination. This is not a surprise since this is neither their object nor their disciplinary field. Most innovation management and boundary-spanning literature rarely talks about projects as organizational forms, nor about projects as a particularly important empirical context (Lenfle, 2008; Davies, 2013). Kellogg et al., for example, consider projects as taken for granted, using the word throughout their paper but completely ignoring the literature on projects and project organizing or theorizing about the project as a mechanism for coordination. This "taken for granted hypothesis" constitutes an important weakness for the development of research in both fields. Indeed from Polaris's Special Projects Office (Sapolsky, 1972) to Clark and Fujimoto's heavyweight development teams (1991), project management research has demonstrated

1) the fundamental role of the setting-up of dedicated teams, co-location, project review, etc. to overcome coordination problems between boundaries, and

2) the difficulty to set up this type of organizations in large organizations which are first and foremost organized by functions.

Thus, we consider the creation of the Rad Lab as a fundamental step for the process of coordination. As pointed out by Galison, the trading zone is also a physical location that allows new types of interactions with people that earlier did interact only to a limited extent. It

allows for the interaction of specialists involved in the project that all have an important role for the collective problem-solving in the project. This might then be viewed as the very raison d'être of heavyweight projects in more general terms (Clark and Fujimoto, 1991). Such projects are created to overcome the limitations of traditional, functional structures (Allen, 1977) and open up for intense collaboration among diverse experts. A classic example is the Polaris Special Project Office (the SPO). This organization was explicitly designed to avoid the bureaucratic quarrels and political processes that characterized traditional large military projects. The SPO would enhance the coordination between the different parts of the project – the Navy and the dozen of firms contributing directly to the project. The SPO had complete autonomy and authority to manage the Polaris project. It was supervised by the powerful Admiral Raborn who implemented a sense of dedication and urgency into the project: "Our religion was to build Polaris" (Spinardi, 1994, P. 35). This allows the SPO to define its own strategy and unquestionably constitutes a key success factor of the Polaris project. (see Sapolsky, 1972). The organizational dimension of the trading zone is probably a precondition for effective coordination, although not sufficient in itself (Engwall, 2003). It is present in Galison's work and in Vaughan's (1999) discussion of the trading zone but here again without any reference to the project management literature.

The question of ***new (inter)language creation*** is absent in most prior research. Kellogg et al. (2006) and Majchrzak et al. (2012) provide an in-depth analysis of the processes of cross-boundary coordination but never mention language creation as a central element that fosters coordination between experts. This is noteworthy in Kellogg et al.'s analysis since they explicitly rely on Galison's idea of the trading zone. In our view, the result of these coordination processes is precisely the creation of the kind of pidgin or creole to which Galison refers. The Rad Lab case demonstrates this very clearly: Julian Schwinger's formula

is the result of the interaction he had with engineers and, finally, allows the coordination between the two groups. The case also shows that, as explained by Galison (2010), language should be understood "*in an expanded sense"* including ""*Images, symbol systems, calculational and diagrammatic schemes* [such as those in figure 3] – *even complex objects"*. Therefore, we suggest, it could be useful to decompose language into three categories: linguistic representation, PM tools and artefact, to allow for a refined analysis of the unfolding of projects:

1. **Linguistic representation**. This element, which is central in Galison's work, is fundamental. If it has recently received more attention in innovation management literature, we think in particular to the work of Seidel and O'Mahoney (2014) which discusses at length the process of concept creation and the role language plays in it. Also, Nonaka and Takeuchi demonstrate the role played by what is referred to as "figurative language" (1995, p. 13), such as metaphors and analogies, in the knowledge-creating process and the development of innovative concepts. It is evident from Nonaka, Clark and Fujimoto, Midler and Seidel & O'Mahoney that the creation of a "project-specific" language constitutes a fundamental characteristic of (successful) projects. Indeed one of the more central roles of setting up a project team in the first place is to design, negotiate and implement the concept that justifies the project (see Clark and Fujimoto, 1991; Wheelwright and Clark, 1992; Midler, 1996). From our perspective, this is a critical part of the language creation process. A simple indication of it being the difficulty, experienced by all researchers working with project teams, to understand what people are saying during project meetings, how people make sense of the overall goal, various ideas about what a project should produce, who should use and benefit from the project result, and so on. To consider a recent case, one may consider the Renault Logan project (Jullien et al., 2013) to

understand how difficult and important it is to progressively define what an "entry" vehicle is (which is different from just being "low-cost") in a company that has never built such cars and think, for a large part, that it's impossible (Midler, 2013)[5]. This concept creation was fundamental to define the identity of the project and, therefore, to be able to negotiate, to trade with the different functions.

2. ***PM tools***. Typically scheduling tools such as PERT and CPM constitute the second chief element fostering coordination. If the dominant model emphasizes the role of PM tools as an aid for rational decision making, recent literature on project management helps to deepen our understanding of their role in projects in a more general sense. Indeed, contemporary research recognizes the role played by PM tools in the coordination process (note that this role is already present, though not theorized, in Brooks' classics on software engineering, 1995). They are a category of boundary objects that help coordination between the different departments. Moreover, the PM toolbox represents a kind of language to enhance coordination, as noted by Galison in the TPC project. Thus different authors have studied how PM tools, such as schedules, play the role of boundary object (Yakura, 2002; Chang et al., 2013) and how PM constitutes a new language to foster coordination (Linehan & Kavenagh, 2006). In the same vein, we can probably argue, following the work of Johnson (2002), that the reliance of large military and space projects on the tools and language of systems management, respond to this need of a new language to manage the interfaces between components and disciplines. We therefore agree with Engwall (2012) when he explains that they play three different, and equally important, roles a) « *As a boundary object for technical coordination of actions and expectations*; b) *As a political feature*

[5] We thank Christophe Midler for this example.

for legitimacy and trust building; c)As a cognitive means for the social construction of a predictable future » (p. 611)

3. ***Artefacts***: there is now an important literature on the fundamental role of artefacts (what Seidel & O'Mahony call *material representations*), be they prototypes, simulations, objects, etc. in the innovation process. The role of artefacts as boundary objects to foster coordination between experts with different background is now well documented. It helps to overcome the problem eloquently summarized by Weick: "*How can I know what I think, until I see what I say*" (1979, P. 133). Our goal is not to contribute to this research stream, but to mention their importance in coordination. The works by Henderson (1999) Ioro & Taylor (2014, on boundary objects as a way to resolve conflicts) or, more recently, Jouini & Midler (2014) provide a good analysis of their different role in the design process. Artefacts were also essential in Galison's study and have been highlighted in other related work on cross-boundary coordination. For instance, Enberg et al. (2006) show how the end product had a central role in coordinating and creating a shared understanding among the many engineers involved in a product development project. Nonaka (1994) also underlines the importance that artefacts have for the establishment of a common understanding and a common language to speak about what to do and how to do things in innovation projects.

Table 1 summarizes the main elements of the trading zone framework. It also presents a few examples of theoretical sources that we believe are particularly important for each element.

Elements	Activities	Primary mechanisms	Consequences	Issues and problems
Organizational Device	Setting up of project organization, integrating diverse expertise, for instance among engineers and scientists, among developers and testers.	Project management as integrating mechanism across functions and integration as generation of knowledge among experts involved in the project. Key role of heavyweight project management and teams in this process. Co-location or people.	Common identity, unifying framework, common pressure, deadline pressure, shared responsibilities. Requirements on establishing some kind of common ground and common language.	Conflicts among people involved. Disagreement between disciplinary experts. Professional requirements that collide.
Project management tools	Use of various kinds of project management tools, concepts, methods to integrate activities and modules in the project.	Project management toolbox as a central coordination mechanism in project. Project management tools as boundary objects, such as plans, schedules, risk registers.	Location of activities in relation to each other. Understanding of interdependencies in the project and information needs from downstream to upstream and vice versa.	Difficulties to establish a logical flow of work that matches the knowledge development process before a common understanding of the product and the process have been established.
Project artefacts	Production and use of physical objects to foster transfer and integration of knowledge.	Artefacts (prototypes, simulation tools, drawings, etc.) as boundary objects that foster knowledge translation and knowledge transformation. Artefacts as central coordination mechanisms.	Improved coordination, better understanding of final outcome and goal.	Problems relate to the difficulty of establishing physical artifacts in projects when actors do not know what to do, or when conditions change frequently and rapidly.
Language	Creation of project specific language that foster coordination between functional experts	Role of figurative language (metaphors and analogies) in the knowledge creation process. Foundational role of "common lexicon". Role of linguistic representations. Creation of inter-language that is more than just translation and which allows for coordination among disciplinary experts. Language comprising both words and material/symbolic objects.	Development of a pragmatic interlanguage that fosters the communication among local and disciplinary languages.	Difficulties to establish a common lexicon that make sense to everyone involved or a language which is developed enough to reflect the complexity of the task and the technology.

Table 1. The trading zone framework: central elements of project organizing

The above framework is, of course, a tentative one. It has to be used and discussed in future research on the management and organization of innovation projects and tried out in other kinds of projects. We believe it to be a fruitful avenue for PM research for two main reasons

1. it emphasizes the process nature of projects,
2. it is grounded in solid literature and would thus offer an example of "borrowing theory" that could offer a lens to look at projects and the management of projects that complementing existing theories and perspectives.

Towards a theory of projects as temporary trading zones

This paper introduces the idea of viewing projects as temporary trading zones. The paper presents an analytical framework for the study of projects that builds on this idea by particularly focusing on four elements of project organizing: organizational devices, language, project management tools, and artefacts. The paper draws upon the work by Galison (1997) and the coordination among disciplinary experts. This specific coordination challenge is relevant to all kinds of project settings, but perhaps foremost in settings characterized by strong knowledge specialization coupled with intense interdependencies. We also believe that this framing is particularly relevant when addressing more innovative projects as these projects lack routines and established guidelines to facilitate coordination.

We argue that the idea of projects as temporary trading zones offers a novel way of looking upon projects that reflects some of the unique and most important features of projects. In particular, we stress the processual nature of projects and the ongoing creation of language for unique and innovative projects (Obstfeld, 2012).

As discussed initially, we believe at least five primary questions would need to be addressed for the future development of theories of projects and project management. How does our idea of projects as temporary trading zones answer these questions? This will of

course deserve further research and our goal here is primarily to outline some novel directions for future works. First, as for the question of why projects exist, our proposal points out that a fundamental reason for creating a project in the first place relates to the need for establishing an interlanguage, that the local languages that need to be integrated are specialized to the extent that communicating without the aid of project management would be extremely difficult. Following this idea, projects could also be expected to differ with regards to the kinds of interlanguages created and the number of local languages involved. The third question relates to the behavior of projects, or perhaps even more accurately the process of projects. We have suggested that projects tend to move through three primary stages of development. We have also suggested that projects could be seen as moving along four different dimensions: organizational devices, tools, artefacts, and language and in that respect argued that the creation of common meanings and a common language is associated with the interaction between several different elements. The behavior of projects would thus be related to these four elements and the interaction between them. Considering the success and failure of projects would not only be a matter of ensuring the creation of an interlanguage but equally so the establishment of the necessary devices, tools, and artefacts for such language to be developed. The success and failure are also associated with these issues – the creation of interlanguage is again underlined as a critical element. These are all hypothesis that would have to be explored in future research. Table 2 summarizes our principal arguments for the development of a theory of projects and project management based on the notion of projects as temporary trading zones.

Why do projects exist?	To create a common language for the sharing of knowledge and expertise.
Why do they differ?	Depending on the number of areas of expertise and divergence in disciplinary languages.
How do projects behave?	Several phases are critical in the development of a common language: (initial and identification of language problems, introduction of "interconcepts", stabilization of interconcepts, further refined of interlanguage, use of interlanguage.
What is the role of management?	Implementing elements to develop a common language for the sharing of knowledge and expertise.
What determines the success and failure?	The creation of a common language allowing members to interact and share expertise.

Table 2. Core elements of a theory of projects as temporary trading zones

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